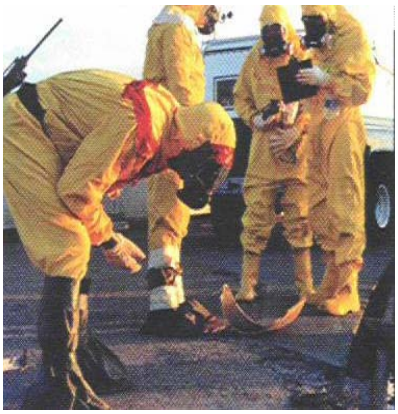

The International Emergency Management Society

9th Annual Conference Proceedings

May 14-17, 2002 Waterloo, ON, Canada

Facing the Realities of the Third Millennium

Editor: Ross T. Newkirk

Published and Sponsored by
TIEMS – The International Emergency Management Society

Hosted by the School of Planning, University of Waterloo
In cooperation with DRIE: The Disaster Recovery Information Exchange

DRIE-SWO

University of Waterloo

The International Emergency Management Society
9th Annual International Conference Proceedings

Facing the Realities of the Third Millennium

Edited by: Ross T. Newkirk

Published by:
School of Planning, University of Waterloo, Waterloo, On., Canada N2L 5B1

Published in 2002 under the authority of The International Emergency Management Society (TIEMS): WWW.TIEMS.ORG

EDITOR'S INTRODUCTION TO THE PROCEEDINGS OF THE 9TH INTERNATIONAL CONFERENCE

It is natural that the horrendous events of September 11, 2001, and the responses and implications for emergency management would receive significant attention in the conference. The screening of the 2-hour documentary filmed by two French journalists set a context for the equivalent of 4 sessions of panel discussion and papers directly related to the events. A particular advantage was hearing presenters who actually were on-site in the response and recovery. The conference benefited from the insights of Dr. James Young, M.D. Ontario's Chief Coroner and Assistant Deputy Minister for Safety and Security in Ontario. He led the Ontario response team at the World Trade Centre, and has devoted much of his time since that event to enhancing Ontario's response to terrorism.

Papers in the regular conference streams continue the broad-based approach to emergency management that have characterized previous conferences and make them so valuable in evolving an integrative framework for emergency management. The sessions on the systems approach and organizational/institutional aspects of emergency management continued to move the agenda forward. The papers on the practical and theoretical aspects of disaster response set the scene for a very interesting consideration of the gender issue in disaster recovery. This has established a valuable new perspective that should generate further discussion at future conferences.

Once again a number of good papers on transportation emergencies contribute to the conference. An important aspect is further discussion of the importance of independent transportation accident investigation. The conference appreciated the strong support given to this topic by Mr. Pieter van Vollenhoven, Chairman, ITSA, The International Transportation Safety Association. This discussion will be carried forward by the TIEMS board and may result in closer cooperation between ITSA and TIEMS.

The good balance between practical and theoretical aspects is evident in the set of papers on earthquakes and extreme natural events, behavioral issues, urban infrastructure, and responses to terrorism and bioterrorism.. It is good to see a series of papers related to risk and vulnerability assessments at the community level. This work is essential if local disaster mitigation is to become effective.

A major highlight of this conference was the very strong set of papers and presentations on business continuity and business crisis management and response. TIEMS was pleased to welcome the special presentation section from the Disaster Recovery Information Exchange to the conference.

The participation in this conference shows that TIEMS has a mature and expanding base in many important aspects of emergency management. It was therefore appropriate that there were sessions for discussion of the future development of TIEMS. This underscores that this is a time of great opportunity for TIEMS to move forward in bringing professionalism to emergency management and mitigation.

The discussion shows that TIEMS can be important in helping the profession move forward from roots in a primarily paramilitary response and reconstruction orientation to a strong beginning in community and national level mitigation. This is made possible by advances in warning systems, predictions and decision support systems – many based on work originally discussed in earlier TIEMS conference papers. The private sector TIEMS members are providing important tools and the academic members are advancing the science and the theory. We look forward to future TIEMS conferences where we will see a broader set of participants – practitioners, academics, private sector providers, decision-makers, politicians and insurers. TIEMS will continue to provide an effective forum for cross-disciplinary discussions which ensure that the values of: equity, safety & security, and sustainability of people, environment, business, and economy are key to professional emergency management.

Ross T. Newkirk,
Conference Proceedings Editor. Vol. 9.

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CONFERENCE PROGRAM

Tuesday, May 14, 2002 – Arts Lecture Building, University of Waterloo

0830 Continental Breakfast, Registration and Exhibits Open

0930 Room 116

***Keynote* Special: 9/11 A Documentary – DON'T MISS THIS!**

The Attack on the World Trade Center Sept 11th 2001.

A gripping 2-hour documentary film.
(Thanks to Jules and Gideon Naudet, photographers, for releasing to TIEMS the special viewing rights for this conference.)
Session Chair: Kathleen Kowalski

1200 Noon: Official Conference Opening Luncheon - Festival Room, South Campus Hall.

Karen Redman, Member of Parliament (Kitchener Centre)

Session Chair: Ross Newkirk

1400 hrs Blue Ribbon Panel Plenary – (Session P 1.1) - Arts Lecture Building – Room 116

The Response to The Terrorism on September 11th

SESSION CHAIR: ROBERT HEATH

THE ORGANIZATIONAL RESPONSE TO THE PENTAGON ATTACK
John Harrald – *TIEMS President, Director, Institute for Crisis, Disaster, and Risk Management, The George Washington University*

CREATIVITY DURING THE RESPONSE TO THE WORLD TRADE CENTER ATTACK
James Kendra - *Disaster Research Center, University of Delaware*

THE ROLE OF NATIONAL MEDICAL RESPONSE TEAMS IN TERRORISM RESPONSE
Lissa Westerman - *Arlington County Medical Response Team*

THE NATIONAL TRANSPORTATION SAFETY BOARD RESPONSE TO THE FOUR SIMULTANEOUS AIRPLANE CRASHES
Sharon Bryson - *(US) National Transportation Safety Board*

THE IMPLICATIONS OF SEPTEMBER 11TH FOR CRITICAL INFRASTRUCTURE PROTECTION.
Richard Little - *National Academy of Sciences, Washington*

1600 hrs Plenary Address and Panel – (Session P 1.2) – Room 105

The International Emergency Management Society – Its Development
Session Chair: Ross Newkirk

TIEMS: ITS EVOLUTION AND CHALLENGES (20 minute address): **Harald Drager** – *TIEMS Vice President & A/S QUASAR Consultants, Oslo, Norway*

PANEL OF TIEMS PRESIDENTS AND CONFERENCE ORGANIZERS:
Jean-Luc Wybo, France, **Verner Andersen**, Denmark, **Jack Harrald,** United States

Tuesday Evening

Octoberfest in May – A Celebration of the Kitchener-Waterloo Heritage

The Transylvania Club is the location for Tapping a Keg of Good Local Beer and enjoying the food and music of the area's German founders. (Extra tickets may be purchased for guests.) Bus transportation provided to/from site (Waterloo Inn & University Accommodations).

Wednesday Morning, May 15 – Arts Lecture Building, University of Waterloo

0730 Continental Breakfast, Exhibits and Registration

0830 Implications of The September 11th Terrorist Attacks

(Sessions A 2.1 & A 2.2) Room 208 Session Chair: Jean-Luc Wybo

RESILIENCE AND REALITY - THE WORLD TRADE CENTRE NEW YORK 11.09.2001

Robert Heath - *International Graduate School of Management, University of South Australia*

OBSERVING AND DOCUMENTING THE INTER-ORGANIZATIONAL RESPONSE TO THE SEPTEMBER 11 ATTACK ON THE PENTAGON

John Harrald – *Director, The George Washington University Institute for Crisis, Disaster, and Risk Management,* Irmak Renda-Tanali - *Research Associate, The George Washington University,* Jeanne B. Perkins - *Earthquake Program Manager of the Association of Bay Area Governments, Oakland, CA*

FEDERAL EMERGENCY MANAGEMENT: IMPLICATIONS OF THE TERRORIST ATTACKS OF SEPT. 11, 2001

Claire Rubin - *President, Claire B. Rubin & Associates and Senior Research Scientist, Institute for Crisis, Disaster and Risk Management &* Irmak Renda-Tanali -*Research Associate, The George Washington University*

A NATION CHANGED: A PSYCHOLOGICAL PERSPECTIVE ON 9/11

Kathleen Kowalski - *Psychotherapist, Private Practice*

CREATIVITY IN EMERGENCY RESPONSE AFTER THE WORLD TRADE CENTRE ATTACK

James Kendra &Tricia Wachtendorf - *Disaster Research Center, University of Delaware. Newark, New Jersey.*

PANEL DISCUSSION BY SPEAKERS CLOSES SESSION

0830 Systems Approaches to Emergency Response and Mitigation

(Session B 2.1) Room 211. Session Chair: Harald Drager

A SYSTEMS APPROACH TO ENVIRONMENTAL HAZARD ASSESSMENTS

Kim Galindo & Seong Nam Hwang,, *Hazard Reduction and Recovery Center, Texas A&M University*

THE SYSTEM APPROACH IMPLEMENTATION IN EMERGENCY MANAGEMENT FOR FLOODS, TRANSPORT AND TERRORISM PROBLEMS

Vladimir B. Britkov - *Institute for Systems Analysis, Russian Academy of Sciences, Moscow, Russia,*

UNDERSTANDING AND CONTROLLING CASCADING FAILURE: A SYSTEMS APPROACH TO MULTI-HAZARD MITIGATION

Richard G. Little - *Director of the Board on Infrastructure and the Constructed Environment of the National Research Council*

1000.. Refreshment Break - Foyer

1030 Organizational And Institutional Aspects Of Crisis Management And Mitigation (Session B 2.2) Room 211 Session Chair: Claudio Balducelli

IS THE EMERGENCE OF ORGANIZATIONAL PATTERNS A SUCCESS FACTOR IN CRISIS MANAGEMENT?
Cédric DENIS-REMIS, **Cheila COLARDELLE**, Valérie GUINET and Jean-Luc WYBO - *Ecole des Mines de Paris*

CAN THERE BE A THEORY OF DISASTER PLANNING?
Ernest Sternberg - *Planning Department, State University of New York, Buffalo*

BRINGING RISK ASSESSMENT INTO URBAN PLANNING
Ross Newkirk – *Director, School of Planning, University of Waterloo, Canada*

IMPROVING THE STATE OF EMERGENCY READINESS IN CHINESE CITIES
Zhong Maohua, *National Research Centre, Beijing, China*

1200 Wednesday Conference Luncheon– (Festival Room, South Campus Hall)

John Clizbe,
Vice President of Disaster Services,
American Red Cross.

Session Chair: Jack Harrald, President of TIEMS

Wednesday Afternoon, May 15 – Arts Lecture Building, University of Waterloo

1330 Disaster Response And Management (Session A 2.3) Room 208 Session Chair: Charles Kelly

DATA COLLECTION IN RESCUE OPERATIONS
Mirko Thorstensson *Swedish Defence Research Agency*

MANAGING THE EMOTIONS OF DISASTER RESPONSE WORKERS: A COMPUTER-BASED DEPLOYABLE RESOURCE FOR SITE WORKERS, COUNSELORS AND VOLUNTEERS
H. Richard Priesmeyer, Deborah K. Knickerbocker, Suzy D. Mudge, Cullen T. Grinnan, St. *Mary's University, San Antonio, Texas*

ORGANIZATIONS, LEARNING AND RISK MANAGEMENT
Jean-Luc WYBO - *Ecole des Mines de Paris*

1500.. Refreshment Break - Foyer

1530 International Disaster Recovery - Is Gender An Issue? (Session A 2.4) Room 208… Session Chair: Kathleen Kowalski

TWO SIDES TO EVERY DISASTER - THE ROLE OF GENDER IN MANAGING DISASTERS
Charles Kelly – *International Disaster Consultant USA*

AN EARLY APPROACH TO COMMUNITY-BASED DISASTER MANAGEMENT: PREVENTION MITIGATION AND PREPAREDNESS
Antony G. Marcil - *Planner in Residence, School of Planning, University of Waterloo*, Richard M. Williams - *World Environment Center (retired)*

WHAT'S THE BIG DEAL ABOUT TEMPORARY HOUSING
Cassidy Johnson - *Faculty of Environmental Design, University of Montreal*

WOMEN'S ROLES IN THE 1998 CENTRAL FLORIDA TORNADO DISASTER RESPONSE AND RECOVERY

Jennifer Wilson, *Florida Division of Emergency Management, Arthur Oyola-Yemaiel, consultant, Tallahassee, Florida*

1330 Transportation Emergencies

(Session B 2.3) Room 211 Session Chair: John Stoop

EMERGENCY RESPONSE POSSIBILITIES AT TUNNEL ACCIDENTS

Nils Rosmuller and **Roel van den Brand** -*Netherlands Institute for Fire Service and Disaster Management*

AN ADVANCED DECISION SUPPORT SYSTEM FOR MANAGING TUNNEL EMERGENCIES

Verner Andersen, Frank Markert and Steen Weber, Risø National Laboratory, Roskilde, Denmark

ADVANCES IN TRAVEL DEMAND FORECASTING AND WHAT THEY MEAN FOR EMERGENCY PREPAREDNESS

Joseph Kammerman - *Texas Transportation Institute*

ONE STEP CLOSER TO THE EFFICIENT MANAGEMENT OF SPEED-RELATED RAIL INCIDENTS

Cheila Duarte Colardelle- *Research Engineer Ecole des Mines de Paris (France)* Jacques Valancogne – *Director*, and Stéphanie Fond, *Maîtrise des Risques Systèmes (MRS) Department of the RATP*

1500.. Refreshment Break - Foyer

1530 Earthquake & Landslide Disaster Management And Mitigation

(Session B 2.4) Room 211 Session Chair: Clare Rubin

A CLOSER LOOK AND GIS-EARTHQUAKE LOSS ESTIMATION METHODOLOGY TO IMPROVE CRISIS MANAGEMENT CAPABILITY

Naill M. Al-Momani and John R. Harrald - *Institute for Crisis, Disaster, and Risk Management, The George Washington University, Washington*

THE ROLE OF NONSTRUCTURAL COMPONENTS OF HOSPITALS: 1999 IZMIT EARTHQUAKE

N.Oztas, **R.C.Myrtle**, R.J.Chen, S. Masri, R. Nigbor, J. Caffrey *University of Southern California, School of Policy, Planning, and Development & School of Engineering*

MULTIPLICITY OF CHOICE AND USERS' PARTICIPATION IN POST-DISASTER RECONSTRUCTION: THE CASE OF THE 1999 COLOMBIAN EARTHQUAKE

Gonzalo Gonzalo - *Reconstruction Research, University of Montreal, Canada*

COMMUNITY BASED PARTICIPATORY MODEL FOR NATURAL DISASTER PREPAREDNESS - LANDSLIDES

A A VIRAJH DIAS & P R WIJEWARDANA **-** *LABORATORY& SITE INVESTIGATION UNIT, CENTRAL ENGINEERING CONSULTANCY BUREAU (CECB), COLOMBO, SRI LANKA.*

1700 TIEMS Annual General Meeting (Session B 2.5) Room 105

Session Chair: Jack Harrald, President of TIEMS

1330 Approaches To Business Continuity

(Session C 2.3) Room 105… Session Chair: Robert Heath

RE-ENGINEERING BUSINESS CONTINGENCY PLANS TO BUILD A RESILIENT COMPANY

Chien-Chih Lin - *Institute for Crisis, Disaster and Risk Management, The George Washington University*

HOW TO DESIGN, DEVELOP AND IMPLEMENT A SUCCESSFUL BUSINESS CONTINUITY PROGRAM

Geary W. Sikich & Thomas Baines, *Principals, Logical Management Systems, Corp.*

THE IMPACTS OF SENIOR MANAGEMENT DECISIONS ON BUSINESS CONTINUITY PREPAREDNESS

John Laye – *Managing Partner, Contingency Management Consultants &* Ma. Isabel Martinez Torre-Enciso

PREVENTION - THE FIFTH AND MOST IMPORTANT PHASE OF EMERGENCY MANAGEMENT

Michael E. Martinet - *Office of Disaster Management - Area G, Los Angeles, California*

1530 Business Continuity – Workshop (Session C 2.4) Session Chair: Geary Sikich

TEN THINGS YOUR ORGANIZATION CAN DO NOW

Geary W. Sikich & Thomas Baines, *Principals, Logical Management Systems, Corp.*

Wednesday Evening Unscheduled - Free time to visit Downtown Toronto, community Theatres or the nearby world renowned Stratford Shakespearean Theatre (University Conference Services will assist individuals with arrangements.)

Thursday Morning, May 16 – Arts Lecture Building, University of Waterloo

0730 Continental Breakfast, Exhibits and Registration

0900 Disaster Recovery Information Exchange: Business Continuity Symposium (Sponsored By The Southwestern Ontario Chapter Drie)

Sessions A 3.1 & A 3.2 - Room 208 Session Chair: Don Brooks

WELCOME AND INTRODUCTIONS

EXECUTIVE COMMITMENT TO BUSINESS CONTINUITY: HOW TO GET IT, HOW TO MAINTAIN IT

Jean Armitage – *Business Continuity Management, Royal Bank of Canada*

BUSINESS IMPACT ANALYSIS: STRATEGIES FOR SOLUTION

Chris Werynski – *Business Continuity Planning, Clarica Insurance, Canada*

BUSINESS CONTINUITY AND TRANSPORTATION

Steve Cooper - *FedEx Custom Critical*

0830 Earthquakes & Extreme Natural Events

(Session B 3.1) Room 211 Session Chair: Duke Jeong

COLLECTION, SYNTHESIS AND QUALITY ASSESSMENT OF RESPONSE DATA REGARDING 1999 TURKEY EARTHQUAKES

Irmak Renda-Tanali, & **John R. Harrald** *The George Washington University*, Jeanne B. Perkins - *Association of Bay Area Governments*

HOSPITAL CRITICAL NONSTRUCTURAL SYSTEMS, DEPARTMENTS AND EQUIPMENT DURING AND FOLLOWING MAJOR SEISMIC EVENTS

R. Myrtle, S. Masri, J. Caffrey K. Lee N. Oztas and R. Chen, *University of Southern California*

A CONTRAST IN EARTHQUAKE PREPAREDNESS: GUJARAT, INDIA & SEATTLE WASHINGTON

Michael Trevits - *Continuity Planner*

SUPPRESSION OF POWERFUL CLOUDS AND PREVENTION OF DESTRUCTIVE TROPICAL AND EXTRATROPICAL CYCLONES, SEVERE THUNDERSTORMS, TORNADOES, AND CATASTROPHIC FLOODS

E. Krasilnikov**, V. Gridin -** *R/D Center of Computer Aided Design, Russian Academy of Sciences*

1000.. refreshment break - foyer

1030 Urban Infrastructure & Water

(Session B 3.2) Room 211 Session Chair: Louise Comfort

A CONCEPTUAL FRAMEWORK FOR ASSESSING ECONOMIC IMPACTS OF MITIGATION STRATEGIES IN WATER SYSTEMS

Irmak Tanali – *Research Associate, Institute for Crisis, Disaster, and Risk Management, The George Washington University, Washington*

KNOWLEDGE MANAGEMENT, FLOODING, AND THE WATERSHED APPROACH AND THE CITY OF WATERLOO, ONTARIO, CANADA

Jason Richard Niles and **Sarah Michaels,** *School of Planning, University of Waterloo, Canada.*

RISK ANALYSIS IN PLANNING: COMMUNITIES AND WATER EMERGENCIES

Ross Newkirk – *Director, School of Planning, University of Waterloo, Canada.*

METHODOLOGY OF ORGANIZATIONAL LEARNING IN RISK MANAGEMENT: DEVELOPMENT OF A COLLECTIVE MEMORY FOR SANITARY ALERTS

Wim VAN WASSENHOVE & **Jean-Luc WYBO**, *Ecole des Mines de Paris*

0830 Responses To Terrorism And Bioterrorism

(Session C 3.1) Room 105 Session Chair: Arne Worm

"UCF 2001": A JOINT MILITARY-CIVILIAN WEAPONS OF MASS DISTRUCTION EXERCISE

J. Peter Kincaid & Renea Moser, *Institute for Simulation and Training, University of Central Florida*; Major Patti Pettis - *4th WMD Civil Support Team Dobbins AF Reserve Base, Georgia,* Chief Joseph Donovan & Lieutenant Michael Bass- *Orange County Fire Rescue Department, Orlando, Florida*

CITIZEN CORPS VOLUNTEERS TO PREPARE FOR AND RESPOND TO TERRORISM AND NATURAL DISASTERS

Russell C. Coile, *Consultant, California*

TERRORISM AND SOCIAL SOLIDARITY: A REVISITED PERSPECTIVE OF CURRENT DEVELOPMENT PARADIGMS

Jennifer Wilson - *Florida Division of Emergency Management. Tallahassee, Florida*

BIOTERRORISM PLANNING: SAN ANTONIO LESSONS FOR SUCCESS

Rasa Silenas, *Col. United States Air Force, MC, FACS*, Charles Bauer, *MD, FACS*

1000.. Refreshment Break - Foyer

1030 Behavioral Aspects Of Disaster Response

(Session C 3.2) Room 105 Session Chair: Susan Smith

ISSUES FOR TRAINING AN EVOLVING EMERGENCY MANAGEMENT WORKFORCE: A VIEW FROM THE U.S. MINING COMMUNITY

Kathleen M. Kowalski, Charles Vaught, Launa Mallett, Michael J. Brnich, Jr., *National Institute for Occupational Safety and Health,Pittsburgh Research Laboratory*

EMERGENCY MANAGEMENT PERFORMANCE, THE IMPORTANCE OF ON-SCENE DECISION MAKING

Eivind L. Rake - *Stavanger University College and Sandnes Fire and Rescue Service*

HOW TO COMMUNICATE WITH THE PUBLIC DURING THREATS OF BIOTERRORISM: STRATEGIES FOR CRISIS MANAGERS

Chienchih Lin - *Institute for Crisis, Disaster and Risk Management, The George Washington University*

1200 Noon: Thursday Conference Luncheon– **(Festival Room, South Campus Hall)**

James G. Young, M.D.,
Assistant Deputy Minister, Public Safety Division,
Chief Coroner for Ontario,
Ministry of Public Safety and Security

Ontario's Response to Terrorism and Sept. 11, 2001

Session Chair: Ross Newkirk

Thursday Afternoon, May 16 – Arts Lecture Building, University of Waterloo

1330 Disaster Recovery Information Exchange: Business Continuity Symposium (Sponsored By The Southwestern Ontario Chapter Drie) Sessions A 3.3 & A 3.4 – Room 208 Session Chair: Don Brooks

CRISIS MANAGEMENT - INCIDENT COMMAND
Richard Turnbull - *Crisis Management Officer- Ontario Provincial Police*

TESTING BUSINESS CONTINUATION PLANS IN TODAY'S ENVIRONMENT
John E. Laye – *Managing Partner, Contingency Management Consultants*

THE BUSINESS CONTINUITY AUDITOR'S PERSPECTIVE
Graeme Jannaway - *Jannaway Associates, Toronto*

1330 Transportation Accident Investigation (Session B 3.3) Room 211 Session Chair: Verner Andersen

HARMONY IN DIVERSITY: METHODOLOGIAL ISSUES IN INDEPENDENT ACCIDENT INVESTIGATION
John A. Stoop - Faculty of Technology, Policy and Management, Delft University of Technology

DISASTERS IN TRANSPORT - USE OF ACCIDENT INVESTIGATION COMMISSIONS AS PROACTIVE APPROACH
Sverre Roed Larsen - Norwegian Work Institute, OSLO, Norway

ISSUES AND JUDGEMENTS IN ACCIDENT INVESTIGATION
Ove Njå - Stavanger University College & Senior Researcher at Rogaland Research, Norway

GLOBALIZATION AND HARMONIZATION: THE ESSENCE OF THE PROCESSES, THEIR INTERCONNECTIONS AND GLOBAL SIGNIFICANCE
Vladimir B. Britkov, Gleb S. Sergeev - *Institute for Systems Analysis, Russian Academy of Sciences, Moscow, Russia*

1500.. Refreshment Break - Foyer

1530 Infrastructure Safety & Warnings (Session B 3.4) - Room 211 Session Chair: Claudio Balducelli

AGENT BASED ARCHITECTURE TO IMPROVE SURVIVABILITY OF LARGE COMPLEX CRITICAL INFRASTRUCURES
Claudio Balducelli & Sandro Bologna – *ENEA, Itay*

TELECOMMUNICATION SUPPORT SYSTEMS IN COMPLEX HUMANITARIAN EMERGENCY SITUATIONS
Juraj Buzolic -*Croatian Telecom & Telecommunication* , **Nenad Mladineo** & Snjezana Knezic - *Civil Engineering, University of Split, Croatia*

USING WIRELESS NETWORKS TO PROVIDE EARLY WARNING OF EMERGENCY INCIDENTS

Johan Jenvald- *Visuell Systemteknik i Linköping*, Johan Stjernberger - *Swedish Defence Research Agency*, Anders Nygren -*Linköping Fire Department*, Henrik Eriksson - *Department of Computer and Information Science, Linköpings Uuniversitet, Swede*

EVALUATION OF THE FERNY CREEK FIRE ALERT TRIAL: THE EVOLUTION OF THE INTEGRATED COMMUNITY WARNING SYSTEM - VICTORIA, AUSTRALIA

Norm Free - *Shire of Yarra Ranges, Victoria Australia*

1330 Incident Management

(Session C 3.3) – Room 105 Session Chair: Norm Free

RAMSAFE AT THE OLYMPICS: A STAND ALONE RESPONDER ASSETS MANAGEMENT SYSTEM SOFTWARE TOOL DESIGNED TO DRAMATICALLY IMPROVE CRISIS RESPONSE IS PUT THROUGH ITS PACES AT THE 2002 WINTER OLYMPICS

William T. Rogerson, Jr. and Susan M. Smith - *Department of Health and Safety Sciences, The University of Tennessee.*

A UNIFIED RESEARCH APPROACH TO COMPLEX SYSTEM ANALYSIS FOR HIGH-RISK MISSION COMMAND SUPPORT

Arne Worm - *Swedish Defense Research Agency*

GEOGRAPHICAL INFORMATION SYSTEM DEVELOPMENT FOR REAL TIME NATIONAL DISASTER INFORMATION SYSTEM: KOREA

Duke Jeong - *Korea*

1530 Incident Management Workshop

(Session C 3.4) – Room 105 Session Chair: Peter Dworsky

INCIDENT MANAGEMENT SYSTEM: A DISASTER MANAGEMENT TOOL

Peter Dworsky - *Assistant Director, Office of Domestic Preparedness, St. Barnabas Health Care System, West Orange, New Jersey*

Thursday Evening
TIEMS BANQUET – A Unique Cultural Experience

The Clay and Glass Museum is the location for an evening of good food, networking, classical entertainment and a chance to view (and perhaps purchase) unique original art work. (Extra tickets may be purchased for guests.)

Friday Morning, May 17 – Arts Lecture Building, University of Waterloo

0730 Continental Breakfast, and Exhibits

0830 Business Crisis Response – Workshop

(Session A 4.1) – Room 208 Session Chair: Robert Heath

SELECTING AN EFFECTIVE COURSE OF ACTION – ANALYZING CONSEQUENCES AND OUTCOMES IN ASSESSING DECISION OPTIONS

Dr Robert Heath - *International Graduate School of Management, University of South Australia*

1000.. Refreshment Break - Foyer

1030 Crisis Management

(Session A 4.2) – Room 208 Session Chair: Robert Heath

A TEN-POINT CHECKLIST FOR EMERGENCY PLANNING

Susan M. Smith & William T. Rogerson, Jr. - *Department of Health and Safety Sciences, The University of Tennessee*

COMPLEX SYSTEMS IN CRISIS: MANAGING RESPONSE TO EXTREME EVENTS

Louise K. Comfort -*Graduate School of Public and International Affairs, University of Pittsburgh*

INFORMATION SYSTEM INFRASTRUCTURE FOR A NATIONAL CRISIS MANAGEMENT CENTRE

Ahmet Tumay, Kivanc Dincer**, Ozan O. Avci,** Murat Demirsoy **–** *TUBITAK, Ankara TURKEY*

0830 Maritime Safety
(Session B 4.1) – Room 211 Session Chair: Sverre Roed Larsen

EVACUABILITY OF PASSENGER SHIPS AT SEA - ADVANCED TOOLS FOR THE MARINE INDUSTRY – ***AUTHOR WITHDREW FROM THE CONFERENCE ON 02-05-09***

Guro Christiansen - *Ship Stability Research Centre, UK*

DOES THE INTERNATIONAL MARITIME ORGANIZATION FORMAL SAFETY ASSESSMENT LEAD TO IMPROVEMENT IN SHIPPING EMERGENCY MANAGEMENT?

Guillaume Chantelauve - *BUREAU VERITAS, France*

NEW TRAINING CONCEPTS IN MARITIME EDUCATION

Steen Weber & Hans K. Andersen **-** *Risø National Laboratory, Roskilde, Denmark*

1000.. Refreshment Break - Foyer

1030 Community Vulnerability Risk Analysis
(Session B 4.2) - Room 211 Session Chair: Sarah Michaels

ASSESSMENT OF THE CAPABILITY OF LOCAL GOVERNMENT FOR THE VISUALISATION OF COMMUNITY VULNERABILITY

Norm Free - *Shire of Yarra Ranges, Victoria Australia*

REDUCING THE GAPS BETWEEN PRESCRIPTION AND PRACTICE BY ANALYSIS AND SHARING OF EXPERIENCE

Valérie GUINET, Stéphanie BENOIT, Jean-Marc VAUGIER, **Jean-Luc WYBO** - *Ecole des Mines de Paris*

AN ASSESSMENT OF DISASTER VULNERABILITY: FIFTEEN TENETS ABOUT A CRUCIAL AND COMPLICATED CONCEPT

David A. McEntire - *Emergency Administration and Planning, Department of Public Administration at the University of North Texas*

1130 TIEMS, Professionalizing Emergency Management & Conference Closing
(Session C 4.2) – Room 105 Session Chair: Ross Newkirk

Note: For Accompanying People, there are opportunities for interesting day trips: Niagara Falls, Stratford, St. Jacobs Mennonite Market and Crafts, Downtown Toronto. The University Conference Centre 519-884-5400 provides information and arrangement assistance.

CONFERENCE PAPERS

SECTION 1: IMPLICATIONS OF THE SEPTEMBER 11TH TERRORIST ATTACKS

RESILIENCE AND REALITY– THE WORLD TRADE CENTRE NEW YORK 11.09.2001

Dr. Robert Heath

International Graduate School of Management, University of South Australia[1]

Keywords: World Trade Center, resilience, terrorism, response management

Abstract:

The terrorist attack on the World Trade Center on September 11, 2001, resulted in the total loss of the two towers and surrounding buildings, with an uncertain number of dead (conservatively over 2,000). Media commentators claim this event changed the world as we knew it.

Ability to cope with change is a factor in level of resilience (Paton, Johnston, Smith, & Millar , 2001). Humans seem to elicit resilience from social bonds, skills, social norms, and perceived self-efficacy (resources (Buckle, Mars & Smale, 2000; Lindell & Whitney, 2000). This suggests that broad clusters of activities may lead to improved understanding of how these factors promote resilience, and absence or low levels of such factors lead to vulnerability and, perhaps, worse impact damage and long recovery periods.

This paper points out that the change may be through perceptions rather than a manifest change – public perceptions of security and invulnerability were shaken if not fractured. Impacts included major disruption to American and world aircraft movements, evacuation of buildings, closure of the New York Stock Exchange, American and global nervousness in share trading, and financial pressures on many airlines. More fundamental and long-term effects included the fall of the Taliban government in Afghanistan, a declared war on terrorism by America and allies, and a suggested annual cost to the US of $151 billion.

Discussion covers entry of first responders and strategic command, risk manage, site management of adjacent areas, return to work messages, security, the focus on Osama bin Laden and Al Qaeda, and vulnerability. These raise questions over conditions for site entry, escalation to "worst case" responses, oversight of other causes and issues, and public beliefs and readiness. The paper concludes with an outline of how resilience can be sustained and improved by attending to psychological as well as physical resilience, and by further attending to public beliefs as well as response agency readiness and to our ability to manage and provide resources for response and recovery activities as well as improving structural strength and integrity.

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1. Introduction

Commentators claim that the world as we knew it changed when two passenger-carrying aircraft were hijacked and deliberately crashed into the World Trade Center (WTC) at 8.45 AM and 9.06 AM respectively with the consequent complete destruction of both towers and several adjacent buildings. This is not quite true. What may have changed was the *perceived nature of risk and threat held by the public at large and maybe by many media commentators* – the threats and risks were (and are) the same before this event and after this event.

This is true for the WTC as an attempt to topple one tower on to the other failed only in its execution in 1993.

2. Resilience

A key factor in dealing with sudden disasters (including terrorist attacks) is that of resilience. Resilience can be defined as the degree to which an impacted resource or organization may resist impact damage and the speed with which that organization recovers or that resource can be recovered. Elements that support resilience include shared values, established social infrastructure, sustainability of social and economic life, presence of partnerships, presence of networks, and the degree of developed skills and available resources (Buckle, Mars & Smale 2000). The rule-of-thumb here is that resilience positively correlates with the number of bonds and the size of skill pools and resources in hand that are appropriate to countering a sudden impact.

Paton, Johnston, Smith, & Millar (2001) provide a more flexible definition in terms of systems. They see resilience as "the capacity of systems to maintain their integrity and the relationships and balance between elements in the presence of significant disturbances by drawing upon internal resources and competencies to manage the demands, challenges and changes encountered" (p, 47). This reflects the combinative factors of resistance to impact ("maintain their integrity") and rebound or recovery speed ("drawing upon internal resources … to manage the demands, challenges and changes encountered").

Levels of individual resilience, on the other hand, may reflect varying degrees of self efficacy (Lindell & Whitney, 2000). One means of increased resilience emerges from focussing on coping with problems (Bachrach & Zautra, 1985). Theories, including Planned Behaviour (Ajzen, 1991), and models, including the Person-Relative-to-Event (Duval & Mulilis, 1999) attempt to link individual and social or community or organizational perceptions into predictive efforts in the adoption of risk reduction behaviours. This is felt to increase resilience. The focus falls on motivation to act coming from perceived threats, and considers self-efficacy, social norms, past experience, and outcome expectation expectancies.

Factors affecting and indicating resilience can be considered within the context of the World Trade Center event of 11th of September, 2001.

3. The World Trade Center Bombing – 09.11.2001

Sometime after take-off from Boston at 7.58 a.m., Los Angeles bound United Airlines Boeing 767 (Flight 175) was hijacked. Similar hijackings happened to American airlines Boeing 767 Flight 11 (Boston to Los Angeles) at 7.59 a.m., United Airlines Boeing 757 Flight 93 (Newark to San Francisco) at 8.01 a.m., and at 8.10 a.m. for American Airlines Boeing 757 Flight 77 (Washington to Los Angeles). In less than three hours all four had crashed. At 8.45 a.m., Flight 11 with 92 passengers and crew was crashed into the North Tower WTC. At 9.03 a.m., Flight 175, carrying 65 passengers and crew was crashed into the South Tower WTC. At 9.38 a.m., Flight 77, holding 64 passengers and crew, was crashed onto the northwest side of the Pentagon in Washington. Finally at 10.37 a.m., Flight 93, containing 45 passengers and crew, crashed relatively harmlessly outside

Pittsburgh (possibly due to passenger action). The South Tower WTC collapsed at 10.00 a.m., followed by a collapse at 10.29 a.m. of the North Tower WTC. The outcome was “the bloodiest day on American soil since our Civil War” (Time, Special Issue, 12.09.2001).

The terrorists selected the quietest day of the air traffic week, which meant they accessed fully fuelled-up passenger jets with low passenger numbers.

<u>Some facts about the WTC</u>

North Tower: 110 floors, 97 passenger and 6 freight elevators, 200 feet (around 60 meters) square, 1,368 feet (around 410 meters) height, completed in 1970.

South Tower: 110 floors, 97 passenger and 6 freight elevators, 200 feet (around 60 meters) square, 1,362 feet (around 408 meters) height, completed in 1972.

Total occupancy was around 50,000 capacity plus visitors and tourists. Each has a mass of around 500,000 tons.

The heat of fires from the fuel of the jets contributed to the collapse by altering the chemical structure of steel (softening) resulting in the above-crash weight of the building leveling the below-crash floors in a chain reaction. Added to this can be probable loss of structural integrity from the aircraft frame bending or severing central core supports, central lift wells and steps spaces acting as flame concentrating torches (see Kings Cross London Underground fire and a number of high rise fire findings), and possible floor truss and floor support-fixing failures. Several other buildings collapsed (the World Trade Center) or became collateral damage from debris and the collapse (including the Marriott Hotel). The South Tower, although struck after the North Tower, eighteen minutes later, collapsed almost half an hour before the North Tower, probably because the aircraft impact was around twice as low down the building (75^{th} as opposed to 95^{th}) and thus the far greater weight made structural failure occur at a faster rate.

Witness and preliminary investigation reports tend to suggest the situation was non-survivable from those above the midpoint impact areas as fire escapes would have been either obstructed or coated with burning fuels.

4. Impacts – immediate and short term

1. Cessation of aircraft traffic in the United States.
2. Gridlock and shutdown of central New York (central and lower Manhattan) and of Washington as both an outcome from the Pentagon strike and the WTC effort.
3. Cessation of trading in the New York Stock Exchange. This cessation stretched over a few days, as did specific market trading areas. Note that one major player in this form of market lost nearly all of the US half of their workforce.
4. Evacuation and/or closure of many public buildings including – the White House, Capitol, Pentagon, United Nations building, Sears Tower (Chicago), L&C Tower (Nashville), John Hancock Tower (Boston), Disney Parks (Florida, California), major league base-ball games and sites, Hoover Dam, the Space Needle (Seattle), Mall of America (Minnesota), Kennedy Space Center, bridges and tunnels into Manhattan (by 9.35 a.m.), museums and monuments in Washington, and most significant structures owned or leased by federal and state governments.
5. A drain on motor vehicle fuel reserves across the US as motorists took emergency precautions.
6. US and global nervousness and climate became such that subsequent evacuations of significant buildings arose around the world and terror by germ warfare via postal services arose in US. This latter fear was reflected in false scare campaigns in countries like Australia. In one sense

the terror campaign succeeded in creating a nervous and apprehensive reaction, particularly in some areas of the US.

5. Impacts -- Middle and Long Term

Longer lasting impacts, outcomes and consequences included:

1. There occurred a local (North American) and world recession in tourist travel. Again, when issues of shattered expectancies and minimal past experiences are considered (as per Ajzen, 1991; Duval & Mulilis, 1999) at least partial explanations emerge for the tardiness of recovery of passenger numbers on aircraft. People still express concerns about flying some six months after the event, particularly within the United States.
2. Uncertainty in stock market values and trading (around the world) combined with an ongoing "fear" of recessional economic environment and a situation-consequent uncertainty over US (and world responses) and terrorist next actions to produce an unsettled and "flat" share and bond market activity.
3. Airlines faced insolvency and increased business costs due to longer throughput hours and security checks – this can indicate a move toward local rather than global business supply chains. September 11 effects may combine with ongoing internal problems to terminate United Airlines (similarly as the Locherbie (PanAm 103) bombing may well have assisted Pan Am into termination). Here, adjustment to risk establishes a slower more detailed set of activities in terms of security checks and monitoring. This may ease as the sharpness of the experience fades and any ongoing and visible consequent events fail to arise.
4. There appeared to be a hiatus to Just-In-Time systems approaches, with a need to stockpile for (1) slower deliver/access times and (2) meet just-in-case needs. Modifications in this strategy may lead to a more permanent adaptation that seeks an optimal balance of just-in-time methodologies with a just-n-case storage process.
5. The Taliban Government in Afghanistan fell to Afghanistan and US-led military forces.
6. American political and civil groups have developed a more confrontive style of interaction.
7. Economic costs for continued trading may be large and thus add to recession concerns. Fortune Magazine (February 18 2002, 145 (4), pp. 6267) estimates an annual potential cost of US$151 billion in transportation, and employee.

   There can be some argument over these figures in terms of (1) size and scale, (2) frame adjustment and (3) factoring in one-off and recoverable costs. Size and scale may be initially high but reduce over time as one-off costs and cost recovery reduce the impact and as inertia prevails with no onset of any successive equivalently sized impacts. One can argue that the prevailing expenditure prior to September 11 was wrong or even negligent and the current state of cost and effort is the real cost of doing business. After all, the actual threat of terrorist behaviour and size of effort involved was present before and after this date (as is directly evidenced by the relatively aborted 1993 WTC bombing). Finally there are blurred estimates that include potentially irregular or even one-off costs (IT hardware for back-up) and process costs (such as delays, logistics, and transportation). While the process costs are increased, these are likely to be the same across competing organizations and can or will be passed on through to end users and customers.

6. Observation and Comments

1. ***Entry of first responders***. This is somewhat of an emotional and an article of public canon – emergency responders were and are heroes. There are aspects of this situation entry, however, which need consideration. At a primary level what was the clear or hard information held by first responders? Bluntly speaking (without subsequent investigative hindsight) a modern large commercial aircraft, laden with fuel, crashing at speed into a building will destroy the impact area by fire alone – and will, by the very nature of the structure of a high-rise tower complex, destroy the tower. Should there be clear awareness of this information at the time and on the site, then there exists a question as to whether site entry was appropriate for more than those assisting the evacuation of the below-impact portion of the tower. Were the responders placed at risk in this situation? Movement towards impact sites may appear to be a questionable practice, given:
   - the area size of each floor (40,000 square feet or over 3900 square meters),
   - the vertical impact damage of between six and nine floors,
   - the high probability of burning fuel draining down the liftwells in the center section and acting as a flue "torch" (or piped fire) element that would spread the fire (increase temperature and precipitate soft steel deformation and structural collapse), and,
   - two hose teams may effectively cope with around an eighth of a floor area.

   Balanced against this can be unclear information about cause and thus likely scale of situation, the action ethos of emergency service personnel (particularly the aggressive get-to-the-seat-of-the-fire response by most US firefighters), the impulse to help those in danger, and a need to be seen to be doing something.

2. ***Entry of strategic command***. The above comments apply equally well to strategic management attendance, again with the need to balance the standard operating procedures against specific situations. Bottom and tactical level of management goes where the coalface response teams. One could be more critical of higher level management placing themselves and their staff at risk (and, indeed, the overly close proximity of the New York crisis management response, from the Mayor down). Reasons for close proximity may include the perceived need to sense and see the site, lack of alternate and readily accessible locations, and the mental impact of the size and nature of the incident. There probably was an underestimate or lack of recognition of the possible (and actual) consequences and thus an underestimate of threat and risk of danger. Given contemporary audiovisual and computer systems we may need to further rethink and refine line-of-command location and activity. Here again we may consider that the size of the structures and a lack of actual experience with this size of situation can lead to possible defects in current zones of operation and positioning.

3. ***Site management of adjacent area***. Probably the comments addressed n the above two points are equally applicable here. Some thought may need to be given to create greater sterile zones earlier in the situation management process to move those in debris line-of-fire to greater safety and restrain encroachment by spectators. In the WTC situation (and others in the future) this would form part of the "Worst Case".

4. ***Risk / threat is greater than conventional perception***. Conventional business continuity, crisis and contingency management practices have perhaps poorly developed worst case scenarios for a preferred more likely case or set of cases based on likely frequency of occurrence. Take heed of the staff and resource loss that faced Morgan Stanley Dean Witter, with 21 floors of South Tower, or Port Authority (6 floors) and Cantor Fitzgerald Securities (six floors) in North Tower. We need either to avoid such concentrations in number of staff onsite or to ensure that our risk management covers these exposures.

5. ***South Tower message to return to work***. Note the confusion and implications of the reported "return to work" announcements made within the South Tower complex. To an extent this met

the perceived situation prior to the South Tower attack, but may not have fully apprehended risks in terms of damage from the North Tower or vulnerability to attack – and thus leaving open potential "duty of career" litigation.

6. ***Security***. For parts of the world less troubled with terrorism, the WTC may well have been somewhat of a wake-up moment. Two things need to be noted:
   - The outcome was in the hands of the terrorists once airport security was breached. Moreover, standing air patrols of fighters serve really as visible images of doing something and possible re-assurance, and as a small deterrent – what serving pilot or government can afford to shoot down a passenger aircraft loaded with their own nationals over densely populated ground.
   - Heightened security will relax over time and vigilance decrease unless further major incidents arise. This will particularly apply when current states of vigilance impede easy flow of business (what is being called "friction", as per Fortune Magazine).

   On the other hand, tightened security can reduce pilfering, insider crime, lost resources, and lead to efficiencies in system management and inflows and outflows of goods. While these do not show up as cash benefits in the security budget, it is worth undertaking a realistic guesstimate.

7. ***Security – Airport and aircraft***. Most airports and airlines try to balance people movement with security measures. The current balance is currently tipped heavily in favour of security, with longer time lags to get from airport entrance to aircraft – the current average lag in February 2002 is one hour extra at large US airports.

   ElAl has the highest physical security, but is relatively speaking a low-volume airline. Larger world airlines, already struggling financially due to competition and the WTC incident, are likely to press eventually for ways in which to speed up passenger throughput. Perhaps the two key areas for increased security surround access to the cockpit crew (locked doors, penetration-proofing of doors) and cabin security. Sky marshals were increased in the US and introduced in Australia. On a tangent, the WTC has increased interest in bomb-resistant containers for aircraft. Increased security has led to further curbs on potentially lethal sharp objects (scissors, pocket knives, metal knives and forks) which may be a little draconian given the limited multiple damage done at one time by one of these, the utility of these for passengers (and in emergencies), and the doubts that were subsequently placed on reports that similar items (including carpet cutters) were used in the WTC aircraft highjackings.

8. ***Focus on Osama bin Laden***. The US government had to walk a fine line between public disclosure and confidentiality for investigation and response purposes. One possible problem in this effort emerges from the real media and public pressures for culprit identification. The key planner was alleged to be Osama bin Laden supported by the Al Qaeda terrorism unit. From time to time governments have released supporting information. However, coupled with an historic cynicism over governments not releasing full information or even doctoring information to suit their needs, is a growing public awareness that many of the early arrests have ended with those arrested being released due to insufficient information or no substantiating evidence at all.

   The central figure and the existing terrorist structure have been disbanded and destroyed by US-led operations around the world, particularly in Afghanistan where the Taliban government was toppled.

9. ***Accent on patriotism – unity and anger***. In many crisis situations two emotions generally emerge – a sense of unity ("us" versus "them") and one of anger (and even a search for a scapegoat). Both forms emerged around the world – remembering that many countries lost

citizens in the incident. The sense of unity led to an increase in felt and visible unity in the US where a publicly-held belief of being distanced from terrorism seems to have been severely shaken. This pre-WTC public belief may seem surprising given the visible effort the FBI has placed on managing chemical weapons of mass destruction, the previous WTC incident in 1993, the Oklahoma City bombing, and other significant disturbances from Waco through to the riots surrounding the court findings over the Rodney King beating in Los Angeles).

As arose in Oklahoma City after the Murragh Building bombing, the sense of unity was very visible among response agencies and among New York residents. Volunteers came from within the city and from across the US.

Anger also leads to scapegoating and undoubtedly contributed to hate-crimes against those with Islamic faith in most countries. Even allowing a ten-fold increase on reported incidents in the US of hate-crime directed at those of apparent Arabic cultures and physical structures associated with Islamic belief, the figure was surprisingly low.

10. ***National psyche – a more vulnerable US***. Perhaps the clearest impact may have arisen within the public belief (or psyche) of Americans. Lack of apprehended threat, perceived economic and military size, and cultural characteristics of individualism and ease of access may have contributed to a sense of invulnerability that has been shaken. Many reports suggest a more inward looking tendency and measures of travel volume and work absence tend to support this increased sense of vulnerability. Some businesses report a need to encourage commercial travel through buddy systems and increased payments.

    Loss of belief certainties and thus an increase in feelings of vulnerability take time and absence of incident to heal. In many ways this loss can be equated to the feelings held by those experiencing their first earthquake, wildfire, "flash" flood, or tornado. Confidence, like reputation, is slowly learned but quickly lost if the loss experience creates doubt over the validity of the belief. These indicate qualitative agreement with research findings (Duvall & Mulilis, 1999; Bachrach & Zautra, 1985) where concepts of expectations and past experiences fail the situation – the US public did not generally expect such a large terrorist event to arise within their community and had minimal past experience upon which to draw.

7. Vulnerability

The WTC event reinforces the need for appropriate risk assessment of risks and of perceived vulnerabilities, with corrective actions being taken when one is not in synchronization with the other. Vulnerabilities that are not addressed by the appropriate business or government management authority will act as a public cancer over time. Risks that exceed publicly-held perceptions of vulnerability need to be managed so decrease the risks and increase public awareness, as any subsequent manifestation of the risk event is likely to shock or even traumatize the unsuspecting population.

8. Resilience

Moving from the factors and thinking outlined by many researchers and theorists (Azjen, 1991; Duval & Mulilis, 1999; Lindell, & Whitney, 2000; Paton, Johnston, Smith, & Millar, 2001) resilience may be viewed as a composite of a number of factors. This composite may be defined in broad groupings that focus on psychological and physical or tangible clusters of factors.

Community and organizational resilience thus can be considered in terms of psychological and physical components. Each of these divides into at least two parts. Psychological resilience, for example, can be seen as a composite of preparedness and group or community beliefs. Physical resilience can be seen as a composite of ability to withstand impacts from the situation and ability to repair and regenerate.

Preparedness stems mostly from core team (responder) training and skill levels and from management planning and support. Across communities and organizations, preparedness tends to be more passive, being based on videos, warnings, and instructions on basic things to do and who to contact. Real preparedness is tested only by encountering a situation. Overall, preparedness diminishes with accent on other priorities that have more immediate outcomes and consequences and lack of precipitating situations.

Community and across organizational beliefs shape the perceptions held by the members of that community or organization. While the size and strength of the belief may vary according to sub-groups within that community or organization, the overall prevailing attitudes and perceptions condition the overall response to impacts. Fractures in these public beliefs can lead to suspension of belief and action, depending on the response capability of those in the preparedness activity. In the WTC case, this was high across the New York City management and response agencies – even after sustaining many casualties from the first responders and their immediate support teams.

Where preparedness within the core team is high the beliefs of the population are fractured the population can impede through disbelief and unwillingness to act. This did not arise in the WTC situation as the situation was relatively localized and nonsurvivable by those trapped in the above impact levels of both towers. On the other hand greater levels of area evacuation and street control may have been possible during the one and a half hours before each tower collapsed had this possibility (belief) been in place.

Where preparedness is low and beliefs are fractured, response can appear random and sluggish and frustration, anger, followed by hopelessness and even learned helplessness develop among the population over time.

Given low preparedness but significant appropriate beliefs then effective response may emerge from volunteer or population efforts. This form of outcome is also visible in situations where the size of the situation exceeds the response efforts (so that overall response appears dispersed or patchy) and people help themselves. Data gathered from the Northridge Earthquake, for example, suggest that between 80 and 90 percent of rescues of trapped people being undertaken by non-response agency personnel.

High preparedness and highly appropriate beliefs obviously indicate an optimal perhaps target or ideal level of resilience.

From the physical half of resilience, "hardened" situation-designed structures directly reduce impact damage and threat to people. Successful strategies here generally follow one or more of the ABC Model – Build Away, Build Better (stronger, more resilient), Build Compatible. By creating immediate physical resilience we reduce costs and can concentrate the core response personnel and resources at specific situation-caused hotpoints. In the WTC situation, the area and the two towers were not generally hardened against terrorist activity or specifically hardened against modern aircraft impact damage. Underscoring this is the question of how well structures and people can be "hardened" – although pointers can be learned from those regions in the world that endure relatively frequent levels of terrorist or other crisis situations

The other half of physical resilience is our ability to physically manage the impacts and recover the situation to some acceptable level of functioning. Here, undoubtedly, strong economic and industrial resources add to resilience – as can be evidenced by the speed with which San Francisco and Kobe recovered from infrastructurally damaging earthquakes and the relative efficient and quick clean-up at the WTC site.

High structural resilience built into the environment and sufficient to excess response and recovery resources provides target and ideal levels of sustainability and resilience. The opposite (low structural resilience and low availability of response and recovery resources) suggest a slow response with increasing consequential impact damage and a slow and enervating recovery. High structural resilience combined with low resource availability suggests reduced or localized damage that may not be quickly recovered (which may within those localities enervate resilience). Low structural resilience combined with high resource availability suggests a broad immediate damage followed by relatively quick clean-up and fast recovery probably focused on core components of an organization or community. Aspects of Kobe's recovery suggest that this can be seen as an example of this last combination.

The picture painted here may suggest that resilience need only be built upon the response and post-response efforts. Look again. Psychological resilience is built on being prepared and holding appropriate beliefs. The strength of these depends on the effort we put into them before a response and that effort needs to cover reducing exposure to risk and thus vulnerability. This can be seen even more clearly when we look at physical resilience. Here, we need to create structures that resist adverse situations – and thus are resilient. Crisis management comes into play when we cannot reduce or eliminate risks. By having sufficient and appropriate resources in hand we can reduce the time taken to clean-up and time spent in recovery mode. This quick recovery promotes resilience.

9. Conclusion

The total loss of the World Trade center and surrounding buildings had a very visible and salient impact. Alongside the loss of life, the management of removing a million tons of rubble, and the need for hundreds of businesses to use extreme business recovery approaches, this event has had economic and operational repercussions within the US and in other parts of the world. Increased security, for example, has meant slower business interactions, longer travel delays, and a range of commercial and access frictions. The impact on the world has included the fall of the government in Afghanistan, changes in international political posturing, and a decline in air travel and tourism.

As suggested in the brief overview of factors contributing and defining resilience, individual preparedness and community bonds help overcome impact damage. Certainly this is evident in the community responses within the Manhattan and New York region in helping each other and demonstrating respect and care for those impacted by the event and for those who handled the response and who are continuing the recovery activities. Certainly the speediness with which the destroyed overburden has been removed demonstrates a visible factor of resilience.

The reported heightened security and sense of vulnerability may decay over time – provided there arise no equally visible and salient events. Investigators and researchers explore why the towers collapsed so quickly, the fractures in the social and cultural beliefs (particularly in the US), and the management of large emergency events in urban environments. From these efforts can emerge greater awareness of the need to focus on building and maintaining communities and regions in which people are not only protected but also able to cope with emergency situations. By doing this we move further into developing sustainable and resilient urban communities.

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OBSERVING AND DOCUMENTING THE INTER-ORGANIZATIONAL RESPONSE TO THE SEPTEMBER 11 ATTACK ON THE PENTAGON

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Key Words: Emergency Management, Pentagon, Terrorism, Emergency Response

Abstract

The National Science Foundation provided funding for the George Washington University Institute for Crisis, Disaster, and Risk Management to acquire and structure baseline data that will support the analysis of the inter-organizational response to the terrorist attacks of September 11, 2001. The documentation of organizational structures and the information flows between and among emergency management and emergency medical decision makers will support future research that will address the problems of communication, inter-organizational coordination, and decision making in complex, multi organizational response environments. This paper focuses on the response to the attack on the Pentagon and describes a very successful, very complex, response operation. The organizational response was based on existing organizational systems: the Federal Response Plan, the Incident Command System, and Unified Command but a significant level of organizational creativity and adaptation was necessary to achieve success.

Introduction

On September 11, the United States has suffered its first civilian mass casualty event since the Texas City Explosions/Fires of 1947 (581 deaths, 3,500 injuries). The toll of the attacks approaches the casualty toll of the Galveston Hurricane of 1900, the most catastrophic disaster in U.S. history. First response, emergency management, emergency medicine, and military organizations responded heroically and effectively. These events have, however, destroyed the myth that somehow the U.S. will remain immune to mass casualty disasters and that the U.S. emergency medical, emergency response, and emergency management systems would not have to deal with tragedies on the scale experienced in less developed countries.

The coordination of the complex organizational systems that are rapidly created to respond to an event such as the WTC collapse and the Pentagon attack is incredibly difficult. After the September 11 attacks, the United States experienced its first large scale integration of emergency management, emergency medical, law enforcement, and military resources prescribed by the Terrorism Annex to the Federal Response Plan. The attacks also resulted in the first activation of the National Disaster Medical System. We do not understand how to ensure that these meta organizations will function effectively, how to best use technology to support their decision processes, how to manage information in such a turbulent environment, and how to retain the organizational knowledge of their successes and failures. Information management and coordination issues that arose in this response must be identified and studied as our response system evolves in the response to this tragedy.

The Attacks

At 8:45am on September 11, 2001, American Airlines flight 11 crashed into the north tower of the World Trade Center complex in New York City. Initially, this unbelievable event appeared to be isolated. Eighteen minutes later, as the media was televising video around the world of the smoking skyscraper, a second commercial airliner came into view and disappeared with an enormous explosion into the South tower. This plane, Flight 175 (also from Boston,) confirmed any initial fears that the United States was under attack by an unidentified terrorist group.

Within five minutes of the second event, the Federal Aviation Administration ordered all New York City airspace 'sterilized', (freed from air traffic). Seven minutes later, all New York City airports were closed, and at nine minutes after that (9:26am), all civil flights were prevented from taking off. Over 4000 planes had been over US land, and several hundred were en route from overseas - all were grounded or re-routed to Canada. This could do nothing, however, to stop American Airlines flight 77 from reaching its crash- course destination of the Pentagon at 9:43. Fearing yet another attack, the White House was evacuated at 9:45. Just after 10am, the South Tower of the World Trade Center complex collapsed, raising the estimated dead and injured exponentially. Secret service agents were positioned in Lafayette Park (10:08), the United Nations complex was evacuated in New York (10:13), and several federal departments and agencies are evacuated in Washington, DC (10:22). By 10:30, the U.S. Office of Personnel management had begun the evacuation of all DC federal buildings.

Also around 10:30am, the North Tower of the World Trade Center complex collapsed, adding to fears concerning the scale of casualties. At this point, Governor Pataki closed all government offices in New York, and New York City mayor Giuliani ordered the evacuation of all Manhattan areas south of Canal Street. It was reported that several airports around the country were evacuating, and rumors of car bombs and additional hijacked planes were making there way into the news. Reports of a fourth plane, which crashed in Somerset County, Pennsylvania, were confirmed.

At noon, it was still not known if the attack was over. Washington, DC closed its city government buildings, and the GSA closed its buildings and courthouses throughout 5 states in the capitol region. DC mayor Anthony Williams declared a state of emergency for the city of Washington at 1:22pm. Soon after, the FAA announced that there would be no commercial air traffic until at least noon of September 12.

By mid afternoon, rescue crews from around the country began arriving at the three sites to assist to local police and fire departments that immediately responded. Mayor Giuliani announced at 2:49, in a press conference, that subway and bus services were restored in New York City. Estimates into the number of injured or killed range from several hundred to tens of thousands, though no official is willing to give specific numbers.

As the evening approaches, it was reported that Building 7 of the World Trade Center complex, which had been burning for much of the day, has collapsed. In addition, other buildings in the area of the towers are reported to be on fire. Mayor Giuliani appeared at an evening press conference and urges New Yorkers to remain at home on September 12th if they can, though Defense Secretary Rumsfeld holds a news conference in which he states that Pentagon employees should expect to report to work.

Timeline of the first 48 hours

September 11, 2001

8:45am American Airlines Flight 11 from Boston flown into World Trade Center North Tower (cnn.com)
8:50 EPA Headquarters EOC activated
8:50~ USCG NRC alerts FBI of WMD terrorist event. (Capt. Mike Eagan, USCG)
9:00~ Airports Authority begins evacuation of Reagan, BWI and Dulles airports
9:01 EPA headquarters and EPA Region 2 begin coordination conference call (EPA Timeline)
9:03 United Airlines Flight 175 from Boston flown into World Trade Center South Tower (cnn.com)
9:08 FAA sends written notice to all NYC airports to 'Sterilize' the airspace
9:10 EPA Headquarters uses GETS conference call system with regions 1-4 (EPA Timeline)
9:17 FAA shuts down NYC Airports (cnn.com)
9:21 Port Authorities of NY and NJ close all bridges and tunnels in NY area (cnn.com)
9:26 FAA issues national "ground stop", preventing all civil flights from taking off
9:30 President Bush gives first press appearance in Florida (cnn.com)
9:32 HHS National Disaster Medical System (NDMS) and Commissioned Corps Readiness Force (CCRF) notified and placed on advisory (HHS Sitreps)
9:40 DC recalls off-duty police officers, begins closing roads and securing government buildings (Washington Post, 9/17, A1)
9:43 American Airlines Flight 77 hits Pentagon - immediate evacuation begins. (cnn.com)
9:45 FAA grounds all planes in the US
9:45 White House evacuation begins (cnn.com)
9:50~ Arlington County activates emergency response plan - County Mgr. Ron Carlee becomes director of the emergency response (Alexandria/Arlington Extra, 9/20, p12)
9:57 President Bush departs Florida for Barksdale, LA (cnn.com)
10:00 EPA begins coordination with NY and VA governments (26 initial staff to NYC and Pentagon) (EPA Timeline)
10:05 World Trade Center South Tower Collapses (cnn.com)
10:08 Secret Service begin patrol of Lafayette Park, across from the White House (cnn.com)
10:10 Partial collapse of the Pentagon (cnn.com)
United Airlines Flight 93 from Newark crashes in Somerset County, PA (cnn.com)
10:13 United Nations evacuates NY headquarters (11,400 employees) (cnn.com)
10:16 DC Mayor COS sends email to 100's of workers 'Evacuate Building NOW' - retracts 4 min's later (Washington Post, 9/17, A1)
10:22 World Bank, State Department and Justice Department evacuate (cnn.com)
10:24 FAA reports all inbound transatlantic flights are being diverted to Canada (cnn.com)
10:25 Alarm sounds at OPM, PA system instructs employees of that building to evacuate
10:28 World Trade Center North Tower collapses (cnn.com)
10:30 OPM and White house begin evacuation of all Washington, DC federal buildings
10:39 FAA closes all operations at all US airports by NOTAM (Notice to Airmen)
10:46 Colin Powell begins his trip back to the United States (cnn.com)
11:50~ DC hospitals move into emergency response mode
10:54 Israel begins evacuation of all diplomatic missions (cnn.com)
10:57 NY Governor Pataki closes all NY government offices (cnn.com)
11:02 NYC Mayor Giuliani orders evacuation of area south of Canal Street (cnn.com)
11:16 CNN reports the Center for Disease Control and Prevention response teams preparing to respond (cnn.com)
12:00pm US closes border to Mexico

12:04 Los Angeles International airport evacuated (cnn.com)
12:15 San Francisco airport evacuated (cnn.com)
12:46 GSA orders federal courthouses and offices in VA, DE, MD, PA, WV closed until further notice
Trains in/out of DC Union Station stopped
DC closes all government buildings and all 19 buildings under Capitol Police jurisdiction
1:04 President Bush gives second press appearance from Barksdale, LA (cnn.com)
1:27 Mayor Anthony Williams holds news conference, declares state of emergency for DC (cnn.com)
1:44 Pentagon announces 5 warships and 2 aircraft carriers have been deployed for NY and East Coast (cnn.com)
1:48 President Bush begins flight from Barksdale, LA to Offutt Air Force Base, NE (cnn.com)
2:00 FBI announces they "are working under the assumption that the 4 planes are part of a terrorist attack" (cnn.com)
2:21 53 people reported injured at the Pentagon
2:30 FAA announces there will be no commercial air traffic until at least 12pm on September 12 (cnn.com)
2:49 Mayor Giuliani announces subway and bus service has been partially restored - no casualty info (cnn.com)
3:55 Mayor Giuliani announces that 200 people are critically injured, of 2100 total injuries reported (cnn.com)
4:06 CA Governor Gray Davis dispatches USAR teams to NYC (cnn.com)
4:25 Stock exchanges (ASE, NYSE, Nasdaq) announce that they will remain closed September 12 (cnn.com)
4:30 President Bush leaves Offutt Air Force Base, NE for Washington, DC (cnn.com)
5:20 World Trade Center building 7 collapses (cnn.com)
6:00 Incident Command Meeting at the Pentagon, led by Chief Schwartz
6:00 AMTRAK resumes rail service
6:10 Mayor Giuliani urges NYC residents to remain home September 12 if at all possible (cnn.com)
6:40 Donald Rumsfeld holds news conference in Pentagon to announce the building is operational except for corridors 2-6 (cnn.com)
6:54 President Bush arrives in Washington, DC (cnn.com)
7:02 CNN reports that some NYC bridges are open to outbound traffic
7:17 Attorney General Ashcroft announces FBI website for attack tips, and that friends/family can call 800.331.0075 to leave contact information (cnn.com)
7:30 President Bush issues major disaster declaration for NYC (FEMA-1391_DR)
7:45 NYPD announces that 78 officers are missing, and at least 200 firefighters are feared dead (cnn.com)
8:30 President Bush gives 3rd press appearance (cnn.com)
9:22 Pentagon fire still burning, but under control (cnn.com)

Unsp. DOD opens media operation center at Marine Corps Post Henderson Hall, Arlington, VA (703.697.9928) (defenselink.mil)
Unsp HHS activates National Medical Emergency System, which put and puts 7000 volunteer doctors in 80 disaster teams on readiness alert. The PHS Commissioned Corps was also put on readiness alert (5700 personnel); waits for orders from FEMA (HHS Sitreps)
Unsp Federal Reserve assures that funds will be available if needed
Unsp DC Emergency Management Agency holds meeting at Franklin D. Reeves Conference Center

Unsp FEMA dispatches 4 USAR teams to Pentagon - claims to have coordinated Emergency Response

Unsp Arlington Fire Chief Plaugher announces 100 - 800 feared dead at Pentagon

Unsp HHS sends 3 DMATs to the Pentagon (46 medical personnel from the U.S. Commissioned Corps DMAT in Rockville, MD; 35 from Winston-Salem, NC; and 36 from Atlanta, GA.) (HHS Sitreps)

Unsp HHS sends 3 DMORTs to the Pentagon, with 102 personnel (HHS Sitreps)

Unsp HHS sends 5 DMATs to NYC (25 personnel from Lyons, NJ; 44 from White Plains, NY; 41 from Boston; 52 from Worcester, MA; and 49 from Providence, RI). (HHS Sitreps)

Unsp HHS sends 4 DMORTs with a total of 169 personnel to NYC from throughout the East Coast. (HHS Sitreps)

Unsp Navy prepares USS Comfort to ship to NYC if necessary

Unsp US Customs goes on Code Red Security Alert

Unsp USCG sends 4 helicopters, 270' Cutter, 3 110' coastal patrol boats and 7 small boats to NYC

Unsp FEMA names Ted Monet as coordinating officer of the disaster

Unsp HHS CDC deploys 4 epidemiologists and 2 laboratory experts to NY to assist assessing medical needs and capacity planning for treating victims in the area's hospitals. (HHS.gov)

Unsp HHS Centers for Medicare & Medicaid Services sends 5 staff to assist at the response center established by FEMA in Edison, NJ (HHS.gov)

Unsp HHS authorized the 1st emergency use of the National Pharmaceutical Stockpile - the shipment arrived in NY at 9pm - 1 of 8 "12-Hour Push Packages" (HHS.gov)

Unsp HHS CDC worked with tetanus vaccine manufacturers and the public health dept's of NY and DC to ensure adequate supplies of the vaccine were shipped to both locations (HHS.gov)

Unsp HHS CDC activates Health Alert Network (provides rapid information to all health departments)(HHS.gov)

Unsp EPA and OSHA both monitoring exposure to potentially contaminated dust and debris; Region 2 emergency response staff stationed at FBI Joint Operations Center in NYC, Trenton NJ EOC, and FEMA's office in Albany, NY; Region 2's Edison, NJ office is providing space for 100 FEMA staff; EPA HQ EOC operating on 24-hour basis; R3 has emergency responders deployed DC, Ft. Meade and at Willow Grove Naval Air Station, PA. (EPA Timeline)

Unsp EPA - REGION II: Deployed 4 On-Scene coordinators to NYC, began 24-hour operations in Edison, NJ, Collected 4 dust samples in vicinity of WTC, initiated daily ambient air monitoring program downwind of WTC, coordinated with NYC and OSHA (EPA Timeline)

Unsp EPA- REGION III: Deployed 4 OSCs (VA, EOC, DC EOC, FEMA ROC, Ft. Meade), Deployed 4 START with OSC to Ft. Meade (EPA Timeline)

Unsp. EPA- HEADQUARTERS: Began 24-hour operation at EOC, prepared for Continuity of Operations Plan (COOP) activation, removed EPA's website to protect against hackers & secure data (OEI), staffed FEMA EST, staffed FBI Strategic Information Operations Center (SIOC), Took precautions to ensure payroll for all EPA employees, Discussion of permitting issues for air and waste with Regions II and III. (EPA Timeline)

September 12, 2001

8:00am FEMA director Allbaugh announces phone number (800.462.9029) for emergency assistance

8:11 Mayor Giuliani announces the rescue of 6 firemen and 3 police officers from WTC (stratfor.com)
8:15 UN announces that all staff are ordered out of Afghanistan (stratfor.com)
9:05 Announcement made that Dulles Airport will open at 3pm for luggage/car retrieval (stratfor.com)
9:53 Pentagon announces that 80 bodies have been recovered (stratfor.com)
10:06 Congress reconvenes (stratfor.com)
10:30~ DOD opens family assistance center at Sheraton Hotel in Crystal City (info, counseling, support)(defenselink.mil)
11:20 FAA bans all air-travel in US indefinitely (stratfor.com)
11:58 Pentagon evacuates because of smoke; staff return shortly thereafter (stratfor.com)
1:00pm Pentagon alerts HHS that it will handle all med and mort needs on -site (
1:07pm FBI conducts search of Boston hotel room (stratfor.com)
1:10 American Airlines distributes passenger lists (stratfor.com)
1:48 United Airlines distributes passenger lists (stratfor.com)
2:20 Flights rerouted on September 11 given authority to resume - all others still grounded (stratfor.com)
2:40 Amtrak train from Boston to Providence boarded - 3 taken into custody (stratfor.com)

Unsp Bush issues Emergency Declaration for Arlington County
Unsp NY Union officials release that ~265 Firemen were killed
Unsp FAA says that flights can resume, but airline executives decide not to do so for safety reasons
Unsp Allbaugh and Bush meet to discuss the role FEMA will play in the disaster
Unsp FEMA Acting Deputy Director Mike Brown holds press conference, gives NYC statistics - 40 bodies recovered, 1600 treated
Unsp Bush requests $20 billion in emergency funding from congress; congress allocates $20 billion
Unsp Army Corps of Engineers sends Structural Assessment Teams to assess debris removal and power
Unsp FEMA Director Allbaugh flies to New York City
Unsp IAFF President Harold Schaitberger says toll to NYC firefighters higher than originally estimated
Unsp Metro opens Pentagon subway stop
Unsp DOE's Energy Information Agency (EIA) releases oil market assessment showing overall U.S. and global oil supplies appeared to be minimally impacted, to quell rising fears of a shortage; DOE coordinates with ACOE to restore power to NYC, provide power generators and fuel; DOE personnel help evaluate the movement of critical oil resources into NY Harbor and review tug and barge availability for oil movement to upstate NY; DOE offers key equipment to assist in the NYMEX re-opening and is coordinates with USCG and local harbors to evaluate oil supplies up and down the East Coast; in conjunction with FEMA, DOE assists in search and rescue using Ground Penetrating Radar (GPR) equipment, adapted with motion detection applications and uses remotely-operated equipment, including infrared cameras, robotic equipment and fiber optic cameras, to aid the search for victims and evidence.
Unsp EPA- REGION II: Received initial mission assignments from FEMA for $200,000, later increased to $500,000, established operations from Edison, NJ with help of 12 OSCs, took initial dust and air samples near WTC, provided 200 Tyvek suits to Monmouth County, NJ Health Department (EPA Timeline)
Unsp EPA- REGION III: Received initial mission assignment from FEMA for $25,000, deployed 4 OSCs and 2 air inspectors to Pentagon and surrounding Arlington/DC area,

deployed OSCs to FEMA A-ROC, ERT-A in Arlington, DC EMA; closed DC EMA, moved 4 START personnel from Ft. Meade to Pentagon (EPA Timeline)

Unsp EPA - HEADQUARTERS: Began twice daily emergency response technical conference calls with regions 1-6, prepared morning and evening special reports, held conference call with the National Response Team agencies, established communications support for Region II, including website and web access to email (EPA Timeline)

pm Donald Rumsfeld announces Pentagon death toll lower than estimated 800 (defenselink.mil)

pm HHS NMRT-E Weapons of Mass Destruction travels to NYC (HHS Sitreps)

September 13, 2001

7:30am Pentagon evacuated after a bomb threat is called in

8:15 Sec. Thompson authorizes first collaboration of DMORT team with FBI to PA crash site

12:00pm Vice President Cheney is taken to Camp David

6:00pm Congress evacuated after a bomb threat is called in

6:00 NYC Mayor's Office (Sam Benson) discusses establishment of treatment center with HHS, to begin at 7am on September 14th

Unsp President Bush declares September 14 a day of remembrance

Unsp President and Congress agree on $40 billion in emergency appropriations

Unsp Airline operations resume

Unsp Army search and rescue move ~60 bodies to Dover Air Force Base, DE from Pentagon

Unsp President Bush announces the creation of Homeland Security cabinet position, names Tom Ridge

Unsp President Bush issues Emergency Declaration for VA

Unsp Tommy Thompson meets with Governor Pataki and Mayor Giuliani to discuss NYC needs (HHS.gov)

Unsp HHS Substance Abuse and mental Health Administration team dispatched to NY to conduct longer-range planning for services to rescue workers, survivors and others. (HHS.gov)

Unsp HHS sends National Medical Response Team (NMRT) to NY to help detect any possible industrial chemical-related problems that may result from the collapse of buildings (HHS.gov)

Unsp HHS sends DMORT team with 35 personnel and a portable morgue with 8 personnel to Pennsylvania crash site at request of FBI. (HHS Sitreps)

Unsp HHS Veterinary Medical Assistance Team (VMAT) activated and sent to NYC - 9 vets. (HHS Sitreps)

Unsp HHS FDA continues to monitor pharmaceutical and blood availability and helped arrange deliveries of skin products for burn victims in New York and Washington, D.C. (HHS.gov)

Unsp EPA- REGION II: Staffed Edison, NJ with 30 personnel, received 15 OSCs who were deployed to Edison, NJ, provided assistance to financial district companies to recover business assets in computers, coordinated with ACOE on WTC debris removal (EPA Timeline)

Unsp EPA- REGION III: Deployed 6 OSCs to Arlington, VA, Initiated air monitoring at Pentagon, transitioned A-ROC activities back to ROC in Philadelphia (EPA Timeline)

Unsp EPA- HEADQUARTERS: Continued EOC operations, technical conference calls, and special reports, initiated procurement of laptops and wireless communications for Region II. (EPA Timeline)

Color Key

= Event
= Action - General
= Action - NYC
= Action - Pentagon and PA
____ = Organizational Response

The Interview and Analysis Process

The project team interviewed key personnel from the Arlington Fire Department, the Arlington National Medical Response Team, The Department of Defense, the FEMA Incident Support Team, Fairfax County Urban Search and Rescue Team, FEMA, The US Army Corps of Engineers, U.S. Health and Human Services Office of Emergency Preparedness, the State of Virginia Office of Emergency Management. The National Response Center, the HHS National Medical Response Team, and the American Red Cross. We obtained and analyzed sitreps and reports from FEMA, EPA, the US Army Corps of Engineers, The Office of Emergency Preparedness, and the National Response Center. We also obtained daily action plans prepared by the FEMA Emergency Response Team (ERT), Disaster Field Office (DFO), and Incident Support Team (IST). Press reports (primarily the *Washington Post, New York Times*, and CNN) were used. We focused on the Federal mobilization of resources for all events and on the incident response to the Pentagon attack because of the proximity to first responders, the limited time and resources for the study, and the complexity and continuing status of the response to the WTC collapse. The on scene response to the attack on the Pentagon was coordinated by the Arlington County Fire Department. However, over 100 organizations played a role in this complex response. Figure 1 is a photograph of the early, fire suppression, stage of the response.

Figure1: The Pentagon

The Response

The initial response to the fire and emergency units from the Arlington County Fire Department, the Fort Myer Fire Department (a U.S. Army Base located adjacent to the Pentagon), and the Metropolitan Airport Authority Fire Unit at Ronald Reagan National Airport. Municipalities in the Washington D.C. Metropolitan Area have a well established mutual aid system, and Fire and Rescue units from Fairfax County, Montgomery County, Alexandria, and the District of Columbia responded without any state or federal intervention or control. The Federal and state mobilization of resources for the response was governed by the structure and process defined in the Federal Response Plan (FRP). The purpose of the FRP is to provide a mechanism for the mobilization and coordination of federal resources to assist states in the response to Presidentially declared disasters. The FRP was amended to provide a Terrorism Annex, providing a collaborative role for the FBI and FEMA during the response to a terrorist attack. The flow of decisions and organizational capability envisioned for the response to a major natural disaster is illustrated in Figure 2 below, taken from the FRP.

Figure 2: Organizational Evolution Specified by the FRP

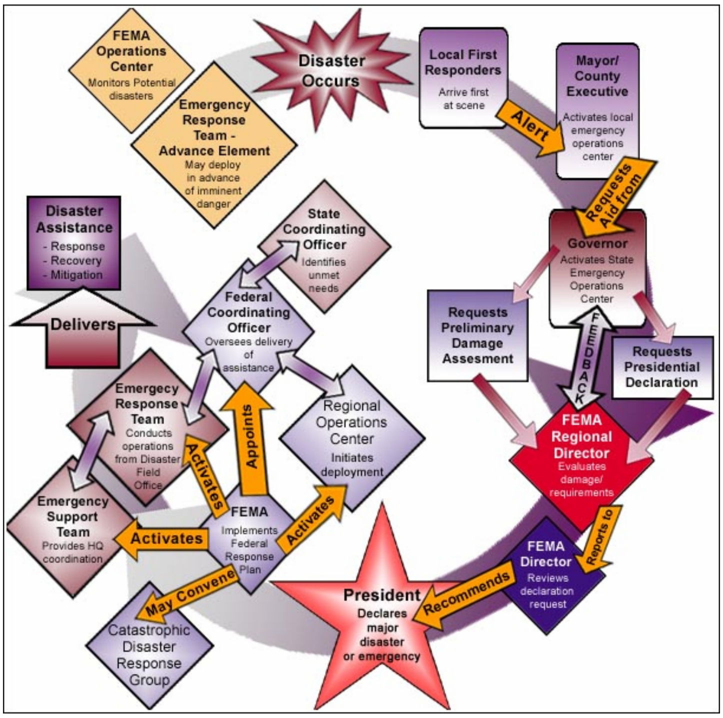

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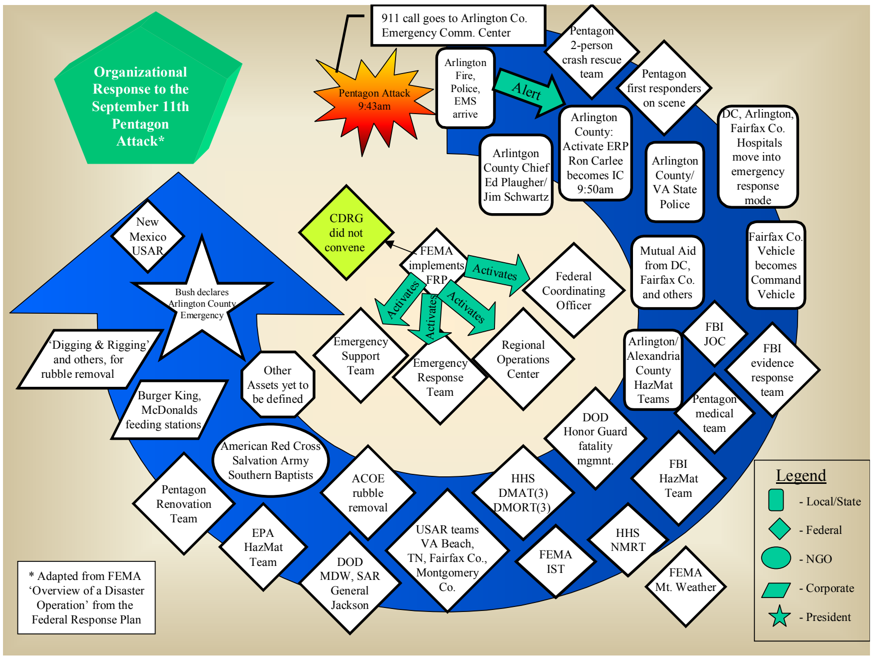
Figure 3: Organizational evolution at the Pentagon
(Preliminary Documentation)



The actual organizational evolution was considerably more complex. Figure 3 provides a summary of how and when organizations became part of the Pentagon response. This diagram is intended to provide an indication of the organizational complexity that faced responders. The Arlington County Fire Department established the incident command structure based upon the principals of the Incident Command System (ICS) and Unified Command. DOD organizations and assets were coordinated through the unified command
Structure

Preliminary Findings

The analysis of interview data for the final report to the National Science Foundation has not been completed. However, the following preliminary findings capture the most significant conclusions that can be made based on the data collected, interviews conducted, and observations made.

1. *The response system designed for natural disasters was effective for managing the consequences of a terrorist attack.* This system includes local Incident Management built on the principles of the Incident Command System, Unified Command, and Mutual Aid and mobilization and integration of Federal and State resources in accordance with the Federal Response Plan (FRP). The ability of the Arlington County Fire Department (ACFD) to rapidly establish an ICS based organizational structure was the key to success. The ACFD and other local fire departments use the ICS for all operations. "Everyone knew that Arlington County was the Incident Commander" and "everyone in the ICS structure knew this is not about turf, it's about getting the job done" were among the comments recorded in our interviews. The Unified Command of ACFD, FBI, Arlington County Police, DOD Military District of Washington and the FEMA USAR Incident Support Team were established during the first day. Arlington, Fairfax, and Alexandria Counties drew upon 25 years of mutual aid

experience. The Arlington County Incident Commander, for example, used a Fairfax County mobile command vehicle as the site for the Unified Command Center.

2. *Federal assets and teams, were obtained through the Federal Response Plan structure, and were effectively used*. Federal resources mobilized included search and rescue teams, disaster mortuary teams, disaster medical teams, medical response teams, EPA Hazmat teams, US Army Corps of Engineers debris removal teams, and American Red Cross mass care resources. The mobilization of federal resources occurred despite that fact that senior Federal and State emergency managers were isolated in Big Sky, Montana at an emergency management conference. The federal response organization was created and the federal mobilization was successfully executed by skilled mid level managers. The Catastrophic Disaster Response Group, the interagency group of senior managers tasked with resolving problems during a disaster response, never convened.
3. *The Pentagon response was effective. An effective on scene response organization was rapidly created. Goals were defined and met.* The response required the local first response organization (Arlington County fire department) to coordinate of a complex meta-organization consisting of organizations from different communities: emergency response (fire, rescue, EMT), emergency management, law enforcement, and the military. The Unified Command created and executed response plans and coordinated these plans with FEMA, the FBI, and DOD. The Arlington County EOC was established within 30 minutes of the event, and supported the first responders. The FBI and FEMA established a Joint Operations Center at Fort Myers.
4. *The complex organization that evolved was based upon the ICS system, but creativity and coordination resulted in a flexible, effective organization*. No one participating in the response to the Pentagon had ever responded to a terrorist attack. The fact that this attack took place in metropolitan Washington, and was on the headquarters building of the U.S. military meant that many organizations would be involved and many organizational issues that were totally unanticipated by response planners would occur. Issues such as the relationship between military and local responders (the ACFD was in charge) and the responsibility for identification of remains (DOD was in charge) were handled professionally and quickly. The incident management structure was a point of departure for creative, effective management…not a strait jacket.
5. *Effectively coordinating organizations with the diverse organizational cultures of first responders, military, medical, and law enforcement in a complex disaster response is a difficult issue for incident managers*. As stated by one senior participant: "How do you, beyond ICS, blend the cultures of local assets and military assets". More than one participant pointed out that pre-established relationships between federal law enforcement and local responders greatly eased potential organizational problems. Unified command is a concept used in the U.S. for pollution incidents and technological accidents, but has not been formally incorporated into the Federal Response Plan. Organizational familiarity was a key factor in the successful coordination of response organizations. Personal relationships were helpful, but not as critical as familiarity with organizational roles, responsibilities, and capabilities.
6. *Information Management and Media Relations are critical to actual and perceived success.* The response was hindered in the early hours by conflicting and uncertain external information. For example, rescue operations were suspended and the site evacuated based on rumors of an additional incoming plane. On site communications were established using radios (common frequencies pre-established through mutual aid agreements) and cell phones (assisted by "cells on wheels"). "Media management was a 'huge' issue in this incident" according to a senior manager. Very early in the process, a media site was established at a gasoline station within view of the site and periodic briefings were provided. This minimized, but did not eliminate, erroneous and conflicting information in media reportage.

During the Pentagon response, a complex management situation involving very disparate entities under severe stress responded surprisingly well. Unfortunately, this is unlikely to be the last time that first responders and emergency managers face the challenge of managing the consequences of a deliberate terrorist event. The fact that systems worked is important. Documenting why they worked and communicating that knowledge is essential.

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FEDERAL EMERGENCY MANAGEMENT IN THE U.S.:

Implications of The Terrorist Attacks of Sept. 11, 2001

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Keywords: emergency management, policy analysis

Abstract

The Sept. 11th terrorist attacks were the first catastrophic terrorist event to occur in the U.S. and the first that required both civilian recovery and military responses. This report sought to determine the scope of the impacts and to begin the process of examining the implications for the federal emergency management systems, programs, and policies.

This report discusses the defining characteristics of the attacks, the role of the media, and the initial role and functions of two of the responding agencies – the U.S. Environmental Protection Agency (EPA) and the U.S. Coast Guard (USCG) in New York City (NYC). It also briefly describes the various impacts: economic and financial, damage to infrastructure, equipment losses, business interruption, human productivity, airline losses, insurance payouts, decreases in tourism, revenue losses, impacts on the stock exchanges, and donations and charities.

The authors also evaluate the effects on public attitudes toward government, the new national public awareness of terrorism, public awareness of emergency management, and changes in public sector focus and workload. The authors describe anticipated changes in federal policy to better deal with such events in the future.

In the course of working on this report, the authors were stimulated to develop a related product: the **Terrorism Time Line: Major Milestone Events and Their U.S. Outcomes (1988-2001),** which was published in March 2002 [1].

Introduction

The terrorist attacks on the World Trade Center (WTC) and Pentagon are horrific events, of a scale and type never before seen in the U.S. or in the world. To our knowledge, no past terrorist disaster in the U.S. has resulted in both recovery and military actions to seek redress for the incident.

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Given the timing, nature, and magnitude of the attacks, plus the immediate extensive media coverage, the topics of terrorism and emergency management have received an unprecedented amount of attention not only in the U.S. but worldwide. Aspects of terrorism usually reserved to a small group of behind-the-scenes operational personnel suddenly have become of interest and concern to citizens throughout the nation.

In researching and documenting the outcomes of the events in NYC and the Pentagon, the authors chose to focus primarily on emergency management at the federal level. Even with this limited focus, the effects of the Sept. 11th events on the federal government involve a vast array of impacts and outcomes. This report will briefly describe the events and their effects, giving more time and space to some of the early impacts and ramifications. The report deals generally with emergency management issues and actions during the first 30 days after Sept. 11th. It does not cover the many problems and issues connected with the public management of health and environmental issues that began to emerge about four weeks after the attacks took place. Finally, our research relied mainly on secondary sources, because it was not possible to gain access to key actors for personal interviews in the first few weeks after the massive events.

<u>The Unprecedented Role of the Public Sector</u> As noted by Waugh, "Emergency management is the quintessential governmental role. It is the role for which communities were formed and governments were constituted in the first place – to provide support and assistance when the resources of individuals and families are overwhelmed [2]." For the emergency management community these vastly destructive terrorist attacks have a large number of aspects, impacts, and implications that are unprecedented. Clearly, these events will go down in history as a major milestone in emergency management and probably will result in major changes in the emergency management systems at each level of government in the future.

Given the vast scope of impacts and ramifications for government actions and policies, at every level of government, this paper can only outline or briefly discuss some of the impacts and outcomes of the Sept. 11th event. This report should be viewed as an early step in what is likely to be a long-term sequence of analyses and reports about a milestone set of disaster events.

Approach

Our approach was to use the conceptual framework for the ***Disaster Time Line: Selected Milestone Events and Outcomes (1965-2001)*** as a starting point [3]. The authors set out to research and document some of the political and policy impacts of the Sept. 11th attacks and their ramifications at the federal level. While working on the DTL, the authors discerned a predictable sequence of actions and outcomes from major defining disaster events since 1965. The key categories are, major after-action reports and documents; legislation, regulations, and executive orders; response plans; and organizational changes. The authors planned to document the expected sequence of actions and determine, to the extent possible, the causal relationships between the events and major outcomes.

Two issues arose while trying to apply the approach noted above. (1) Initially, it appeared as that the Sept. 11th events did not fit into the sequence observed previously. The authors later decided that although these events have some aberrations, they did fit into the basic pattern. The details of this finding will be discussed later. (2) The authors prepared a new, separate graphic, the **Terrorism Time Line,** in order to focus on the level of detail and space needed to adequately and appropriately display all of the details and underpinnings of the federal involvement in counter-terrorism.

Events of September 11th

Many researchers and journalists have produced detailed descriptions of the events and the response efforts. Highlights of some of the most pertinent facts and some observations about their implications follow.

At 8:45 am (EDT) on Tuesday, September 11, an American Airlines aircraft was hijacked by a group of terrorists after taking off from Boston and crashed into the north tower of the World Trade Center Complex in New York City. At that time, the severity of the incident, the numbers of people involved, and the reason for the crash were all unknown. At 9:03 am a second plane, this time a United Airlines plane, hit the south tower of the World Trade Center.

During the period between the first and second crashes in NYC, the Washington Area Airport Authority had begun evacuating Reagan, BWI and Dulles airports as a precaution. Immediately after the second crash, FAA issued a national "ground stop," which prevented all civil flights taking off, thereby acknowledging that these actions were deliberate and that more attacks might be underway.

The roads were being closed in Washington, D.C. and the mayor had just given the order to evacuate the city of Washington, D.C. when another American Airlines plane hit the Pentagon office building in Arlington, VA at approximately 9:40 a.m.. The Federal Aviation Administration (FAA) issued an immediate order to ground all the planes flying in the U.S. airspace. The news spread quickly through blanket media coverage that a fourth plane was heading towards Washington, DC with the expectation that it was aiming for the Congress or quite possibly the White House. The decision to evacuate the White House occurred around 9:45 a.m.

Around 10:00 a.m. a fourth commercial plane went down in Somerset County, PA, about 80 miles southeast of Pittsburgh. About the same time a partial collapse occurred at the Pentagon building in the area of impact. Shortly after 10:00 a.m. the south tower of the World Center collapsed. Within the next half-hour, the northern tower of the World Trade Center collapsed. At approximately 5:30 p.m. a third tower in the World Trade Center complex, Building #7 also collapsed.

<u>The Defining Characteristics</u>. These attacks obviously were extraordinarily well planned and coordinated. They clearly had the goal of damaging the symbols of power in the U.S., causing as many casualties as possible and spreading fear. Also, by hitting at the World Trade Center Complex in NYC, which is the heart of the international financial community, there is no doubt that the terrorists hoped for long-term negative economic consequences.

Not just the people living in New York City or in Washington DC, but many millions of people all across the country felt they were potential targets, especially those living in other large cities. The local, state, and federal responses were immediate and massive amounts of resources were deployed to the attack sites. Initially, it was estimated that the casualties in the WTC could be around 10,000 and 800 people were estimated to be dead in the Pentagon incident. Sadly, the initial fire fighting teams, including the NYC Fire Chief, deployed to the scene were among the dead and missing. The loss of about 300 skilled fire fighters and their chief was a major blow to the response force.

In addition to responding to the known disasters, prevention of further damage was a major concern. As these catastrophic series of events occurred, it was not - - and it still is not – clear whether there were other attack plans and when the threat of further attacks would end. Both elected and appointed officials had to take immediate actions and make the kind of decisions that they had never done before to fulfill their duties to the citizens. No doubt the terrorists intended to shake the public trust towards the government. One immediate worry was how could four commercial jetliners have been successfully hijacked from different airports and their whereabouts while in the air remained unknown.

President Bush's mission changed profoundly in a matter of hours. He was forced to assume a defensive role for both himself and the country as a whole. And when the source of the attacks was determined, he had to mount a war offensive against the perpetrators and other allied terrorists located in many countries. Within hours, measures were taken to ensure the continuity of the government, to avoid mass panic, and to protect the nation and its citizens from further attacks.

As thousands of members of urban search and rescue, emergency medical, emergency response teams, and tons of equipment were deployed, it became obvious that the debris removal would take months, if not years, and hopes of finding any survivors quickly faded. The FBI, other federal teams and the New York Police Department (NYPD) began the enormous task of sorting and sifting through debris for bodies and evidence, a task that also could take several months.

The Role of CNN and other Media

Given the time of day, and the fact that many governmental and financial workers have access to Internet and TV news, word and pictures of the events spread fast. Thanks to CNN and other media, many public officials could see the actual scenes of the events in NYC and at the Pentagon only within minutes of their occurrence and were able to take action, such as opening emergency operations centers (EOCs) before being requested to do so officially.

What follows are two brief examples of initial response actions on the part of federal and military organizations, U.S. EPA and the U.S. Coast Guard.

(1) U.S. Environmental Protection Agency HQ (EPA)

On Tuesday morning, Sept. 11th, at the time of the first attack on the WTC, at EPA headquarters, in Washington, D.C., the Emergency Coordinator for the Agency, Jim Makris, and his deputy were engaged in a previously scheduled briefing for the EPA Administrator about the Agency's emergency management system and capabilities. They received a call and were told to turn on the TV to see the attack details. The officials then ended their meeting and opened the Emergency Operations Center immediately thereafter to begin disaster operations, according to Ed Terry, the Manager of EPA's EOC. Shortly thereafter, EPA headquarters established links with all of its East Coast regional offices to begin coordination and support of the NYC response efforts.

EPA has the authorities and responsibilities needed to perform emergency response functions under the National Contingency Plan. Plus, when the Federal Response Plan is activated, EPA has the lead responsibility for Emergency Support Function #10: Hazardous Materials. In this case, no one waited for formal initiation of any of the emergency response plans, but went right to work with their existing authorities [4].

(2) U.S. Coast Guard– Initial Response in NYC

Captain Dennis M. Egan, U.S. Coast Guard (USCG), who is the Director of the National Response Team (NRT), first learned about the NYC disaster on CNN TV. He immediately ordered that the alarm to the FBI's Weapons of Mass Destruction (WMD) hotline be activated. Rescue helicopters were sent to NYC from USCG bases in Atlantic City and Cape Cod. When helicopters arrived one hour later, NYPD helicopters already were on scene. The USCG's Long Island helicopter facility was stocked for support of the NYPD for several days, but not used in the search and rescue. The NY City government immediately moved its resources from Staten Island to Manhattan.

Various ferry ships, under USCG direction, were used to evacuate civilians out of Manhattan. The ships involved were the Staten Island Ferry and three other ferries; there were no major USCG ships in the area. Capt. Egan commented on the fact that the USCG ships were heading in, while the Navy ships were heading out of harbor. Many people fleeing the fires and destruction from the

WTC area ran toward the water, at the foot of Manhattan. The local police and Coast Guard officials on board the ferries were armed and available for assistance. Egan commented that USCG was a counter-terrorism "node" in these actions. The USCG went quickly from the response to security phase when it began screening passenger vessels and putting armed guards on cargo ships.

When the second plane hit the WTC, CG area commanders were contacted. The Boston USCG Admiral invoked "'regional incident command," and was established as the senior USCG official in NYC. He was instructed not to be in charge of the entire incident. He joined in the governor's and the mayor's response activities, but returned shortly thereafter to his post in Boston.

The Coast Guard Strike Teams set up in NYC to get the stock exchanges open again. They also did air sampling in the area. The Coast Guard used the "Vessel Traffic System" for navigation around the city. Because the antenna on the WTC tower was a major part of the system, range was reduced significantly. A new antenna was rigged on Staten Island as a backup.

The Coast Guard observed that FEMA set up their Regional Operations Centers after a five or six-day delay, due to the communications failures at the Federal Center in New York City, discussed elsewhere in this report. Egan commented that there were no major initial turf wars to report. The mayor was "significantly in charge."

Communication was perhaps the greatest problem. All cell phone lines were dead. Only two major phone trunk lines into New York City remained, and both were completely saturated (this problem persisted for several days). The National Response Center sent three portable communication units by van to New York City the night of Sept. 11. Those units were established at Battery Park, Staten Island, and on the USS Comfort. Nevertheless, the CG had trouble setting up communications with those in charge in NYC.

Battery Park was taken over by the City of New York and by the FBI as a command center. The FBI Atlantic Strike Team had some initial trouble getting communications set up because their system was dependant on access by a self-contained van unit, which could not navigate the rubble-covered streets.

Within two hours of the start of the attacks, there was a National Response Team conference call. At about 1:00 p.m., there was another NRT conference call. The Coast Guard established a liaison at the FBI Strategic Intelligence Operation Center; this post was filled for two weeks.

Captain Egan noted that the most valuable preparations for the actual response of the USCG on Sept. 11th was due to TOPOFF, which was a major federal disaster exercise, mandated by Congress, held in 2000. This exercise apparently created many contacts that were vital in the September 11th response [5].

Emergency Management Considerations

In NYC, initial efforts on the part of local federal regional offices to deal with emergency response were hampered by damage to the city's emergency operations centers. New York City had recently completed a multi-million dollar state of the art EOC; but it was housed in one of the WTC buildings that was totally destroyed. The State of NY seemed to fare better. The Federal center in NYC was not physically damaged, but telecommunications were knocked out, which meant that FEMA Region II, EPA II and other federal agencies had to find other operational locations [6].

In Arlington, VA, the response relationships appeared to be efficient and effective, since the Arlington County Fire Dept. and Pentagon officials had worked with each other and conducted response exercises prior to Sept. 11th.

At the national level, things moved very quickly with Presidential declarations of emergency for the Pentagon and disaster for NYC. The conventional procedures for obtaining a Presidential declaration were not necessary; "self-initiating" requests, as allowed by the Stafford Act, occurred and the federal government as well as the military services began their response actions very rapidly.

Among the response actions that are highly unusual or unique to the events of Sept. 11th:

- **Emergency and Disaster Declarations**: "self-initiating" declarations; use of emergency and then disaster declaration at Pentagon;
- **Problems with Emergency Operations Centers** at the local and federal levels due to destruction and incapacitation, respectively.
- **White House Involvement:** rapid creation and selection of a director for the Homeland Security Office. While fully operational, the White House and some federal agencies were making, or planning, major changes in processes, procedures, funding, and organizational arrangements for emergency management.

The Impacts

As of March 17, the latest information from federal and local officials give the following totals for the number of people dead or missing from the September 11 attacks:

- In NY City, approximately 2830 deaths have been confirmed. That number includes the 157 people on the two hijacked planes at the WTC. Only 773 of the 2830 people who died have been recovered and identified, though the remains of many are still being analyzed [7]. At the time of writing, additional remains are recovered almost daily.
- At the Pentagon site, a total estimate of 189 persons died; 64 persons, including the crew, died on board the hijacked plane; another 125 were dead or missing in the Pentagon building.
- At the Pennsylvania plane crash, 44 were confirmed dead on the hijacked plane initially. The number of injuries was a relatively small number, because all of the above events were so devastatingly deadly.

The Economic and Financial Impacts. It is a challenging task to calculate the overall costs of September 11th attacks. The destruction of the WTC obliterated about 12 million square feet of Class A office space, which is the equivalent of all office space in Atlanta or Miami [9]. An additional 18 million square feet of office space in downtown Manhattan was damaged.

Infrastructure. In NYC, a significant amount of infrastructure was ruined in the neighborhood of the World Trade Center Complex, including a crushed subway station, plus the loss of five phone-switching stations, two electrical substations, 300,000 telephone lines and 33 miles of cable. It has been estimated that replacing the destroyed subway lines would cost around $3 billion and that utility repairs, including 300,000 telephone lines, one phone switching station and six miles of electrical cable are estimated to cost $2 billion. Additionally, rebuilding the PATH NY/NJ station below WTC would be about $2.4 billion. The estimated total cost for replacing the basic infrastructure is $7.4 billion [9].

The Pentagon office building, which is owned by the Department of Defense, is estimated to have sustained $1 billion in damages. It was fortunate that the hijacked plane hit the Pentagon in the newly remodeled section, since relatively few people were in the not-yet-completed offices and the structure, windows and other construction details were more attack-resistant than the rest of the building.

Equipment Losses. Going beyond the infrastructure costs in NYC, there were equipment and related losses - such as fire trucks, thousands of computers furniture, and other equipment items - that disappeared with the towers. Early estimates suggested that anywhere between $2 to $5 billion worth of telecom and computer equipment was destroyed. The total property loss was estimated at $34 million, according to the New York City Comptroller Alan Hevesi. That is nearly twice the $16.8 billion record set by 1992's Hurricane Andrew [9]. Similarly, but on a smaller scale, at the Pentagon, there were computers, office equipments, and other unknown equipment and supplies were consumed in the fire after the plane hit.

Another unusually large cost in NYC was related to dealing with the immense amount of debris over the multi-acre area disaster site. The debris had to be sorted first for human remains, evidence, and later deposited in a landfill. The NYC Controller predicted that it would cost a $14 billion just to clean up and police the site.

Business Interruption. The NYC site probably set an all-time record for business interruption costs, which were initially estimated at $21 billion; the most serious losses occurred in the downtown neighborhoods that were inaccessible for weeks after the attacks [10]. Six months later, an official from the City of New York, Office of Emergency Management, gave an estimate of $83 billion for the overall economic impact on the city from the attacks, based on her discussion with the business community [11].

Built in 1970, the World Trade Center housed more than 430 companies from 28 countries. They were engaged in a wide variety of commercial activities, including banking and finance, insurance, transportation, import and export firms, customs brokerage, trade associations and representatives of foreign governments. An estimated 50,000 people worked in the World Trade Center, and another 140,000 visited the complex daily. Estimates of how many people were in the WTC when the attacks began vary from 15,000 to 40,000, according to an article in the Washington Post [12]. Thus, the ratio of people who safely got out of the many impacted buildings was many times higher than the number who died there on Sept. 11th.

Companies like Morgan Stanley, which by far was the WTC's largest tenant -- with 3,700 employees (all but 15 unaccounted for) -- was fully operational less than 48 hours after the tragedy. Remarkably, Cantor Fitzgerald lost 680 of its 1000 employees but was operational for bond trading two days after the attacks.

Many Wall Street firms would have been inoperative for many more weeks after the attacks if it were it not for the careful contingency planning they began after the 1987 stock market crash and accelerated after the 1993 WTC bombing. These financial firms rely on two critical services to guarantee a quick rebound from natural and man-made disasters: (1) information backup services that collect computer tapes and store them in highly secure suburban facilities, and (2) alternative facilities that are fully equipped with mainframes and computer servers that replace lost computing power. For a subscription fee, plus a disaster assessment that may run into the millions of dollars, stricken firms were able to move their personnel to such a service provider's centers for up to six weeks [9]. (After that the companies had to find their own space). Many companies have decided that it is prudent to spread operations over multiple locations on different electrical grids and telephone networks [13].

Human Productivity. Another sad but important indicator of loss is the loss of human lives and their future productivity as indicated in purely financial terms. Given the average age of the workers who lost their lives (40), the NYC Comptroller estimated the "lost human productive value" to be about $11 billion. Measured by payroll, NYC, with less than 3% of the country's workforce, accounts for 37% of the U.S. securities industry, 20% of advertising, and 18% of book publishing. The best and brightest from around the world are drawn to New York because it is where they can do their finest work and reap the highest rewards. In the short run, the September 11 attack would add a $500 billion blow to a city economy already stumbling from the bear market on Wall Street and the nationwide slump. More than 100,000 New Yorkers thus would eventually be thrown out of work by the attack, according to New York State Labor Dept. estimates [13].

Airline Losses. The airline industry received a major blow due to the temporary shutdown of the air travel system and later widespread fear of flying by potential customers. Airlines and airfreight were down for weeks. People who chose to fly faced long lines due to increased security measures. Anything suspicious became a reason to ground planes. After the attacks, the airlines received a $15 billion government bailout, announced 100,000 layoffs and slashed 20 percent of their flights [13].

In the Washington, DC area, Reagan National Airport and its businesses were the hardest hit in this ordeal. The airport was ordered to shut down immediately after the attacks and was not allowed to open until 23 days later due to its proximity to so many potential targets. The cost for closing was $330 million per day to the airport and Northern Virginia businesses and $27 million to state and local tax revenue [13].

Insurance Payout. The $126 billion commercial insurance industry is facing a $30 billion payout. This industry will never quite be the same, since insurers and reinsurers had never considered terrorism when pricing their premiums. The uncertainty about how to predict the future attacks is a huge challenge for the insurance industry.

Tourism Income Losses. The tourism industry hit has been hardest in Washington, DC area and New York, but with secondary and tertiary effects in Boston, Los Angeles, Las Vegas and other major tourist destinations. About one-third of the nation's 265,000 unionized hotel and restaurant workers have been laid off. Hotel expansion plans have been on hold almost everywhere [13].

Revenue Losses**.** The U.S. economy, threatened by recession before September 11, has suffered a number of blows in the weeks since. The leading economic indicators dropped in September. Yet the nation's financial markets have thus far weathered the uncertainty, making up losses experienced in the days after reopening.

Former Mayor Rudolph Giuliani estimated the city would lose $1 billion in revenues this fiscal year – including a 20% decline in personal income taxes and more than 30% declines in hotel and real estate transfer taxes. Additional costs for additional police overtime, downtown cleanup, and other services would soar into the billions. Even with the help from Washington, New York was expecting a budget deficit of $4 billion in the next fiscal year. The city agencies would have to cut $1 billion from their spending plans. The federal government would reimburse the city for $11.4 billion in expenditures directly related to the attack, such as $5 billion for emergency construction at the WTC site, and $3.8 billion for police, fire, and health services. Congress approved $20 billion in aid for New York, Virginia, and Pennsylvania [13].

The NY and American Stock Exchanges were closed for a week until September 18th. The stock market declined by double digit percentages immediately after the terrorism attacks. The NYSE dropped 1, 369 points, the biggest point loss and the fifth worst week ever for the Dow Jones industrial average.

Charities and Donations. As a result of the attacks on the WTC, and all of the media attention given to it, an unusually large number of charities formed, in addition to the major ones already in existence – such as the Red Cross and the Salvation Army - - and an unprecedented amount of donations were received. The resulting problems ultimately had to be straightened out by the Attorney General of the City of NY. As a sidebar to this topic, the current President of the American National Red Cross lost her job as a result of some disputes with the Board of Directors of that organization. It should be noted that donations related to the Pentagon disaster do not appear to have the same complications.

Health and Human Services Operations. According to a news release from the U.S., Dept. of Health and Human Services (HHS), the "9/11" response in New York City, constituted the largest National Disaster Medical System (NDMS) response ever. Of the more than 9,500 rescue workers, 1364 were volunteer health and mortuary professions who provided their services as part of the national NDMS, and more than 600 others were health professions from HHS Commission Corps Readiness Forces and the Centers for Disease Control and Prevention. Disaster Mortuary Operations Response Teams (DMORTs) supported the NYC Medical Examiner's Office, processing 15, 528 human specimens, 270 bodies, and identified 750 victims. On Sept. 11, 2001, the Dept. of HHS declared a national health emergency; the Office of Emergency Preparedness immediately deployed NDMS and Commissioned Corps teams to the disaster site. The HHS funding totaled $301 million for response and recovery activities resulting from the Sept. 11 attacks [14].

Outcomes

It is not possible to overstate the dramatic changes in political culture, attitudes, and philosophy of the federal government regarding emergency management and counter-terrorism that have resulted from the Sept. 11th attacks. Plus, many of these changes were immediate. Some elements of the emergency response went extremely well, such as the personal leadership of Mayor Giuliani, Governor Pataki, and the high level of competence of the Arlington County, VA Police and Fire Services. But, many concerns about the weaknesses in the nation's ability to deal with a major terrorism event quickly surfaced, such as: (a) need for better detection and warning systems for a terrorist attack, (b) central coordination at the federal level, (c) weaknesses in the public health and disaster medical systems, and (d) core capabilities of some states and localities to manage a massive disaster.

Other related systems were severely criticized for failures of weaknesses, such as the intelligence gathering and analysis capabilities of the international and domestic federal agencies; lack of coordination among various federal agencies with information about suspected terrorists; and problems in tracking foreign visitors and supposed students. The ramifications and implications are so substantial that it will take years of research and documentation to capture them.

A Major Sea Change. Within days after Sept. 11th, the Bush Administration and the Congress rapidly made a major philosophical shift in their attitudes and willingness to combat terrorism, including major changes in national priorities, budget, and spending plans – all in a matter of a few weeks after the events.

Public Attitudes Toward Government. On Sept. 30th, a **N.Y. Times** article titled ***Now Government is the Solution, Not the Problem***, stated:

"After 20 years of exulting in the power of the private sector, in deregulation, tax cuts and reining in the Washington bureaucrats, Republics and Democrats alike are talking about a muscular role for the government in the aftermath of the Sept. 11th terrorist attacks. They are bailing out the airlines, establishing a new Office of Homeland Security, passing a big new aid package to rebuild the areas devastated by the attacks and pondering an even bigger effort to stimulate an ailing economy. When the chips are down, where do we turn? ... To the government's firefighters, police officers, rescue teams. To the nonprofit sector's blood banks and shelters. And to big government's Army, Navy and Air Force [15]".

Another perspective is that of the professional public administration community, which noted that the aftermath of the Sept. 11th events, provided a unique glimpse at public employees at work. In the newsletter of the American Society for Public Administration (ASPA), it was noted:

"In a way unmatched in history, Americans had a chance to watch public administrators at work and, sometimes, under attack. They saw countless cases of unmatched bravery. The broadcast heroism, in fact, only hinted at the ways that government works rose to the challenges of their jobs."

ASPA further noted *"The real work – how to refashion the field to master the enormous new challenges facing it – begins now. Public administration will not only become more important, but its job has been dramatically transformed* [16]."

National Public Awareness of Terrorism. Given the timing, nature, and magnitude of the attacks, plus the immediate extensive media coverage, the topics of terrorism and emergency management received an unprecedented amount of attention not only in the U.S. but worldwide. Topics usually reserved to a small cadre of behind the scenes operational personnel suddenly were of interest and concern to citizens throughout the nation. This was captured in a **Washington Post** Article entitled ***Think-Tank Presses are Suddenly Best-Selling Publishers.*** The article noted, *"Across Washington, think tanks are find their once obscure books, studies, and policy reports are hot with the general public* [17]." Discussions of Terrorism, Bio-Terrorism, and Weapons of Mass Destruction are now commonplace among the general citizenry in the U.S. The Sept. 11th events provided a crash course on the topics. What was a somewhat esoteric technical area of interest, pursued by a relatively small group of responsible persons is now discussed everywhere.

Public Awareness of Emergency Management. Citizens have become more aware of their public officials and how they conduct emergency management at each level of government. In New York City, Former Mayor Giuliani and Governor Pataki were directly involved in the response efforts and were highly visible doing their jobs on a daily basis. It should have been clear to most citizens that their local and state government officials were working ardently and effectively to help them.

One interesting indicator of the level of commitment and depth of the local emergency management effort is that at the third and final location of the city's emergency operations center (EOC) ultimately contained 350 workstations, according to newspaper accounts. That huge number is a crude indicator of the amount of coordination involved in the response and early recovery activities.

Similarly, public awareness of the key roles and functions of local public officials in Arlington, VA was heightened by the attack on the Pentagon. Prior to the event, Pentagon staff had worked closely with Arlington County Fire Dept. in the event of a major fire in that building. The County Fire and Policy Departments also were highly effective and committed to their jobs, according to two reports in the **Washington Post**. They too received great support and encouragement from the local citizens.

Changes in the Public Sector Focus and Workload. As was noted above, the role of public practitioners in emergency management has changed and probably will continue to change as the U.S. goes into the recovery period. A related outcome is the effect on public officials, both elected and appointed and the long-term burden on their workloads. For example, Senator Hillary Clinton (Dem., N.Y.) described the economic damage as "incalculable" and said "... [She has] *been consumed with the details of organizing federal assistance for the city and expects that responding to the emergency on both the national and local levels will dominate her Senate career for the foreseeable future* [18]*"*.

Some Specific Outcomes. The five specific categories of observed outcomes of major disaster events that the authors developed and used in the **Disaster Time Line; Selected Major Milestone Events and Their U.S. Outcomes (1965-2001)** were applied to the Sept 11th events in order to capture some of the most frequently observed aspects of outcomes from a political and policy perspective.

(1) Major Reports and Documents. After examining dozens of major disaster events during the years 1965-2001, the authors noted that immediately after a major event, either the Congress or the White House initiated hearings, after-action reports, and/or studies to determine what the problems and deficiencies were in responding adequately to disaster events. This step occurred without exception in the 36 years examined [19]. Yet, in less than a week after the Sept. 11th events, major national legislation was enacted and organizational changes occurred. There were two highly unusual aspects in the immediate aftermath of the terrorist attacks: (1) no hearings or studies were ordered to determine what went wrong and what remedies were needed, and (2) the speed and bipartisan nature of the legislative process were unprecedented.

The authors noted the sequence with great interest because it was an aberration from the pattern observed since 1965. After making a rough time line chart of the sequence, the authors surmised that several major reports about terrorism had already been completed by September 11th were used rather than ordering new studies and reports. Some relevant ones that were quickly updated and issued are several GAO reports on counter-terrorism ([20], [21], [22]) and on protecting critical infrastructure; the Gilmore report III update; and the Stimson Center reports.

It would appear that the information and knowledge about what to do already existed before Sept. 11th. What was lacking was the political backing for change and the political will to act. A rapid sequence of actions regarding improved emergency management and protection of critical infrastructure then followed.

(2) Legislation In a matter of about 16 weeks after the terrorist events, the degree of national attention and commitment to dealing with the outcome of the incidents led to the rapid enactment of four major pieces of legislation: the Supplemental Act for Response and Recovery; the U.S.A Patriot Act of 2001; the Defense Authorization Act; and the Aviation and Transportation Security Act.

Other unusual characteristics of the aftermath of this disaster are (1) the speed with which the federal government and the NY state delegation met and agreed to create and pass congressional legislation and appropriation of $40 billion to finance the costs of response and recovery efforts, and (2) that major federal organizational and coordination changes occurred relatively rapidly, even before Congressional hearing or special task forces were formed.

Since Sept. 11th, many new bills relating to terrorism are pending before Congress. The list of pending legislation is sizeable, and has been changing at a rapid rate.

(3) Executive Orders. Again, within about 16 weeks, three Executive Orders (E.O.) and two Homeland Security Presidential Directives (HSPD) were issued. They include: E.O. 13228, Homeland Security; E.O. 13231 Critical Infrastructure Protection, and E.O. 13234 Citizen Preparedness. HSPD1 deals with the Homeland Security Council and HSPD 2 covers Immigration Policies.

(4) Key Federal Response Plans. It is expected that both the Federal Response Plan and the National Contingency Plans will be reviewed and revised, based on the Sept. 11th attacks. It is too early to know the natural of these changes. The structural and organizational issues as well as the basic authorities for Homeland Security Office probably will have to be clarified before the implementing mechanisms and response plans are changed.

(5) Major organizational changes. There were at least three new federal offices created, the Homeland Security Office and the Homeland Security Council (in the Executive Office of the President) and the Transportation Security Administration (in the Dept. of Transportation.). Paramount among the changes here is the rapid creation of the **Homeland Security Office.** Other major changes pending include a wide array of security concerns, such as changes in airport and airline safety responsibilities, regulations, procedures; changes in immigration and naturalization laws and regulations; and changes in the transportation systems in the country.

It is too early to know just what the Homeland Security Office (HSO) will do with regard to contributing to changes in response plans, systems, and even recovery. Given the breadth of the

Executive Order mandating the formation of that office, it would be likely major changes are in the offing. Some of the other changes that are likely to occur in the coming months: improved warning and alert systems, improved detection and treatment for chemical and biological agents; improved intelligence gathering and analysis from both domestic and international sources; changes in emergency management systems and personnel training; changes in FEMA's National Preparedness Office, changes in the Federal Response Plan and the National Contingency Plan, and more national Counter Terrorism (C-T) exercises.

Given the vast complexity of the attacks and their aftermath, the authors created the **Terrorism Time Line: Major Milestone Events and their U.S. Outcomes (1988-2001).** Also under development are a narrative explanation of the chronology and a policy analysis of the major events and their outcomes.

In closing, in an article entitled ***Suddenly, Americans Trust Uncle Sam,*** noted author Francis Fukuyama is quoted as saying: *"Trauma and war bring out communal solidarity and remind people of why we have government.*" Regarding the creation of trust in government, he said *"... a national crisis alone does not create trust in government. It's a combination of external threats and government effectiveness* [24]".

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Acknowledgements

1) The authors acknowledge the assistance of Mr. Damon Coppola who shared his notes from an interview conducted for another George Washington University research project.

This article was based on the authors' early report, Quick Response Report #140, entitled "*The Terrorist Attacks on September 11, 2001: Immediate Impacts and Their Ramifications for Federal Emergency Management,"* completed with a small grant from the University of Colorado's Natural Hazards Center, Nov. 2001. URL: www.colorado.edu/hazards/qr/qr140/qr140.html

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Ms. Rubin has worked as a consultant for many organizations -- private, non-profit and governmental. Her work includes basic and applied research; the development and conduct of training programs; and the creation and operation of various information dissemination and utilization efforts regarding natural hazards and disasters. Recent projects include the Terrorism Time Line, the Disaster Time Line (www.disaster-timeline.com) and Disaster Central (www.disaster-central.com). She also has developed a web site for Digital Disaster Educational Resources at GWU: www.seas.gwu.edu/~cbrubin.

Ms. Rubin holds a B.S. from Simmons College and an M.A. from Boston University in Political Science. Her majors included political science and public administration. She has written more than 36 publications on hazards and disasters, and in addition, has given many lectures and talks on emergency management topics.

Irmak Renda-Tanali

Ms. Tanali is a Research Associate at the George Washington University, Institute for Crisis, Disaster, and Risk Management. She has conducted basic and applied research for various organizations in the fields of emergency, disaster and risk management and organizational management since 1998. She has recently served as a principle graduate research associate in the collection and synthesis of human needs data in the aftermath of 1999 Turkey Earthquakes, and in observing and documenting the inter-organizational response to the September 11, 2001 terror attacks (both funded by the National Science Foundation) and in evaluating the United States Army

Corps of Engineers' ESF #3 support to the September 11, 2001 disasters at the World Trade Center and Pentagon. She has also collaborated in the development of the *Disaster Time Line* and the *Terrorism Time Line* with Ms. Claire B. Rubin.

Ms. Tanali's past work experience is in the field of engineering design and construction. She was formerly the vice president and project manager of an engineering design and consulting firm in Ankara, Turkey.

Ms. Tanali holds a B.S and an M.S. degree in Civil Engineering and an M.B.A. Her interests include Engineering Economy, Project Management and Disaster and Risk Management. She is a Doctoral Degree Candidate at the Department of Engineering Management and Systems Engineering of The George Washington University. Ms. Tanali is currently working on her Doctoral Dissertation entitled "*Life Cycle Cost Analysis of Water Systems as Critical Lifelines*".

A NATION CHANGED: A PSYCHOLOGICAL PERSPECTIVE ON 9/11

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Keywords: traumatic stress; first responder stress; 9/11; stress response

Abstract

Drawing on a psychological perspective, this paper discusses the cataclysmic events surrounding the terrorist acts of September 11, 2002, committed on the World Trade Center in New York, the Pentagon in Washington, D.C., Flight 93, which crashed in a field in western Pennsylvania, and the subsequent anthrax scare. Background information on human response to disaster with respect to psychological stages and common reactions is presented, along with relevant selected research from terrorist events of 1995: the sarin gas release in a Tokyo subway and the Oklahoma bombing of the Murrah Building. Attention is focused on public response and the first responder community, including firefighters.

Introduction

<u>Our world has changed</u>.

For the people of the United States of America the world changed drastically since September 11, 2001. An almost naive sense of safety has been replaced with a sense of vulnerability. Some of our valued freedoms have been restricted in the name of security. Homeland Security is a new phrase in our vocabulary and a new government program. New fears have emerged and old fears have resurfaced. We have lost something we still cannot quite define. *On 9/11 our hearts were broken.*

Throughout the United States immediately after 9/11, the phrase "*our hearts are broken, but not our spirit*" appeared on storefronts, poster boards on trees, in windows, on signs in neighborhood yards, and scribbled on school notebooks. The United States flag was displayed everywhere - homes, cars, trucks, private buildings, on lapels and clothing, in the city, the suburbs, the small towns, along country roads all over rural America. *On 9/11 our spirit united and strengthened.*

From a psychological perspective, researchers have studied the human traumatic stress response systematically over the past fifty years. We know that ordinary people reacting to an abnormal circumstance may exhibit specific symptoms. But 9/11 was different, more complicated. We are still framing the questions to define that difference and as yet, after more than six months, have few answers. 9/11 was an unexpected event, but it was different in magnitude and design from previous unexpected disasters. The size was monstrous, inconceivable. It was a violent and deliberate crime on our nation, evoking both extreme anger and deep pride. More than 2,800

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people died as a result of the terrorist acts on 9/11. Unlike with a natural disaster, we still cannot determine the outcomes (see figures 1 & 2).

Figure 1: World Trade Center 9/11

Psychological Phases and Common Reactions after a Disaster

According to the American Red Cross Manual on Disaster Health Services I (1992), victims are likely to experience five psychological phases after a disaster. These phases may also relate to groups, including organizations, communities, and nations.

1. *Initial impact phase.* This phase is characterized by increased anxiety and fears, sometimes shock.

2. Heroic phase. During this phase, the survivors help each other to deal with the catastrophe.

3. Honeymoon phase. The honeymoon phase is characterized by experiences of joy and happiness at having survived and the feeling of being important and special as the receiver of attention and aid from private and government organizations, including the media.

4. *Disillusionment phase.* During this phase, there is increased resentment and frustration at officials and agencies for failing to provide assistance in a more timely fashion.

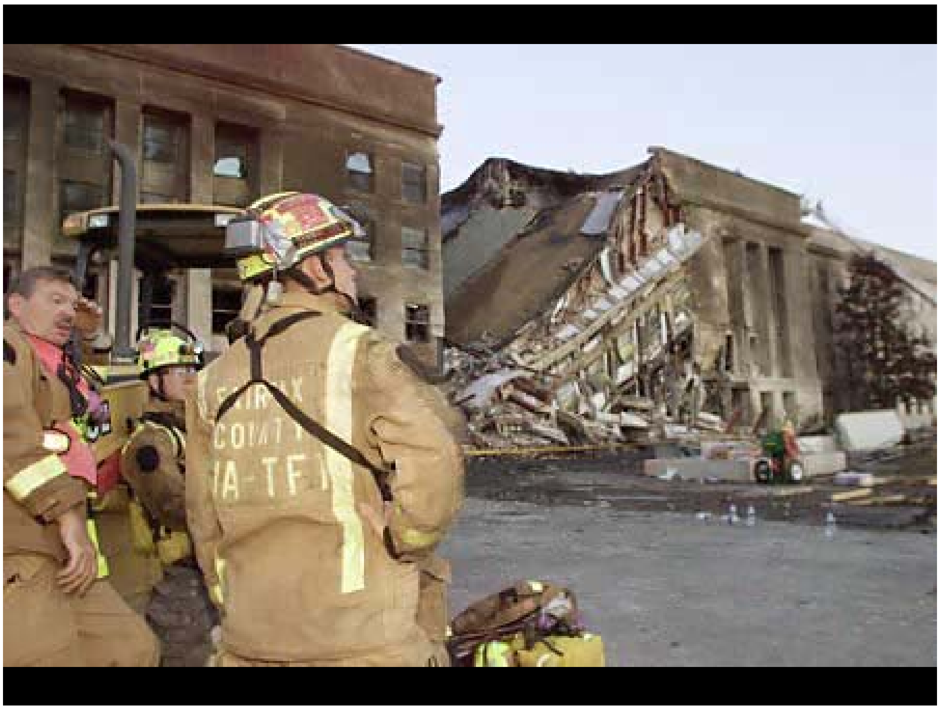
5. Reconstruction phase. This phase is characterized by thoughts and plans for reconstruction and acceptance of the need to assume responsibility for personal problems. Among other attitudes, setting goals and the recognition that life moves on support the reconstruction phase.

These phases are not linear, and they often overlap. The amount of time spent in each phase varies for each individual or group.

Paralleling these psychological phases, there are known, common reactions to trauma that include the following four responses or stages. First, victims experience **shock and disbelief.** Survivors are emotionally numb or in denial because the psychic pain is severe - in fact, unbearable. Second, there is a **strong emotional response.** Survivors are cognizant of their situation and feel overwhelmed and unable to cope with it. Their response is emotional and encompasses behaviors ranging from withdrawal to acting out. Third, there is **acceptance.** The survivor begins to accept the magnitude of the situation and makes an effort to deal with it. At this stage, the survivor feels more hopeful and is able to look toward the future and set goals. Survivors are able to take more specific actions to help themselves, their friends, and families. Finally, the survivors feel as if they have returned to their pre-disaster level of functioning. A sense of well-being and adjustment is restored and realistic memories of the experience are developed. This is the fourth and final stage, that of **recovery**. These stages are similar to the well-known stages terminally ill individuals pass through as they approach death, and similar to the stages of grief one undergoes after losing a loved one (James, 1980).

These universal stages are particularly important to understand when working with victims of a disaster. An effective program provides for the expression of emotion and helps guide the survivor to stage three, acceptance, and stage four, recovery (Kalayjian, 1995). Many people have difficulty moving out of stage two and continue exhibiting symptoms, including: withdrawal, sleep disturbances, anger, loss (or gain) in appetite, loss of concentration, increase in alcohol and drug use, and sometimes an increase in domestic violence. A continuation of symptoms beyond one to three months may lead to a diagnosis of Post Traumatic Stress Disorder (PTSD).

Figure 2: The Pentagon 9/11



Post Traumatic Stress Disorder PTSD

PTSD is considered to be the most severe and disabling variation of stress. The general public became aware of PTSD after the Vietnam War, when soldiers were reporting symptoms of a duration and intensity that called for medical intervention. Medically, this disorder was recognized in 1980 by the American Psychiatric Association and described in the Diagnostic and Statistical

Manual for Mental Disorders (1995), the medical diagnostic manual for psychiatric disorders. The diagnosis considers both symptoms and duration. Researchers have identified both immediate and long-range symptomatic reactions to trauma. Initially, symptoms include numbness, denial, avoidance of places or things that remind the individual of the trauma, withdrawal from social interactions, depression, difficulty with concentration, and problems with relationships. Long-range, but more acute symptoms include fearfulness, irritability, sleep disturbance, and flashbacks. In addition, exaggerated startle responses, feelings of guilt, and high levels of anxiety are often noted (Kowalski, 1995). A diagnosis of PTSD is likely if these symptoms are still present three to six months after the traumatic incident (Rundell et al., 1989).

The risk of becoming a victim of PSTD is mostly an outcome of having been exposed to a high-risk, potentially traumatic situation or experience. By definition, a traumatic event is one that is outside the normal range of everyday life events and is perceived by the individual as overwhelming (Doepel, 1991). A traumatic incident may produce an emotional reaction with the potential of inhibiting a worker's ability to function either at the scene or later (Mitchell, 1983), or it may affect the functioning of any individual exposed to the trauma. Clearly, 9/11 qualified as a traumatic incident.

Some psychologists suggest that the greatest emotional vulnerability after a traumatic incident is from the six-month anniversary to the one-year mark after the incident. One New York psychologist is credited with saying that she fears an upsurge in rages, self-destructive behavior, and even suicides. "The despair, the helplessness gets so intense... it bursts out."(Lagnado, 2002, P. B1). An associate professor of clinical psychiatry at Colombia University's medical school says it is classic to see unraveling occur several months after a disaster. After the "honeymoon phase" where everyone pulls together, it all falls apart (Randall in Lagnado, 2002).

An additional component with a terrorist event is that a situation that used to be perceived as benign can now be dangerous. Normal activities, such as sitting at a desk working, walking down a street, attending large public gatherings including sporting events or concerts, or opening daily mail, may become fraught with concern for unknown dangers. Suicide bombers in the Middle East have had a drastic effect on the population there, where the people are fearful of public places, restaurants - any gathering place.

Previous Studies

What do we know about the psychological response to terrorism? What differences exist in the psychological response to a natural disaster in comparison to an act of terrorism? Data in this area are limited. Most of our information is the result of studies of human behavior during and after events such as hurricanes, floods, fires, earthquakes, tornadoes, war, and mass violence. However, we can look to the events in 1995 of the Oklahoma bombing and the Japanese sarin release subway incident for guidance in answering these questions.

<u>Japan Incident</u>

On March 20, 1995, members of the fanatic cult AUM Shinrikyo released sarin, a chemical nerve agent, at five points in the Tokyo subway system. The attack resulted in the death of 12 people and more than 5,000 people sought medical treatment at local hospitals. However, only 500 to 1,000 people actually suffered from exposure to the sarin nerve agent - the majority presenting themselves for treatment were what some experts call "the worried well." Hospitals were overwhelmed (Lord, 2001).

For five years, investigators followed the 582 sarin patients who were given emergency care at St. Luke's International Hospital on the day of the attack, investigating psychological and physiological symptoms. The study demonstrated that victims continue to suffer symptoms five years after the terrorist attack (Kawana et al, 2001). The most common physical symptoms reported were eye symptoms such as tiredness of eyes, fatigue, muscle stiffness, and headache. Psychological symptoms did not decrease significantly over the five years except for a depressed mood, which significantly improved. In addition, interventions including counseling, medical treatments, and support group activities were associated with fewer symptoms among the victims.

The investigators suggest that the response to traumatic events may differ in different cultures. The example given was that it is not uncommon in Japan to find somatized depression patients who are call "masked depression" patients. Nakano (2001) has suggested the term "masked PTSD" for traumatized patients with unexplained physical symptoms.

Oklahoma Incident

The following quote captures the immediate emotional response of our nation to the 1995 Oklahoma City Bombing: "April 19, 1995, around 9:03 a.m., just after parents dropped their children off at day care at the Murrah Federal Building in downtown Oklahoma City, the unthinkable happened. A massive bomb inside a rental truck exploded, blowing half of the nine-story building into oblivion. A stunned nation watched as the bodies of men, women, and children were pulled from the rubble for nearly two weeks. When smoke cleared and the exhausted rescue workers packed up and left, 168 people were dead in the worst terrorist attack on U.S. soil." http://www.cnn.com/US/OKC/bombing.html

A retired Oklahoma firefighter who led the department's stress-debriefing team notes that six years later, the bombing rescue workers are still haunted by their memories. He noted that alcohol consumption was up and retirements have increased since the incident. This firefighter further said:

> "I'm active in the Retired Firefighters Association of Oklahoma City, and there's some retired firefighters there that stood up and said, 'This is really screwing my head up, and I'm going to go get help.' They're still having problems to this day. Maybe they wake up seeing the bomb scene. Maybe they wake up with the smell. It's just all sorts of things seem to trigger these people off. I've been looking to put together a bunch of fire fighters that were involved in the bombing—like a peer-support group, maybe. But that hasn't happened yet. Fire fighters are real—like I said—the macho-man stuff, and you don't let people see you sweat. So it's just really hard for people that were raised that way." (David Bowman Newsweek Web exclusive http://www.msnbc.com/news/585091.asp#BODY)

The divorce rate in the Oklahoma City Fire Department went up 300% after the Murrah Federal building bombing. Dog handlers at the Oklahoma tragedy reported that the stress of the rescue even affected the search dogs. Again and again these rescue workers and the animals entered the debris-filled bomb crater pit, searching for life and finding only death. (CNN Correspondent Don Knapp)

Public Response to 9/11

In the weeks after 9/11 a news commentator noted, "the tears are never far away." Across the country, there was a tremendous need for people to comfort one another. There was an immediate response across the nation to *do something* - give blood, money, services, prayers. It is normal to experience a feeling of being out of control after exposure to a traumatic incident and the need to normalize, contribute, intervene, to *do something* is a strong motivator. When competent individuals feel helpless, they want to get back in control as soon as possible. Fire departments across the nation collected money in firemen's boots at stop lights; money poured into the Red Cross and relief agencies, medical personnel, mental health professionals, construction workers, and law enforcement personnel from across the country volunteered to go to Washington and New

York. At one point, there were public announcements not to go to the local blood banks as they were overwhelmed with donors. Then, the anthrax scare began when several federal government officials received the powder in their daily mail. Fears escalated.

Figure 3: Split picture: Flag raising WW II and WTC

A note on mass panic behavior

Panic may be defined as nonsocial, blind, irrational behavior (Hodgkinson, 1990). There are two schools of thought on mass panic. One promotes "every man for himself" behaviors, while the other supports attachment or affiliation behavior. Generally, the latter thinking is accepted and supported by studies related to escape from fires - i.e., panic is not automatic in a disaster. This thinking suggests that groups and individuals do adjust to a crisis and only in *extremely threatening* situations may some individuals try to save themselves at the expense of others (NIOSH, 2000).

Data on disasters suggest that 12 - 25% of people remain cool and collected when faced with a disaster, 50 - 75% are stunned, and 10 - 25% evidence disorganized behavior. Overall, on 9/11 the behavior of individuals, victims, responders, and the general public supported the affiliation model. In fact, there were many examples of altruism - the most stunning on Flight 93 where passengers, aware of the terrorist's events in New York and Washington, sacrificed themselves to prevent a possible fourth airplane target.

First Study of 9/11's Psychological Impact

In what is being called the first comprehensive survey of the disaster's psychological impact, a telephone survey of more than 150,000 New Yorkers was conducted between October 16 and November 15, 2001, five to eight weeks after the attack (Galea et al., 2002). This survey offers a glimpse of psychological symptoms in the weeks after 9/11. The research, funded by the National Institute on Drug Abuse and the September 11 Fund and published in the New England Journal of Medicine (March 28, 2002), found that the New Yorkers suffered from the listlessness of depression or the recurring nightmares and vivid flashbacks associated with PTSD.

For the survey, researchers randomly called approximately 1,000 adults who lived within seven miles of Ground Zero. Half of the subjects were women and nearly three-fourths of the population identified themselves as White. Slightly more than 5% lived within a mile or two of the attack site. Thirty-eight % reported witnessing the attacks, 16% feared they would die, and 11% lost a loved one in the event. Overall, about 1 in 13 reported symptoms consistent with PTSD - nightmares, avoiding thinking about the tragedy, and difficulty falling asleep or concentrating. Nearly 1 in 10 reported suffering symptoms of depression within the past 30 days - change in eating habits, an inability to get out of bed, loss of joy. That is about twice as many as one would expect in the general population.

We can understand these statistics by recognizing that the magnitude and nature of 9/11 changed our responses. We struggle to understand an event of such horrific proportions and devastation. There is anger, and because of the anger, it is more difficult to manage the grief. Nearly 14% of the individuals surveyed reported symptoms of either PTSD or depression. That translates to more than 150,000 New Yorkers living south of 110th Street, according to the researchers. In addition, New Yorkers who had two or more stressful life events in the past year were 5.5 times more likely to develop PTSD than those who had none. Those who had a panic attack during the tragedy were 7.6 times more likely to develop PTSD. Those who lost possessions were 5.6 times more likely to develop PTSD.

As with any disaster, there were a number of factors that appeared to predict whether an individual would develop psychological problems, including proximity to the event, what they saw, whether loved ones were killed or injured, whether they were injured, and whether they suffered the overwhelming feeling they were going to die of a panic attack. The researchers also reported some surprises, such as the finding that Hispanics were two times more likely to suffer PTSD and three times more likely to be depressed than White subjects. This finding is consistent with studies of Vietnam veterans showing higher PTSD rates among Latinos (Galea et al., 2002). This finding needs further study.

Finally, the findings pointed to the need to offer support and help to those living further away from the attack. Robert Butterworth, a Los Angeles psychologist uses the analogy that if you throw a pebble into the water, the closer you are in relation to the bull's eye, the greater the ripple. Similarly, people closest to Ground Zero which can be widened to include the Pentagon, the PA crash site, and the anthrax letter locations are most likely to develop a stress disorder or depression. They are also more likely to be offered help. Generally people are not as sympathetic to people further away from the attack site, in this case, those who lived in uptown Manhattan.

Impact on The First Responder Community

The "line of duty" death toll at the World Trade Center is the largest loss of emergency services personnel in history. An article in The Miami Herald, International Edition, in February 2002 reported that "hundreds of firefighters and emergency medical workers who responded to the WTC attack have reported nightmares, sudden anger, and other psychological symptoms so severe that they were taken off active duty. The 14,000-member NYFD said it has put about 350 people with stress-related problems on light duty or medical leave since September 11. Nearly 2,000 more firefighters, fire officers and workers in the departments Emergency Medical Services unit have seen a counselor since September 11 through the FDNY's (sic) counseling services" (Weissenstein, 2002, P. 7A). This is an unexpectedly large number for an institution that traditionally prefers to handle problems within the close-knit firehouse fraternity.

In December 2001, a conference was held in New York City that brought together individuals with experience in responding to acts of terrorism. The purpose of the conference was to hear and document the first-hand experiences of emergency responders with their personal protective equipment. In the subsequent report that was issued (Jackson et al, 2002), it was noted that the "intensity of responders' work, the long duration of the response campaigns, the multiplicity of risks, the horrifying outcomes of the attacks, and the lack of knowledge about hazards all contributed to stress." (P.16). At the WTC, many victim bodies recovered were horribly mangled, and in many cases only parts of bodies were recovered.

The report continues to note that stress can also affect responders' judgment about their own health and safety. At the Pentagon, workers wore heavy equipment and it was reported that some workers actually succumbed to seizure-related heat exhaustion due to the excessive heat in the building, their Personal Protective Equipment, and the exertion of carrying the long hoses. Yet, "they were in it until their bottles (air) ran out, and then they'd have this long retreat. In the rescue mode, they would change (air bottles) and go back in. They worked until they dropped." (P.17). The high-stress environment at the World Trade Center, combined with personal and professional bonds, led to greater risk-taking by the first responders during the response and recovery.

There is a bond, a brotherhood amongst responders. Their job is to respond to emergencies, and on 9/11 the police and especially the firefighters were anxious to get to work - they were anxious to get the people out. They, too, experienced feelings of vulnerability. Later, the unknowns related to the anthrax attacks resulted in high levels of uncertainty in response. Information and recommendations kept changing - noted one responder, "how do you protect them (the victims), how do you treat them?" (P.16)

In March of 2002, The Wall Street Journal reported that as the six-month anniversary of 9/11 approached, psychological problems appeared to be mushrooming in the Fire Department (Lagnado, 2002). More than 100 firefighters were out on stress leave in March 2002 as compared to December 2001, and growing numbers are seeking psychological help from the counseling unit. Irritability, lethargy, and an inability to focus are widespread. The article suggested that the firefighters were emerging from the numb phase and suffering terribly, as the funerals were over and there is now time for them to reflect upon the experience.

In conclusion

The psychological response to 9/11 is enfolding. If we correlate with the known psychological stages of trauma as discussed earlier in this paper: 1) shock and disbelief 2) a strong emotional response 3) acceptance and 4) recovery, we may suggest a measure of response. As a nation we have experienced shock, disbelief, and a strong emotional response. The moving tributes to the victims, the renewed patriotism in the country, the heartfelt and varied contributions, and the gratitude expressed to our firefighters and law enforcement personnel attest to this.

We are far from integrating this terror into the fabric of our lives and complete acceptance and recovery are in the distant future. Physical steps have been taken towards recovery with the clean-up of the scarred earth where Flight 93 crashed and removal of the twisted steel and remains of the buildings. New policies and safety procedures are in place, others in the planning stages. Rebuilding at the Pentagon was underway quickly and the restructuring of businesses, jobs and lives has begun. Retribution and justice is sought. Individual daily life moves forth. As time progresses, we continue to find new questions to pose. The situation is dynamic.

We can also evaluate our psychological status according to the five phases of response to a traumatic event presented in this paper: 1) initial impact phase, 2) heroic phase, 3) honeymoon phase, 4) disillusionment phase, and 5) reconstruction phase. We can categorize ourselves as fluctuating between the honeymoon phase and the disillusionment phase. The relief of survival is intermingled with a frustration with the method and timeliness of support for victims both financially and emotionally. There are many indirect victims with the closure of businesses and lost jobs, especially in the vicinity of the terrorist attack in New York. The effect on the financial community continues to ripple across the country and around the world. The psychological effect on the firefighters and rescue workers is immeasurable. It is suggested that the more debilitating effects of this catastrophe are just beginning for them. This author suggests the importance of developing not only long term psychological support for first responders, but preventative mental health training programs to be incorporated into emergency personnel training curriculums. The mental health effects of 9/11 will last a very long time.

There is pride in the courage of Americans in their response to the trauma of 9/11. This is especially reflected in the stories related to Flight 93, where it appears that the passengers knew about the events in New York and Washington and even in the face of death, they took charge, resulting in the fatal crash and their own deaths in a field in Pennsylvania. Previously, we have been told that in the final stage of the human response to disaster - that of recovery - survivors return to "their pre-disaster level of functioning." However, our response to 9/11 defies this thinking. As with the Civil War, WWI, the attack on Pearl Harbor, WWII, and Oklahoma City, we Americans know we will not return to a pre-disaster functioning (see figures 3 & 4). We may go about our daily business, but life has changed forever.

Our United States Constitution provides for a promise of life, liberty, and the pursuit of happiness. Our precious value of freedom allowed the perpetrators of these terrorist acts access to our country, our education system, our many opportunities for training, our people, and ultimately access to our heart, our very core. How could this have happened? We frame the questions: How could others loathe us so much? How can we protect ourselves? The magnitude of the event forces us to try to find answers to these questions. Emotionally, we are now citizens of the world and can relate to others attacked in their homeland. We became part of the world community in a new way. It happened to us. The terror was within our borders. We experienced what so many other peoples and countries have experienced. Much of the world embraced us and shared our sorrow.

The Chinese have a rich language. There are two symbols for change, and one represents *crisis* and the other *opportunity.* Thus, change is both a crisis and an opportunity. Because of the 9/11 crisis, we in the United States have developed a new sense of community, a deepened respect for firefighters and enforcement personnel, and we have experienced the positive caring and affirmation of others.

Figure 4: Statue of Liberty 9/11volcano

For the future, from a psychological perceptive, *preparation* is the most important activity in which to engage. This is true for the individual, the family, the organization, and the government. The United States is deeply engaged in prevention on a national level. Preparedness is a key component of recovery for survivors as they move on with their lives after a traumatic event. The goal of helping the victim to learn about the enemy/perpetrator/natural disaster and prepare himself or herself, provides a common thread in post-intervention. Information lowers anxiety. There is also a need to move beyond the hate.

Our world has changed. But our world goes on and history supports our survival. Just as an eruption leaves a mountain black and barren. The mountain later comes back to life, different, but alive.

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The International Emergency Management Society
9th Annual Conference Proceedings
University of Waterloo, Canada, May 14-17, 2002

CREATIVITY IN EMERGENCY RESPONSE AFTER THE WORLD TRADE CENTER ATTACK

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Keywords: World Trade Center, creativity, emergency response, improvisation

Abstract

This paper discusses the role of creativity in mounting an emergency response, using the World Trade Center attack as an exploratory case study. The paper observes that the exercise of creativity by emergency managers is the source of positive adaptive responses to unexpected or rapidly-changing situations. The paper notes however that creativity, because of its different manifestations, can introduce a random, unpredictable element into the response milieu, varying with the magnitude of the event, and can lead to tensions within an organization that vary with the timeframe over which decisions must be made. Volunteers and others who converge to a disaster site also exhibit creativity in the pursuit of their objectives, which can present both benefits and challenges to emergency managers. Nevertheless, creativity will remain an important component in initiating and sustaining the emergent methods and organizational networks that researchers recognize as important in emergency response. The paper suggests that plans and exercises should include a dimension that considers creativity.

Introduction

In this paper, we examine creativity as an important contributor to successful disaster response. While advance planning and preparedness serves as a backbone to disaster response efforts, creativity enhances the ability to adapt to the demands imposed upon individuals and organizations during crises and bolsters capacities to improvise in newly emerging physical and social environments. Borrowing from the literature on entrepreneurial creativity, we apply a framework developed by Amabile (1997) to categorize creativity in private sector firms to the activities of responders working in the disaster context of the September 11th, 2001 World Trade Center attack and describe how individuals and organizations involved in various aspects of New York City's management of the disaster generated and implemented novel ideas to deal with challenges posed to them during the early response.

Creativity

The literature on creativity is vast, spread among the arts, psychology, business and management, and philosophy. In a summary, Clemen (1996: 188) describes creativity as "…new alternatives with elements that achieve fundamental objectives in ways previously unseen. Thus, a creative

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alternative has both elements of novelty and effectiveness, where effectiveness is thought of in terms of satisfying objectives of a decision maker, a group of individuals, or even the diverse objectives held by different stakeholders in a negotiation." He also observes that "All definitions include some aspect of novelty. But there is also an element of effectiveness that must be met" (188). In looking at entrepreneurial creativity, Amabile (1997: 18) defines creativity "as the production of novel and appropriate solutions to open-ended problems in any domain of human activity; we have defined innovation as the implementation of those novel, appropriate ideas." In other words, creativity involves both success as well as newness: it is both positive and adaptive.

Amabile (1997: 20) further dimensionalizes *entrepreneurial creativity*: "(a) the products or services themselves, (b) identifying a market for the products or services, (c) ways of producing or delivering the products or services, or (d) ways of obtaining resources to produce or deliver the products or services." These dimensions, though derived with respect to business enterprises, provide a useful way of conceptualizing the kinds of creativity that are often exhibited by responders in disaster situations. At the same time, they allow us to make connections with other well-developed literatures on creativity that will both enrich our understanding of creativity in disasters and, through further research, allow us to use disaster experiences to advance understanding of creativity more generally. Relatedly, Woodman et al (1993: 293) have defined "*organizational creativity"* as the creation of a valuable, useful new product, service, idea, procedure, or process by individuals working together in a complex social system," which they further characterize as a common conception of creativity "placed within an organizational context." Amabile (1993: 20) is also careful to distinguish between what is and what is not entrepreneurial creativity:

> It is not limited to the establishment of new businesses, because it can be found when new enterprises are established within existing businesses. Moreover, it is not necessarily present in the creation of any new business; some significant degree of novelty must be involved, at some stage of the process… Entrepreneurial creativity is not present in many of the incremental product or service improvements within established systems or paradigms, unless some significant novelty is required… Moreover, even when a truly novel product or service idea is present, or when there is a novel insight about a market opportunity, entrepreneurial creativity does not exist unless the ideas are implemented in the creation of a new business or enterprise.

An important difference between the disaster and the business environment, of course, is the time pressure involved and the overall urgency of the creative decisions to be made; nevertheless, the types of creativity are analogous. Some or all of them can be seen in different instances of creativity and creative action that occurred in New York City. Not every instance of creativity in New York City involved creating a new product or item; some of the creativity involved "the means for creating or delivering the product—the identification of new market opportunities, or the organization and the systems that are established for bringing the product to market" (Amabile, 1993: 18, citing Stevenson, 1984; Timmons, 1977; Timmons, Muzyka, Stevenson, and Bygrave, 1987).

According to Comfort (1999: 29), creativity is also strongly related to the capacity for "sensemaking" that Weick (1993) has described: the ability to comprehend aspects of the environment and to make decisions. She draws on Luhmann's (1989) conception of "autopoiesis," calling that process "a powerful, driving force for creative self-expression…in individuals that, if extended to social groups and organizations through articulated communications processes, serves as a vital source of creativity, renewal, and regeneration in social systems undergoing change." Comfort (1999: 59) observes that "Autopoiesis necessarily involves interaction with the environment." Woodman et al (1993: 294) draw on Woodman and Schoenfeldt's (1989, 1990) interactionist model of "creativity [as] the complex product of a person's behavior in a given situation;" "group creativity is a function of individual creative behavior 'inputs.'" What emerges from these different research approaches is a view of collective creative action rooted in gathering environmental information, considering the implications of that information with respect to ambient challenges, and the generating, identifying, and selecting of actions that are anticipated to meet those challenges.

Creativity as a Contributor to Improvisation

A disaster is an event that is defined, at least in large part, by the improvisational aspects of the response (Tierney 2002). Since disasters break down the patterns of what can be governed or absorbed by routine procedures, an event that does not demand the exercise of improvisation does not, by definition, constitute a disaster. Indeed, Kreps and Bosworth (1993) argue that disaster research was meant by the pioneers of the field to place a theoretically based focus on organizational stability and change in the crisis context. This research is well represented by a large body of literature examining emergent groups (Stallings and Quarantelli, 1985), organizations that form new or altered organizational structures and perform non-routine tasks in a disaster (Dynes 1970), organizational adaptation in disaster (Stallings, 1970), improvisation in organizational domains, human and material resources, tasks, and activities (Kreps et. al 1994), role improvisation (Webb, 1998), and enhancing improvisation through decision-support tools (Mendonca et al, 2001). The catastrophic collapse of the World Trade Center following the September 11th, 2001 terrorist attacks and the magnitude of the impact on New York City necessitated a wide range of improvised activities (see Wachtendorf and Kendra, 2002). Hundreds of thousands of people were evacuated by boat from lower Manhattan; telephone communication was, in large part, temporarily disabled in parts of the city due to the destruction to telephone lines and cellular phone towers; the city's Emergency Operations Center (EOC) at 7 World Trade Center was evacuated and eventually collapsed, necessitating the establishment of interim and then semi-permanent EOC facilities; the damage to the World Trade Center area necessitated complex site management, security, safety, and clean-up processes (while response and recovery activities overlapped), processes not previously seen in this way or to this extent by any of the organizations involved. Organizations and individuals improvised, some more successfully than others, to meet the demands generated by these and other emerging challenges. We argue here that entrepreneurial creativity, not unlike that described by Amabile (1997), played an instrumental role in the success of the improvised action.

Planning and creativity work in concert to produce effective improvisation. The new social arrangements that emerge following a disaster and in response to an evolving crisis situation cannot be divorced from previously existing arrangements (Kreps & Bosworth, 1993). Prior preparedness increases the ability to improvise (Kreps, 1991). This planning forms the basis for decision-making in emergent environments, informs decisions by anticipating possible challenges or pitfalls that could come as a consequence of improvised activities, and often provides some element of stability – whether of organizational structure, role, task responsibility, resources, or the physical environment – when other elements are in flux or demand unplanned-for action. At the same time, the very need for improvised action points to an inability of plans to adequately take into account one or more specific demands – sometimes quite understandably so, since it is not practical or feasible to adequately plan for every possible scenario. Existing social arrangements also are always subject to change (Kreps & Bosworth, 1993), particularly when coupled with the ambiguity and confusion that often accompanies large-scaled disasters (Webb, 1999). For these reasons, creativity emerges as an instrumental contributor to successful improvisation.

This fact is not surprising. Of course, the application of creativity in established planning efforts, whether in new activities or making changes to existing activities, can improve the effectiveness of those actions. Creativity in the disaster context, however, must be performed under increased time constraints and in environments that have higher degrees of ambiguity. In both disaster and non-disaster periods, the generation and implementation of novel approaches to a challenge can result in positive or negative outcomes. A creative activity may, in fact, generate new problems, have not adequately taken into consideration the social environment, or quickly become ineffective in a dynamic and changing disaster context. Therefore, improvisation is most successful when existing structures and planning are in conversation with creativity.

Along with researchers, practitioners appreciate the creative aspects of their work; creativity is a trait or characteristic that is strongly associated with emergency managers and is often cited as a prime job-related skill, as the following passages indicate:

> "The Texas Emergency Manager (TEM©) certification is an indicator of experience, hard work, continuing education, dedication to integrity, and creativity."
>
> (Emergency Management Association of Texas, nd)

> "A disaster is any event that overwhelms your ability to respond," [Judi Van Swieten] says. "You have to be prepared for the worst and work from there, often changing the plan as you progress.
>
> Flexibility, adaptability and creativity -- those words guide my career."
>
> (Thomson, 2002)

One publication by The International Emergency Technical Rescue Institute notes that

> "the future belongs to those who can recognize the needs of an emergency situation and respond with speed, accuracy, creativity, innovation and calm leadership".
>
> (USARAA News, 1999: 1)

Though most of the emphasis on creativity relates to the response phase of a disaster, creativity should not be seen as being limited to the emergency response, which distinguishes it from improvisation, normally used in the literature to refer to actions taken when the disaster occurs. Creativity is an important quality for disaster managers even outside the environment of a disaster: it is important during hazard identification, developing plans, and communication and outreach to the public, processes which often have strong entrepreneurial aspects as well. A disaster plan may have to be developed and "sold" to elected officials or corporate officers, for example. Yet even though creativity and flexibility are regarded as important qualities of emergency managers, and though people involved closely with emergency response recognize that emergencies demand these qualities, having to exercise creativity during a response is, paradoxically, often regarded as dysfunctional for emergency personnel: an indication of failure to plan properly ahead of time. This is because emergency management plans, apart from their function as guides to action, also serve rhetorical or political purposes (Clarke, 1999). Clarke argues that they are meant to attest to the competence of emergency planners to foresee events and also that plans fulfill the symbolic function of converting the uncertainty that surrounds hazards or accidents into the kind of certainty that can then be managed. Sometimes the planning process can be stretched beyond credulity; at that point plans become "fantasy documents" (Clarke, 1999) that accept as possible that which is improbable. In other words, planning is such an important activity that plans must be written for situations in which the event will almost certainly differ from what is anticipated, and the anticipated response will be based on preconditions that are likely to be radically altered.

Given the emphasis on plans, even those that are impossible to execute, it is not surprising that departing from them is often defined as evidence of a failure. Disasters, however, break the rules that frame the ordinary conduct of business and government, at least for a period of time. Disasters create a new environment that must be explored, assessed, and comprehended. Disasters change the physical and social landscape, and therefore require a period of exploration, learning, and the development of new approaches.

Method

The data used for this paper are qualitative in nature and were gathered during exploratory fieldwork commencing within two days of the terrorist attack on the World Trade Center and continuing for two months thereafter. We base our findings on over 750 collective hours of systematic field observations. In particular, we closely observed key planning meetings at highly secured facilities, including the Emergency Operations Center, incident command posts, and the federal Disaster Field Office; we spent extensive periods observing operations at volunteer, supply, and food staging areas, the “Ground Zero” area, family assistance centers that were established for victims’ families, and respite centers that were established for rescue workers; we spent time observing activities at major security checkpoints in Lower Manhattan and at locations central to the emergency response. In the course of our fieldwork, we generated a large volume of notes providing rich description of observations and experiences, took over 500 photographs, and sketched and collected floor plans of various facilities to track the spatial - organizational changes over time. Of primary interest to the field research teams were the activities of formal and informal organizational and the multi-organizational response elements that were underway. That is, we were concerned with identifying which organizations were involved in particular response and early recovery functions, the activities in which these organizations were engaged, the level and success of interorganizational interaction or lack thereof, the degree to which planned emergency response activity was implemented and the extent to which alternative response strategies emerged, and the successes and challenges encountered by those responding to the disaster.

In addition to direct observation in New York City, we collected a wide array of documents produced by local, state, and federal agencies as well as by individuals and organizations with less formal ties to response efforts. These documents included but were not limited to internal and public reports, requests for information or resources, information handouts, internal memos, schedules, meeting minutes and agendas, maps, and internal directives.

DRC also compiled an extensive electronic database of articles and web-based information. Newspaper articles from major local New York City papers were collected for six months following the attack. Articles from major periodicals, selected articles from newspapers from around the world, and information from the many government, charity, community-based, individual, and private Internet sites that emerged after the disaster event were included in this database. The subject matter included in this collection is diverse; however, all of the information was later coded according to relevance to the response and early recovery as well as to the primary functions related to the response effort. The functions according to which this information was coded were informed by the literature on disasters and based in large part on the activities observed during the fieldwork component of the research.

The use of multiple methods and data sources – direct observation, reports and other documents produced internally by New York City responding agencies, analysis of documents produced by victims of the disaster and informal supporters of the official response, analysis of newspaper accounts, and coding of Internet-based data – allowed us to triangulate the data collected. That is, we were able to compare the information collected from one source with other sources as a means to check for accuracy and validity of the data (Denzin, 1998).

In this paper we apply the framework provided by Amabile (1997) to the World Trade Center disaster context. Adopting Amabile’s definition, we will look at (a) new products or services that responding agencies provided or used; (b) situations in which responders identified a particular market or need to the services they wished to provide; (c) creativity in producing or delivering response-oriented products or services; and (d) obtaining resources for the disaster response. We emphasize that, in our use of this entrepreneurial model, we are not suggesting that responders were acting like business entrepreneurs. Instead, we use the model in a more strict analytical sense because of its usefulness in conceptualizing the different manifestations of creativity and in characterizing an operational environment in which new ideas, strategies, and methods came to fruition under extreme conditions.

Having introduced our methodological approach and theoretical orientation for our discussion, we turn next to describing instances of creativity with respect to the four dimensions described above.

Creativity in New York City

Responding to a disaster is from the beginning a task of both creativity and improvisation, in which plans end up providing, not a blueprint for action, but at most an orienting framework. In extreme cases, such as the September 11 attacks, plans may offer very little guidance on how to address disaster-related problems The emergency response in New York City following the Trade Center attack was created on virtually a daily basis as needs were identified, solutions considered, and actions implemented.

New Products; New Market; New Ways of Producing or Delivering the Products or Services; New Ways of Obtaining Resources

In earlier work (Kendra and Wachtendorf, 2001a) we describe how the New York City Emergency Operations Center was reconstituted following the destruction of their very advanced facility at 7 World Trade Center. After moving to a succession of intermediate facilities and making use of a mobile communications van, the Office of Emergency Management finally moved to Pier 92, a cruise-ship pier that had been scheduled to be used for a bioterrorism exercise on September 12. The Office of Emergency Management re-constructed the emergency operations center in this space, bringing in, or facilitating the delivery of, computers, fax machines, printers, desks, chairs, even carpet. Emergency managers, in many respects, faced a new operational environment, comprised of many more agencies than previously dealt with in a cityscape that was fundamentally altered, both by the destruction itself as well as by road closures, detours, and facilities that were put to new, unusual uses: a hotel and a university student center became respite areas for rescue workers, for example. Stated most generally, emergency managers had to explore and reclaim an altered environment. They had to develop a new "map" of a response that had not been previously envisioned, and identify the important locations, which themselves were changeable as the response evolved. The term "mapping" can be used in a literal and not just metaphorical sense. Ground Zero, itself a new term for a transformed area, was an entirely altered landscape, difficult even for New York residents to orient themselves with respect to the familiar features of the area. Command posts, respite centers, warehouses, and washdown stations were among the needed facilities for which space had to be found, locations mapped, and maps made available to responders. Apart from the reconstitution of the EOC as a whole, development of the mapping capability within the EOC shows creativity as well (see, ArcNews, 2002 for an extensive narrative) which exemplified all of Amabile's (1997) creative dimensions involving product and process. This capability involved bringing in hardware and software from a variety of sources, including both private vendors such as ESRI and also local colleges along with a process of learning, by cartographers and emergency managers, what spatial information was required for the response and what was possible to produce given the available information. The use of maps was an instance of creativity in this case, but so too was the development of a mapping infrastructure. Here were aspects of creativity that focused not just on creation of new maps, displaying information such as the extent and orientation of the debris pile and the direction of ash movement, but on the development of the network of creators and users of the end product. They created new relationships to supplement those that already existed, and they used technologies that had been designed for other purposes (Tierney, 2002).

New Ways of Producing or Delivering the Products or Services

The waterborne evacuation of lower Manhattan after the World Trade Center attack provides an excellent example of creativity (especially along two dimensions identified by Amabile: "ways of producing or delivering the products or services," and "ways of obtaining resources)" and emergence, in which responders departed from their normal and even their disaster-related roles and in which many responders took part on an unplanned basis. An evacuation of that magnitude was not planned; one Coast Guard officer referred to it as an "ad hoc" event, while another described it as an extension of the agency's existing catastrophic search and rescue plan (which had been designed for the thousands of people who might be, for example, involved in a ferry accident) that the Coast Guard is now working to codify ("memorialize"). Available vessels arrived to assist and were assigned by Coast Guard officers working aboard the Sandy Hook Pilots' pilot boat and then aboard a cutter (Sherwood and Schoenlank, nd). According to Coast Guard officials, between 500,000 and 1 million people left Manhattan by boat, whether by tour boat, military vessel, passenger ferry, or private craft. In another instance of people using existing skills and capabilities to perform new tasks, the Pilot Boat *New York* fueled fire trucks and other vehicles (Sherwood and Schoenlank, nd). It was a creative exercise, in which people rose to the occasion with all sorts of vessels, and it is also an example, especially initially, of the kind of self-organization that is important in complex adaptive systems (Comfort, 1999).

> "We moved about 30,000 people on our six boats," says Peter Cavrell, senior vice president of sales and marketing for Circle Line. "It wasn't any kind of coordinated effort. We just started doing it." Continues Cavrell, "In its own small way, Circle Line is a symbol of New York. We just wanted to do our part."
>
> (Snyder, 2001)

New Products; New Ways of Producing or Delivering the Products or Services

Though creativity is accepted by researchers and practitioners as significant in managing emergencies, and though feats of creativity were significant in New York City's response on September 11, exercises of creativity during the pressure of a response to an emergency may give rise to future complications. We can anticipate that, the greater the magnitude, scope, and/or duration of a disaster, the greater or more frequent the complications might be. Plans promise coherence in a dynamic situation, and the ability to comprehend and respond to a disaster as a total unit. Response strategies that involve creativity, though, approach disasters as more segmented entities, comprised of micro-events to be managed which may or may not be anticipated. Difficulties may therefore arise later.

There was tension within the formal disaster response organizations regarding the nature and scope of creative efforts, in particular over what timeframe to consider emergent needs. The time horizon is an important consideration when planning courses of action; some officials have jobs which compel them to look at different spans of time when contemplating actions. Creativity within the response milieu developed as an iterative process among various officials and, as in any work setting, there were clashes over the direction of the creative endeavor. One of the needs identified early in the response was washing down debris and vehicles, especially trucks and heavy equipment that would be leaving the Ground Zero area. Much of the debris was dangerously hot after having been extracted from the rubble pile (hot enough in some instances to ignite the tarpaulins on the trucks), and in addition, the dust and ash posed a health hazard. Officials from the Department of Health and the Department of Design and Construction quarreled over whether it was better to have washdown apparatus in place as quickly as possible, or whether some time should be taken to design an engineered structure that would be heated ("winterized"), in anticipation of the cold weather that would arrive in December. The official from DDC, an engineer, argued that building winterized facilities required a "substantial planning process," and that they were at the position of being able to plan how to develop that plan. The official from the Department of Health was perplexed by what he saw as unreasonable delay in meeting immediately pressing needs as opposed to problems that could develop a couple of months later. The longer a crisis lasts, the more tension there will be among officials whose jobs and whose professional imperatives involve different timeframes for action.

New Ways of Producing or Delivering the Products or Services

Creativity doesn't necessarily mean building something; rather, solutions can take the form of altered procedures, e.g., by doing or not doing something that would be done ordinarily. Working closely with Department of Health officials, New York State Department of Environmental Protection officers slackened the issuance of citations to truckers without tarpaulins, recognizing that it was impossible for them to comply with the regulations requiring trucks with bulk cargoes to be covered. With respect to the seagoing evacuation of Manhattan, Coast Guard inspectors at the point of loading were authorized to use their discretion to permit vessels to exceed their certificated passenger capacity. In these examples of process adjusted with respect to ambient conditions, authority devolved to personnel closer to the scene for greater flexibility.

Detailed plans developed in advance of an emergency are intended to provide coherence and predictability to the response; a plan with which everyone is familiar should be a source for re-establishing an orderly, predictable response in the uncertain and dynamic post-event environment. The prime difficulty with the exercise of creativity is that, by necessity, it occurs outside of a framework of control. Sometimes individuals exercise creativity; other times groups or organizations do so. Creativity is a function of inspiration and artistry (Kendra and Wachtendorf: 2001a). It doesn't emerge on schedule, and as a consequence creative and innovating steps can occur out of sequence with other actions being undertaken by responding organizations and groups. Therefore it introduces a random and unpredictable element into the response milieu. One person's or group's creative insight can become another's challenge, and it also becomes a new part of the operational environment about which people must learn and to which they must adjust, just at the time when people want stability.

Prior to the September 11 attack, the Office of Emergency Management had decided to adopt the E-Team emergency management software, a web-based application that allows for tracking of resource requests and deliveries. The decision had only recently been made, but OEM decided to make use of the software in this emergency, though the agency had little experience with it. OEM brought in E-Team personnel, as well as other emergency management specialists familiar with its use, to install the software at Pier 92. Few of the workers in the EOC had any experience with E-Team, and it was necessary to run training sessions to acquaint people with its use. One logistics officer said that the middle of an emergency was a bad time to bring in new software. Yet this is also an example of the importance of the timescale over which creativity operates; bringing E-Team, a new process for this organization, in early allowed it to be used during nearly the entire course of the response. When American Airlines Flight 587 crashed in November, EOC staff were experienced with E-Team and able to use it.

Procedures that developed around security and credentialing constitute an additional instance of "creative ways of obtaining resources to produce or deliver products or services." Not only was the Trade Center attack a high impact disaster that produced numerous casualties, it was a complex emergency with added ambiguous dimensions such as the ongoing terrorist threat, the criminal investigation, an ongoing process of remains recovery and identification that persisted more than six months after the attack, and a very dangerous collapse site situated within close range of an extremely dense urban population. Early in the response, it became clear that controlling access to various affected sites would prove a significant challenge. In addition to standard concerns about discouraging the movements of sightseers and preventing non-essential personnel from exposing themselves to dangers at the collapse site, security was a major consideration because of the persistent terrorist threat and the perception of continuing vulnerability. In addition, the standard OEM visitor badges had been lost in the destruction of the EOC at 7 World Trade Center and even if available, these badges would have been entirely inadequate for the hundreds of people who passed through the reconstituted EOC on a daily basis or who require access to other secured zones and facilities throughout the area.

One of the ways that this complex emergency was dealt with was through the development of a credential system. This system, in the form it took after 9/11, was not a previously existing process. While based on other credentialing procedures, but it evolved over the course of the response. Beginning on Saturday, September 15 and continuing over the course of a few weeks, OEM developed a serious of badges and transitioned through several phases from relatively a simplistic credentialing system where anyone given 'clearance' received a blue and yellow badge featuring the OEM insignia -- this computer-printed badge was essentially a piece of paper placed in a name-tag holder, could be easily duplicated and had no information identifying information – to eventually a plastic white badge with a white background and the title "WTC 2001," a digital color image of the individual, the person's title and organizational affiliation, and a variety of codes indicating particular areas to which the person could have access. At the same time as the more sophisticated WTC 2001 badges were distributed, temporary badges were developed for contractors and volunteers who would require short-term access to specific areas.

The process involved in obtaining badges was at times very time-consuming for some individuals. Although it was important for the city to restrict the number of people with access, there was a real and legitimate need to move along with critical assessment and recovery tasks, including the inspection and repair of many surrounding buildings. Some of the contracted workers utilized in the inspection and repair function of the response employed creativity to obtain resources - in this case, the resource was access badges – in order to deliver their response services and meet the responsibilities they were assigned to undertake in an expedited fashion.

Supervisors of construction workers were only allowed a certain number of contractor badges. Again, it is important to stress that this procedure was for safety and security purposes. At the same time, demands were placed on the supervisors to rapidly carry out their responsibilities. The number of badges allocated to them did not always match the number needed to undertake or promptly complete these tasks. The supervisor would then contend with a certain competing tensions that needed to be resolved. On the one hand, the contract workers needed to do a task and on the other hand they did not have the resources – access badges – that would allow them to complete the task. This tension resulted in some supervisors engaging in creative strategies in order to achieve their ultimate response goal.

This scenario recounted by one supervisor of contract workers illustrates their employment of creativity. This supervisor received approximately twenty badges needed for access to complete the inspection or repair of a building. More workers were needed, however, to complete the task at hand. As a solution, twenty workers would go in, one worker would take their badges, and then this worker would give separate groups of nineteen workers the same badges for access to the building. Temporary badges for contract workers did not have identifying information, but instead expired after a certain time period. Supervisors retained control over the badges and a contract worker could not enter or exit that building or area without a badge. Still this solution enabled responders in charge of inspection and repair to 'make do' with the badges they were allocated by implementing a creative approach to getting access to resources to achieve their ultimate goal.

Identifying a Market

Just as important as the creativity exhibited by emergency managers in the official response structure is that exhibited by the convergers. Creativity is not the sole province of official emergency responders. As noted earlier, the subtext of emergence is creativity: while people may not always be creating something that has never been seen before, the essence of creativity is that the actions undertaken are new to them. Emergent groups and convergers, often display considerable imagination and ingenuity in meeting their objectives. In many instances it was a matter of adapting their existing talents to the new post-disaster environment (for example, boat operators). We encountered, for example, bicycle couriers who delivered food along the secured perimeter when they weren't permitted to help in other ways. (see Kendra and Wachtendorf, 2001b). We observed chiropractors who, by skillfully allying themselves with Red Cross workers, gained access to the EOC and worked on a stack of pallets with a pad thrown across. As Amabile (1997: 18) observed, "[N]ovelty may appear in the means for creating or delivering the product…" and in reaching new markets, not just in creating something new. Some of the volunteers exhibited skills that were quite entrepreneurial, not in a business or financial sense, but there was a kind of volunteer "market" in place; many people were competing for an opportunity to help, not in a direct sense but certainly implicitly. The imagination and resourcefulness of such well-meaning volunteers was sometimes an irritant to emergency managers, to say nothing of the creativity shown by exploiters and the disaster opportunists who also converged. Convergers can often be a source of additional assistance to emergency managers, bringing skills that may not exist when and where they are required, but they can also present challenges, since they are another potentially uncontrollable element in the response milieu whose appearance can create other complications for security and site safety.

Implications for Planning

New York's Office of Emergency Management had conducted many drills and exercises that addressed response to different kinds of emergency events. Included at these drills were representatives from a broad range of local departments and agencies. When responding to the World Trade Center attack, these agencies essentially recreated their ongoing and planned relationships on a daily basis, accounting for changes in the social and physical context but also using sets of skills and capabilities that were developed in earlier training and practice. At the same time, other individuals and organizations played important roles in the response that had not been involved in any of the city's exercises. These individuals and organizations, however, were able to draw upon their experiences, informational resources, and existing networks and augmented those established resources with creative ideas in order to achieve their goals or fulfill their responsibilities. For all these groups, the requirement in this disaster was to deploy these skills and capabilities in new ways that were adapted to the emerging situation. Although creativity is generally regarded as emerging from flashes of inspiration or insight, but it is also founded on broadly-applicable abilities. Bruner (1983: 183, cited in Weick, 1993) argues that creativity is "figuring out how to use what you already know in order to go beyond what you currently think."

In earlier work (Kendra and Wachtendorf, 2001) we considered the tension between anticipation and resilience, especially as articulated by Wildavsky (1992). Wildavsky argued that the likelihood of experiencing events that could not be planned for was such that a strategy of developing resilience to stressors would be better than trying to anticipate and plan for every type of event. Since it is not possible to anticipate everything, such an effort would lead to failures in many cases. In our view, however, anticipation and resilience are not in opposition. Rather, the sought-after quality of resilience can be achieved only by developing sets of capabilities that can be applied in a variety of disaster situations. Indeed, we argue that the World Trade Center attack shows that creativity is such a significant feature of response to an extreme event that planning and training should move explicitly toward enhancing creativity at all levels of responding organizations. Given that creativity undergirds improvisation, and is an important dimension of resilience (Weick, 1993), such a widely recognized and vital component of emergency response should not be left for emergency managers to acquire by chance, nor should it rely on emergency managers fortuitously bringing these skills to the job or developing them on their own.

As mentioned earlier, Mendonca et al (2001) are building a decision-support system with a training mode that features improvisation, and they note that there are other techniques that can be used within organizations to promote creativity, such as brainstorming. Clemen (1996) summarizes some methods that are used in corporate settings to develop creativity skills; these might be applied in the emergency management field as well. He first distinguishes between "fluent" and "flexible" thinking. "Fluency is the ability to come up with many new ideas quickly. Flexibility…stimulates variety among these new ideas" (Clemen, 1996: 203). Relevant exercises that Clemen mentions include thinking of new uses for familiar objects, use of "idea checklists," and using or generating lists of questions such as Osborn's "Idea-Spurring Questions" (Clemen, 1996: 204, citing Osborn, 1963).[2] Emergency managers should investigate other techniques that might be useful in their particular circumstances.

In our discussion, we compared creativity in New York City to entrepreneurial creativity in business settings. Another theme in that literature is the analysis of the impact of organizational factors on facilitating or impeding creativity. Whether the same factors obtain in emergency management organizations is an important question for future research, but it seems that, at a minimum, emergency managers should try to identify and mitigate the features inside and outside their organizations that might suppress or impede creativity, such as deleterious reward structures and other maladaptive motivational influences (See Amabile, 1997 and Woodman et al 1993 for a discussion of some of these).

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[2] For example: "*Substitute?* Who else instead? What else instead? Other ingredient? Other material? Other process? Other power? Other place? Other approach? Other tone of voice?"

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Acknowledgements

This research is supported by National Science Foundation/Multidisciplinary Center for Earthquake Engineering Research grant 2001/02: R76828, World Trade Center Crisis Response.

We gratefully acknowledge Professor Kathleen Tierney for her many valuable comments and suggestions on successive drafts of this paper.

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SECTION 2

SYSTEMS APPROACHES TO EMERGENCY RESPONSE AND MITIGATION

A SYSTEM APPROACH TO ENVIRONMENTAL HAZARD ASSESSMENTS

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Keywords: Risk Assessment, Systems-approach, GIS, Texas, Hurricanes, and Hazards

Abstract:

The work of two separate projects are united in this paper, which is a project proposing a systems-based approach to disaster risk analysis. These projects are focused upon the Clearlake region of south Texas, which includes the southern district of Harris county and northern Galveston county. The Clearlake region is composed of growing urban, recreational and industrial developments on the outskirts of the southern Houston metroplex. This area of Texas has historically had the worst natural and technological disasters in the United States of America.

The purpose of this paper is to examine the interplay between industry (especially hazardous material facilities), topography, geography, demographics and politics. The primary data used in this paper is collected from a series of interviews with emergency managers in the area. The information is then juxtaposed with secondary data gathered through GIS analysis and information accessible through the Internet, such as hazardous material sites, and demographics. The GIS analysis shows the extent to which each segment of the study area is likely to be vulnerable to hurricane, flood and chemical hazards.

A unique feature of this paper is the systematic approach to risk analysis which is employed to evaluate the physical dimensions of hazard vulnerability as well as the political and social constraints that exist on preparedness, response, recovery and mitigation. Within this framework, hazard vulnerability is evaluated in light of the Clearlake region's susceptibility to hurricane, flood, and chemical hazards that could severely tax the resources of the area. Ten variables are defined and then applied to the various sub-regions within the study area providing an overall score to represent the risk for each variable. A summary score for each city is then obtained. These scores are averaged together to give an overall risk assessment of the cities in the Clearlake region. The variables examined include: (1) disaster history, (2) special hazard zones, (3) topography, (4) hazardous facility sites, (5) demographics, (6) non-structural mitigation efforts (7) special resources, (8) socio-political dynamics, (9) special administrative districts, and (10) the integration of the planning process.

Introduction:

This paper introduces a systems-based approach to risk analysis for natural and technological disasters, using the city as the principal level of analysis. Through out the paper the terms "disaster planning" and "emergency management" are used interchangeably. We realize there is a difference in these two activities, but in our case study the disaster planners were also the emergency managers in most instances, and therefore the terms became easily interchangeable. The systems approach to risk analysis is achieved through a multidisciplinary endeavor involving the work of two independent research projects concentrated in the south central region of Texas. The first research project uses secondary data to evaluate spatial land-use patterns to assess relative risk. The Geographic Information System (GIS) is primarily employed to delineate the spatial distribution of hazardous material facilities and their relationship to population centers and surge danger zones. Additionally, secondary data is used to assess risk in relation to population densities, socioeconomic status, hazardous facility sites, and topographical features. The second research project involved an evaluation of the disaster planning process among emergency managers in the region which comprises the southern portion of Harris county and northern parts of Galveston County. In this project many of the sociological and cultural aspects found in this region were considered and their effect on the planning process was assessed. The combination of these two research endeavors has led to a systemic approach to risk analysis which takes into account issues such as planning, geography, industry, urbanization and disaster history.

Previous assessments of risk analysis for natural disasters have tended to focus on a single aspect of risk, such as risk communication (Rogers, 1992, and Lindell, 1997), psychological and social components of risk (Bolin, 1986), or structural and non-structural mitigation efforts. Additionally, most of these research efforts have been focused on securing disaster-related information for the benefit of emergency managers or other researches. Our approach is to use ten variables that can be summarized into a single index; this would give an overall measure of risk for a particular city. In principle these ten variables can then be applied to other cities so a similar risk analysis can be conducted in other areas, and there will thus be a common basis for a comparative risk index. This approach allows a comparison between cities, even when the risk is based on different hazards. For example, one could calculate a relative risk index for Tampa, Florida, and compare it to the risk index for Palo Alto, California; although the potential hazard for the two areas are different. A new home-buyer could then, compare the risk indices of various towns in order to determine the relative risk of living in one town verses another. Obviously, this approach would also have implications for emergency managers, land-use planners, and insurance companies. One of the strengths of using a system's-based approach to measure risk is that it incorporates many societal and cultural factors. Many of the variables identified in the measurement of the risk index can be addressed by local authorities, who may be interested in reducing the region's perceived risk. Emergency managers would gain a certain level of control over how risk is evaluated and perceived for their city, and feel less victimized by the circumstances of their regional geography or a sense of fatalism.

The basic unit of analysis for this is the city, as defined by the political boundaries of those communities in our study area. The variables involved in this study are as follows: (1) disaster history, (2) distribution of special hazard zones, (3) topography, (4) hazardous facility sites, (5) demographics, (6) non-structural mitigation efforts (7) special resources in the area, (8) socio-political dynamics, (9) special administrative districts, and (10) the integration of the planning process. The one element both authors feel is missing in this assessment is a measure of the public's own awareness and knowledge of risk and mitigation behaviors. However, that data was not available at the time of this study. We hope to refine the assessment tool in the future through the development of an interview schedule or survey, and thereby assess the scope of the public's risk awareness, and of their knowledge of appropriate hazardous response behaviors.

Variables:

Disaster History:

Disaster history accounts for those natural disasters that are particular to a certain area. In our case study, which is concerned with the south Houston metropolitan region and Galveston County, the disaster history is rather significant. Galveston Island was the scene of the worst natural disaster in American history. In September of 1900 a major hurricane hit the island, resulting in the death of over six thousand people (Larson, 1990). This was followed years 47 later by the worst technological disaster in American history, which occurred in the port of Texas City. An explosion of a cargo ship carrying Ammonium Nitrate caused a shockwave, which was registered on a Richter Scale as far away a Denver, Colorado. The explosion had the impact of a force equal to that of the Nagasaki bomb (Thomas, 1987). These two events, in particular, have had a large impact on American disaster history; however, they seem to have had little impact on the development of a functional disaster culture in the area (Davenport: 17-18). Disaster cultures tend to develop when there is a cyclical occurrence of a disaster, such as yearly flooding, and when there is advanced warning of an impending disaster that happens in some predictable fashion, such as a typhoon in the summer months (Schneider, 1957). The history surrounding our study area does not have such a predictable disaster history or all the elements that have been identified as requisite for the development of a disaster culture. There has, therefore, been little development of a disaster culture; instead a sense of bravado has emerged, especially among long-time residents, who feel they can withstand anything nature puts forth (Davenport: 20; Larson, 1999).

New migrants to the area, attracted since the 1950's by the expansion of the oil industry and the technological sector of the economy (Rogge, 1996), have had little exposure to extreme storms and therefore seem to be more sensitive to threats of severe weather. However, as migrants settle into the area and experience severe weather, such as tropical storms and mild flooding, they tend to underestimate the power of truly extreme hurricanes and other disasters. This experience has also been confirmed by researchers as Cutter (1993: 25) who states: "Lack of experience tends to amplify the risks until such time as risks are moderated or people have adapted to them." Through interviews with emergency managers, and informal conversations with local residents, the researchers conclude that a combination of these two factors, a sense of bravado and a decreasing sensitivity to severe weather warnings, has led to an overall sense among residents of invulnerability to a disasters; this is in spite of numerous attempts by the media and emergency managers to provide hurricane and tornado information and education each year. The risk factor that gets the least attention by the media and others is technological risk. This risk factor is an ever-present and eminent danger in the area due to the many petrochemical plants in the region and the smaller industries that have built symbiotic relationships with them. This brief overview of the area presents some of the historical event relating to disasters which have affected the region, and gives a framework within which one might develop a greater understanding of the culture in the area.

The area under study has a history of four types of disasters which continue to pose risks to the populations, even if that sense of danger diminishes with time. The risk factors identified for this area are as follows: hurricanes, tornadoes, flooding, and toxic releases. Each type of risk is given a weight of one to provide a score for the first variable in the risk index (see table 1). This table is developed a little differently than the rest. Instead of developing categories for each risk type, we have just listed the various risks that have had a historical presence in the area. For the purpose of this analysis, each risk type is valued equally, though we are aware that some hazards have greater frequent and intensity than others.

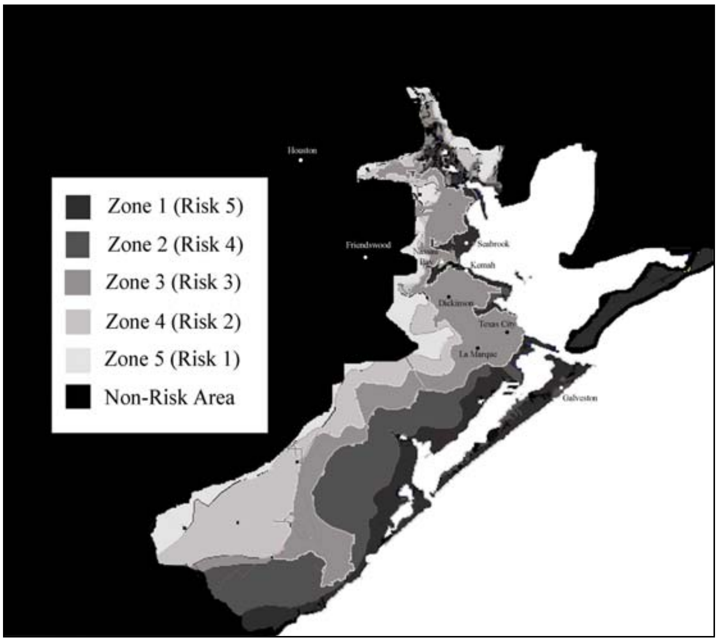
Table 1

COUNTY	CITY	INDEX	Tornado	Hurricanes	Flooding	Hazmat	POP	Total R POP
GALVESTON	Clear Lake Shore	4	1	1	1	1	1,205	1,205
GALVESTON	Dickinson	4	1	1	1	1	17,093	17,093
GALVESTON	Friendswood	4	1	1	1	1	29,037	21,237
GALVESTON	Galveston	4	1	1	1	1	57,247	55,888
GALVESTON	Kemah	4	1	1	1	1	2,330	2,330
GALVESTON	La Marque	4	1	1	1	1	13,682	13,682
GALVESTON	League City	4	1	1	1	1	45,444	38,901
GALVESTON	Texas City	4	1	1	1	1	41,521	41,521
HARRIS	El Largo	4	1	1	1	1	3,075	3,075
HARRIS	Houston	4	1	1	1	1	1,953,631	1,888,476
HARRIS	Nassau Bay	4	1	1	1	1	4,170	4,170
HARRIS	Seabrook	4	1	1	1	1	9,443	9,443
HARRIS	Shoreacres	4	1	1	1	1	1,488	1,488
HARRIS	South Houston	4	1	1	1	1	15,833	15,833
HARRIS	Taylor Lake Village	4	1	1	1	1	3,694	3,694
HARRIS	Webster	4	1	1	1	1	9,083	9,083

Mapping of Special Hazard Zones:

For our second variable, we have employed a GIS mapping system of special hazard zones. The purpose of this variable is to identify different geographical areas that would be associated with a specific natural hazard, such as fault lines, hillsides, or surge zones. In our study area, we are interested primarily in the land areas that are susceptible to surge inundation and ocean winds due to hurricane action. To locate the risk areas in the two counties, we used data developed at the Hazard Reduction and Recovery Center at Texas A&M University. Hurricane risk areas are divided into five categories that correlate to a hurricane's strength. These categories were developed based on topographic characteristics of the area, wind vulnerability and the surge height of a storm. The risk areas delineate the population susceptible to hurricane damage according to the severity of the storm. Areas that are most susceptible would be those that lie along the shoreline or at low elevations and in close proximity to the waterfront. Thus, populations living in area one would be susceptible to surge and wind damage in the event of a category one hurricane, using the Saffir/Simpson scale. As one moves further inland, populations become less vulnerable to wind and surge action from a hurricane. Those areas identified as zone five are the least susceptible to a hurricane and would only be affected by surge inundation and wind damage in the event of a hurricane five (See figure 1).

Figure 1



Since the city is being defined as the basic unit of analysis, we have considered each city and averaged in the hurricane risk for inundation and wind damage. However, in order for the index to have meaning, we must first reverse the level of risk associated with each zone. Thus, zone one would be given a risk rating of five, zone two a risk of four and so forth. Modification was necessary to ensure that all risk indices are on a scale of "1" as the least risk, to "5" as the highest risk. The lower the index number, the lower the risk for any particular category. If a city or part of a city was completely out of the risk zone, it was given a value of "0". We then averaged the risk indices of various zones within each city to achieve an overall risk index for the city. Thus, if a city lies partly within three different risk zones, we multiplied the percentage of the city in each zone and then tallied up the scores to arrive at a special hazard risk value for the city. We did not establish risk zones for tornadoes due to their erratic behavior and movements, and because there is no data to demonstrate any predictable patterns of occurrence, other than what is generally recognized as tornado alley.

Table 2

COUNTY	City	FR_INDEX	FR_TOTAL
GALVESTON	Galveston	5	4.11
GALVESTON	Clear Lake Shore	4	3.63
GALVESTON	Texas City	4	3.22
HARRIS	Shoreacres	4	3.07
HARRIS	Nassau Bay	3	2.92
GALVESTON	La Marque	3	2.25
GALVESTON	Kemah	3	2.21
HARRIS	Seabrook	3	2.17
HARRIS	Taylor Lake Village	2	2.00
HARRIS	El Largo	2	1.98
GALVESTON	Dickinson	2	1.89

GALVESTON	League City	2	1.50
GALVESTON	Friendswood	1	0.15
HARRIS	Houston	1	0.01
HARRIS	Webster	0	0.00

Topography:

The third variable examined is that of topography. The topography of a region can have many different consequences depending on the types of disasters typical to an area. In our case study, we are particularly concerned with topography in relation to a city's susceptibility to flooding. Using GIS modeling, we have taken The Federal Emergency Management Agency (FEMA) flood insurance Q3 data to identify those areas in our study region which are most susceptible to flooding; these correspond to the 100 and 500 year flood plains. We then compared these readings with actual flood data, and found that they closely resembled the available flood records. Due to the close correlation between topography and available flood data, and since only incomplete flood data was available in this region, topography was used directly to assess flood susceptibility. Once the GIS mapping was complete, we were able to take measurements in increments of one meter to determine where the low-lying areas were within a city. The lowest elevations were given a ranking of "5" since they were the most susceptible to flooding, while the highest elevations where ranked as "1" since they least susceptible to flood damage. The areas with elevation heights of 1 to 5 meters are the most vulnerable to flooding, compared to other areas at an elevation of more than 5 meters. The maximum ranking is five meters, or about fifteen feet, which is approximately the average rise in water level within the 100 year flood plain (FEMA National Flood Insurance Program, 1998). To arrive at a risk index for the city, we have determined the percentage of the population which lies within the various flood-risk zones (1-5) and then averaged these together. For example, if one city had a population center that spanned flood zones "5," "3," and "2," we would determine what proportion of the city's population lived in each risk zone and then multiply the risk zone value by the proportion of the population in the particular zone. These products are then added to give a total flood-risk index for the city (see table 3).

Table 3

COUNTY	CITY	INDEX	POP	1 M	2M	3M	4M	5M	TOTAL R POP
GALVESTON	Clear Lake Shore	5.0	1,205	1,205	0	0	0	0	1,205
GALVESTON	Dickinson	3.0	17,093	0	3	16,786	304	0	17,093
GALVESTON	Friendswood_G	0.4	21,237	0	0	0	680	6,379	7,059
GALVESTON	Galveston	4.5	57,247	29,977	27,270	0	0	0	57,247
GALVESTON	Kemah	3.9	2,330	739	551	1,040	0	0	2,330
GALVESTON	League City	2.8	45,444	4,839	2,894	23,895	4,669	9,069	45,366
GALVESTON	Texas City	3.0	41,521	151	344	40,917	82	27	41,521
HARRIS	El Largo	5.0	3,075	3,075	0	0	0	0	3,075
HARRIS	Friendswood_H	0.8	7,800	0	0	0	251	5,876	6,127
HARRIS	Houston	0.0	1,953,631	14	215	4,236	17,789	32,255	54,509
HARRIS	Nassau Bay	4.9	4,170	3,768	369	0	0	0	4,137
HARRIS	Seabrook	5.0	9,443	9,443	0	0	0	0	9,443
HARRIS	Shoreacres	2.7	1,488	0	711	373	0	0	1,084
HARRIS	Taylor Lake Village	4.5	3,694	3,328	0	0	0	0	3,328
HARRIS	Webster	3.2	9083	2,805	2,022	1,061	1,331	1,398	8,617

Hazardous Facility Sites:

The fourth variable is the potential for hazardous material exposure, which correlated with proximity to hazardous faculties. Here we are interested in identifying various industries that use, store, and produce hazardous chemicals or materials. To arrive at this end, we have used the Toxic Release Inventory (TRI) developed and published on the Internet by the U.S. Environmental Protection Agency (EPA) (http://www.epa.gov/tri/). Using GIS mapping, we established the geographical distribution of hazardous facilities, which we then juxtaposed with population centers and special hazard zones. This helped us to identify both the vulnerability of population groups as they relate to potential toxic release sites, and the vulnerability of hazardous facilities themselves to hurricane damage, which would potentially result in a release to hazardous materials. Population density, which is the attribute we used to identify populations centers, is considered the variable that correlates most closely with toxic releases (Rogge, 1996). In stating this, it should be noted that toxic releases in this instance relates to fugitive releases which are do not pertain to normal emissions released through smokestacks, pumps or other mechanisms which are an integral part of daily operations. (Rogge, 1996). Population densities give a measure of urbanization and general levels of development for any particular city. Density can additionally provide a better understanding of risk; the more dispersed a population, the less risk incurred from any single event. Conversely, the more crowded, a population, the more susceptible that population is to a common threat. Population densities were mapped to show geographic dispersion patterns and the relation of concentration centers in respect to other risk factors.

As with the previous variable, we developed a gradation of risk, based on population density and proximity to hazardous substance facilities. We determined what percentage of a city's population could be exposed to a toxic release for each facility based on a half-mile, one-mile, two-mile, three-mile, and four-mile circumference. These proportions were then treated in the same way as was the variable for topography and special hazard zones (see Table 4). This formula, thus, provides an overall risk index for the city based on proximity to hazardous facility sites. However, it should be noted that the dynamics related to toxic releases would be changed considerably if the toxic release occurred as a secondary disaster, for instance, as a consequence of a tornado or hurricane. The proximity of many hazardous facilities to the coastline has raised concerns among researchers because of the susceptibility of these facilities to surge and wind damage. However, the petrochemical industry, which owns most of these facilities, has a powerful presence in the area, and a culture of passive acceptance has prevailed. People are discouraged from speaking-out about these issues or raising voices of alarm.

Table 4

COUNTY	CITY	INDEX	0.5M	1M	2M	3M	4M	POP	Total R POP
GALVESTON	Clear Lake Shore	3.09	0	109	1,096	0	0	1,205	1,205
GALVESTON	Dickinson	1.237	0	0	429	3,198	13,466	17,093	17,093
GALVESTON	Friendswood_G	2.328	0	754	8,004	9,927	2,552	21,237	21,237
GALVESTON	Galveston	2.692	637	2,532	36,484	15,126	1,109	57,247	55,888
GALVESTON	Kemah	2.226	0	0	588	1,681	61	2,330	2,330
GALVESTON	La Marque	3.015	453	2,954	6,617	3,658	0	13,682	13,682
GALVESTON	League City	1.942	3,447	3,673	8,816	6,893	16,072	45,444	38,901
GALVESTON	Texas City	2.917	1,206	8,072	18,492	13,591	160	41,521	41,521
HARRIS	El Largo	3.175	0	538	2,537	0	0	3,075	3,075
HARRIS	Friendswood_H	1.135	0	0	0	1,052	6,748	7,800	7,800
HARRIS	Houston	2.952	253,686	401,978	670,468	316,812	245,532	1,953,631	1,888,476
HARRIS	Nassau Bay	3.749	379	2,364	1,427	0	0	4,170	4,170

HARRIS	Seabrook	3.243	1,011	515	7,671	246	0	9,443	9,443
HARRIS	Shoreacres	3.782	236	691	561	0	0	1,488	1,488
HARRIS	Taylor Lake Village	3.171	0	632	3,062	0	0	3,694	3,694
HARRIS	Webster	2.594	0	0	5,413	3,656	14	9,083	9,083

Demographics:

The next variable incorporates three demographic aspects: household income levels, education, and ethnicity. Since the socioeconomic indicators were not yet released at the time of this report, we used data from the 1990 census (http:// www.census.gov/main/www/cen1990.html), though other demographic data were obtained from the 2000 census (http:// www.census.gov/main/www/cen1990.html). The socioeconomic and ethnic status of the population is an important factor since numerous studies have established an inverse relationship between socioeconomic status and risk (Rogers, 1995). People with a lower-income status stand a higher risk of loss in the event of a natural disaster and they have less ability to recovery after one (Rogers, 1995). Ethnicity is also closely linked with socioeconomic status, but may pose additional complexities not explained solely by education or status differences. The concept of ethnicity refers to “individuals who consider themselves, or are considered by other, to share common characteristics which differentiate them from the other collectivities in a society within which they develop distinct cultural behaviors" (Marshall: 1998, 201). Diversity among ethnic groups can lead to many communication problems based on language differences as well as a lack of shared assumptions and experiences between the ethnic minority and the majority group. Often, these communication differences become critical when dealing with issues of warning and access to institutional aid in the recovery process (Drabek, 1986).

To arrive a measure of risk on these factors, we grouped education into five categories (1) less than high school, (2) high school graduate or equivelant, (3) some college - includes associates degree, (4) a bachelors degree, and (5) a post-graduate degree. In order to do this we combined two of the standard categories used in the US census. The first category of less than High school education or equivelant is two separate categories in the US census data, as is our cagtegory "3". The US census has two different categories for some college (no degree) and associates degree. We combined these categories primarily to stay within the scheme of five that has been set up and provide a sense of consistency to our schema.

Table 5

COUNTY	City	INDEX_TOTAL	EDUCATION	MEDIAN INCOME_HOUSEHOLD	% OF WHITE
GALVESTON	Clear Lake Shore	4	4.53	37,241	0.96
GALVESTON	Dickinson	3	3.85	30,159	0.80
HARRIS	El Largo	4	5.08	58,884	0.99
GALVESTON	Friendswood_G	1	4.49	50,492	0.94
GALVESTON	Galveston	4	3.59	20,825	0.61
GALVESTON	Kemah	3	3.25	26,797	0.91
GALVESTON	La Marque	3	3.37	27,914	0.64
GALVESTON	League City	3	4.35	45,043	0.88
HARRIS	Nassau Bay	4	4.98	50,574	0.94
HARRIS	Seabrook	4	4.41	34,658	0.91
HARRIS	Shoreacres	4	4.45	52,418	0.96
HARRIS	Taylor Lake Village	4	5.27	74,362	0.96
GALVESTON	Texas City	4	3.29	26,144	0.67
HARRIS	Webster	2	4.08	32,377	0.82

Non-structural Mitigation Efforts:

Nonstructural mitigation efforts refers to political and planning efforts within the area which arise in response to a knowledge of risk, but which do not include the construction of a physical structure. In particular, our study considers five different types of nonstructural mitigation efforts: (1) Community education and outreach, (2) the development and enforcement of building codes, (3) land-use planning which takes into account disaster prone areas, (4) the establishment and publication of evacuation routes or other disaster preventative methods, and (5) governmental compliance with special disaster related ordinances. Community education and outreach can include such actions as having current fliers available on disaster education, making presentations in schools, conducting town hall meetings, and delivering news reports about how to behave in the event of a disaster. Development and enforcement of building codes refers to the implementation and enforcement of construction standards, which are implemented in response to the disaster history of the area. This may mean retrofitting buildings for earthquake resistance, raising buildings above a certain elevation, or conforming to other measures as are appropriate to the circumstances of the area. In our case study, structures had to meet the Southern Building Code standards that require a building be constructed such that it will be able to withstand a hurricane three or less on the Saffir/ Simpson scale (Davenport: p.14). Land-use planning relates to specific measures taken to forbid the construction of new homes or other buildings in areas that are known to be vulnerable to destructive forces. Examples of this type of planning could include setting aside frequently flooded riverine coasts as a wetland preserve or declaring beach fronts as public land so people cannot build directly on shorelines. The establishment and publications of evacuation routes or other disaster-preventative methods would include any measures aimed at keeping the public out of harms way. Since we are not capable of adequately predicting all types of disasters with enough lead time to evacuate populations at risk, this aspect of the variable would include such measures as alleviating extra weight on mountainsides prone to avalanches, or the controlled burning of brush to prevent forest fires, and establishing evacuation routes. The last type of mitigation effort addressed is that of governmental compliance with special disaster-related ordinances such a community involvement in FEMA's flood insurance plan, and the development of a disaster plan as mandated by the federal government. The variable of "non-structural mitigation efforts" is different from the variables previously discussed, in-so-far-as it cannot be assessed empirically. It is for this reason that we have defined five categorical subsections which can be using a binary code which indicates whether a certain type of activity exists or not. However, in keeping with the notion of the "lower the variable index, the lower the risk," we have calibrated these ordinal categories by using a score of "1" and "-1". A score of "1" means that the city or community being discussed does NOT have the sub-category discussed, thus, in effect raising the average risk index. Conversely, if the community does have the mitigation efforts, they score a "-1", which in turn lowers the risk index.

Table 6

COUNTY	CITY	INDEX	Out-reach	codes	Land-use	Evac. routes	Ordinances	POP
GALVESTON	Clear Lake Shore	-1	1	-1	1	-1	-1	1,205
GALVESTON	Dickinson	-1	-1	-1	1	-1	1	17,093
GALVESTON	Friendswood_G	-3	-1	-1	1	-1	-1	21,237
GALVESTON	Galveston	-1	-1	-1	1	-1	1	57,247
GALVESTON	Kemah	1	1	-1	1	-1	1	2,330
GALVESTON	La Marque	1	1	-1	1	-1	1	13,682
GALVESTON	League City	-3	-1	-1	1	-1	-1	45,444
GALVESTON	Texas City	-3	-1	-1	1	-1	-1	41,521

HARRIS	El Largo	1	1	-1	1	-1	1	3,075
HARRIS	Friendswood_H	-3	-1	-1	1	-1	-1	7,800
HARRIS	Houston	-1	-1	-1	1	-1	1	1,953,631
HARRIS	Nassau Bay	-3	-1	-1	1	-1	-1	4,170
HARRIS	Seabrook	-3	-1	-1	1	-1	-1	9,443
HARRIS	Shoreacres	-1	1	-1	1	-1	-1	1,488
HARRIS	Taylor Lake Village	-1	-1	-1	1	-1	1	3,694
HARRIS	Webster	1	1	-1	1	-1	1	9,083

Special Resources:

The seventh variable, special resources, refers to entities that have strong vertical ties, which could supersede or substantially augment the planning and recovery process within the city. "Vertical integration helps to expand the resources potentially available to a community" (Berke, et al., 1993). This variable has been assessed through the examination of five distinct types of special resources: (1) large governmental agencies or operations, (2) large multinational companies, (3) large universities or other academic institutions. (4) national or international non-profit institutions, and (5) distinctive local phenomena. Large governmental offices or operations include special governmental entities (such as the Los Alamos National Research Labs, military bases, or as in our case study, the National Aeronautic and Science Administration [NASA]: Johnson Space Center) that could channel additional resources into the area, which would not normally be present in other communities.

Large multinational companies, such as Amoco, Exxon, or Citibank can be an unusually helpful source of support in all phases of disaster response and recovery. Within our study area, there were a few examples of multinational companies whose presence was strongly felt at the local level. One example is Texas City, which has a state-of-the-art emergency operations center that was made possible through the support and financial contributions of Amoco. Multinational companies like these often have a vested interest in helping their local communities prepare for disasters and recover from them quickly. Because of their expansive international network, they can often tap into resources which may not otherwise be available to such a community. These resources can range from expertise in disaster planning and recovery to financial support for various projects. Two other types of institutions that can provide strong vertical ties are large research universities and large national or international non-profit agencies (often referred to as NGO's). In our study area, we had the presence of Texas A&M University, Galveston Campus, and both the Red Cross and Salvation Army. These institutions could be potential sources of assistance through the provision of expertise, supplies, access to networks, and man-power, which reach beyond the access of the affected region.

The last type of potential resource which could be identified as a source of vertical ties is what we refer to as a "distinctive local phenomena". This category includes any feature, natural or man-made, which is unique to the area and is potentially threatened by a disaster or by the recovery process. An example of this is a city that has a special historical attraction such as Roswell, New Mexico, or Mount Rushmore, South Dakota. These are places that have a distinctive identity and history which makes them easily identifiable to the general public, and therefore there is a general expectation to help preserve these "cultural" places. This expectation makes justifying the allocation of funds for disaster planning easier, which would both help protect them from a disaster and recover from one quicker. This variable follows a similar coding system as the previous one, a bi-modal distribution, except that in this instance "-1" is given for each type of special resource the city possesses, and a "0" is assigned if the resource does not exist. Since the lack of a special resource is not seen as a weakness in the risk assessment, the city is not penalized for its absence. These types of resources help lower the risk index for the cities in question.

Table 7

COUNTY	CITY	INDEX	Gov't Agency	Multi-national	Univ.	Non-profit	Local Phenom.	POP
GALVESTON	Clear Lake Shore	-1	-1	0	0	0	0	1,205
GALVESTON	Dickinson	0	0	0	0	0	0	17,093
GALVESTON	Friendswood	0	0	0	0	0	0	29,037
GALVESTON	Galveston	-2	0	0	-1	-1	-1	57,247
GALVESTON	Kemah	-1	0	0	0	0	-1	2,330
GALVESTON	La Marque	-1	0	-1	0	0	0	13,682
GALVESTON	League City	-1	0	0	0	0	-1	45,444
GALVESTON	Texas City	-1	0	-1	0	0	0	41,521
HARRIS	El Largo	0	0	0	0	0	0	3,075
HARRIS	Houston	-4	-1	-1	-1	0	-1	1,953,631
HARRIS	Nassau Bay	-3	-1	-1	0	0	-1	4,170
HARRIS	Seabrook	-1	0	-1	0	0	0	9,443
HARRIS	Shoreacres	0	0	0	0	0	0	1,488
HARRIS	Taylor Lake Village	-1	-1	0	0	0	0	3,694
HARRIS	Webster	-1	-1	0	0	0	0	9,083

Socio-Political Dynamics:

"Socio-Political Dynamics" and the categories of which it comprised, is the most difficult variable to assess. The political practices and the power struggles endemic to all levels of government are not easily assessed. Albeit, power is essential to achieving one's aim, be it for disaster planning or some other issue. In the field interviews with emergency managers, we were able to ascertain some of the political practices and agendas that both hindered and assisted the advancement of disaster planning. However, because of time constraints and the delicacy with which the subject is treated, some assumptions were made based on the evidence that presented itself to the researcher: such as a lack of time and resources for disaster planning, comments alluding to power struggles, or conversely, the show of support by providing emergency managers freedom and funding. The variable of socio-political dynamics was broken down into five categories: (1) grass-root support, (2) political support, (3) political initiative, (4) funding, and (5) institutionalization of the disaster planning process. These categories were scored on a bi-modal system, where a "-1" is a positive indicator of that category and a "1" a negative indicator, showing that a specific activity has not occurred at the city level (see table 8).

The first category, grass-root support refers to the existence of any group that has taken a political stance to advance disaster planning and actively pursues that agenda, either through lobbying efforts, community education, or other activities. In our case study, the Galveston Branch of the League of Women Voters was seeking an issue it could adopt and promote, and which had immediate significance for the community. They realized that disaster planning was not a well-developed practice in Galveston, and that this lack of a planning process could have a detrimental impact. This was a significant issue for the entire county, not just the island, and it was an indisputable weakness in the administrative system. The support and work of these women helped bring disaster planning to the attention of political power holders who where in a position to fund the activity and elevate its importance in the county administrative agenda. Their work has also assured that the next people in posts of power will be aware of issues relating to disaster planning and emergency management.

The second category, political support, relates closely with grass-root support. Political support refers to the idea of emergency managers having the support (e.g. time, funding, and administrative help) to pursue disaster planning from their political superiors, such as mayors, city councils, or county judges, or others. However, since these offices are positions of public service, the superiors are accountable to the public, and if there is someone or some group in that constituency that has identified disaster planning as a need, the allocation of funds for this activity is made easier, in the face of competing agenda items. In our case study, political will was found to support disaster planning, because, in addition to improving preparedness, the planning process also helped bring cohesion to the county, as pointed out by several emergency managers and the League of Women Voters. Emergency management met a need that the entire county required, therefore cities felt a push for disaster planning coming from the county administrative offices, as well as from the grass-root issue promoters. Political support, however, is not a one-dimensional element. There are occurrences when a political superior may support disaster planning, even though s/he does not have the political clout to follow through on that support. In a situation such as this, grass-root support can be essential to the emergency planning process because it provides additional leverage to initiate a disaster planning process.

The third category relates directly to some early writings by Drabek and his colleagues that found "[that] in order for policies to be adopted a key individual or small number of persons with legitimate authority to take action had to be concerned and actively promote the issue" (Mittler, 1989). This notion of issue champions is very similar to the political activity of lobbying, the difference being that issue champions work from within the system to bring about change. Essentially, this category attempts to measure if there is any person or group with political power who is willing to champion the cause of disaster preparedness in light of the many competing issues on any community's agenda, and how well those issue promoters are integrated into the planning process. By keeping concerned citizens involved, one insures that the planning process is maintained.

The fourth category, funding refers to the availability of funds to support the emergency management process. This may be problematic, especially in small communities, where funds are very limited. There may be political will to be involved in a disaster planning process, but not the available funds to fully support such an activity. This appeared to be the case in several of the communities we visited in the Clearlake area. These communities are primarily bedroom communities, and they have little or no business-tax base with which to support an extended disaster planning process. However, because of a well developed disaster planning program on the county level and among the neighboring communities, disaster planning is generally recognized as a necessary process and one everyone appears to openly support, even though the money is not there. Of course, the opposite may also be true. A community may have money allocated to it for disaster planning, but because of a lack of political support or awareness, the money is left unused or diverted to other area.

The last category refers to the institutionalization of the disaster planning process. This has been accomplished to some extent throughout the United States because of a congressional mandate which states that every locality must have a disaster plan, if they want to be eligible for recovery aid, in the event of a disaster. However, as happens with many unfunded or poorly funded mandates, the disaster plan becomes just an item to check-off a list, and the planning process is circumvented. In this instance we were looking for the establishment of a process; one that is not dependent on any particular leader or event. Examples of this type of work could be seen in the development of full-time offices for emergency management at the county levels, in large cities, and at the NASA space center. The interaction between these entities and their surrounding communities helped establish an expectation for disaster planning and assisted in the development of a comprehensive planning process for the entire region.

Table 8

COUNTY	CITY	INDEX	Grassroot	support	initiative	funding	establishment	POP
GALVESTON	Clear Lake Shore	1	1	-1	1	-1	1	1,205
GALVESTON	Dickinson	3	1	1	1	-1	1	17,093
GALVESTON	Friendswood	-1	1	-1	-1	-1	1	29,037
GALVESTON	Galveston	-3	-1	-1	-1	-1	1	57,247
GALVESTON	Kemah	3	1	1	1	-1	1	2,330
GALVESTON	La Marque	3	1	1	1	-1	1	13,682
GALVESTON	League City	-1	1	-1	-1	-1	1	45,444
GALVESTON	Texas City	-3	1	-1	-1	-1	-1	41,521
HARRIS	El Largo	5	1	1	1	1	1	3,075
HARRIS	Houston	-1	1	1	-1	-1	-1	1,953,631
HARRIS	Nassau Bay	1	1	1	-1	1	-1	4,170
HARRIS	Seabrook	3	1	1	-1	1	1	9,443
HARRIS	Shoreacres	5	1	1	1	1	1	1,488
HARRIS	Taylor Lake Village	5	1	1	1	1	1	3,694
HARRIS	Webster	5	1	1	1	1	1	9,083

Special Administrative Districts:

The ninth variable refers to potentially conflicting situations because of an overlap of emergency response jurisdictions in an area. Conflicts can arise in all the various stages of disaster planning (mitigation, planning, response or recovery) because two or more jurisdictions are competing for dominance in a disaster response scenario, or conversely, because there is the assumption that another agency is attending to issues in that jurisdiction. As before, we divided the possible scenarios into five different categories in which jurisdictions could overlap one with the other: (1) governmental authorities, (2) local jurisdictions or authorities, (3) national or regional jurisdictions, (4) volunteer organizations, and (5) private response groups. In our case study we had many examples of these types of overlaps. An overlap of governmental authorities would be found in a situation in which a city may straddle more than one county or state. The city of Friendswood exemplifies this situation in our study area since it lies in three different counties: Harris, Galveston, and Brazoria. This type of overlap has actually led to problems in the past, where one county was declared a disaster area, while the other part of the city was not. This led to frustrations and problems as some residents received federal aid for recovery but others did not, though they had suffered equal losses. This type of situation can happen in places that are administered by different political entities, yet share a common location. Unfortunately the fall out often means that local politicians pay the cost, and the community may lose cohesion, while subsequently delaying the recovery process for the entire community.

The second category in our variable is that of overlapping local jurisdictions. Examples for these types of overlays would probably be most notable in the planning stage of disaster preparedness, as there are many specialized local jurisdictions within a city's reach. Examples of these include municipal utility districts, local emergency planning committees, school districts, and others. To complicate matters further there may be national and regional jurisdictions covering various areas, such as a port authority, Coast Guard, or Ranger Service. In our case-study many of the cities had to interact with various different authorities such as the Coast Guard, that patrolled the ocean front; the Channel Emergency Management Association, which was developed to respond to such incidents as explosions or toxic releases in the ship channel; the Houston Port Authority, which deals with trade and customs issues, and the Marina Patrol that controls the third largest marina area in the USA.

Volunteer organizations and private response groups can also lead to conflicting situations, not only due to overlapping jurisdictions, but also due to overlapping loyalties and role designations. Both volunteer organizations and private corporations often draw on the same sources of man-power within a specific area. Thus, a particular person might work as an engineer Monday through Friday, and as a volunteer firefighter on the weekends. However, if an incident should happen in the plant on a Wednesday, should the person react as an engineer or as a firefighter? These dilemmas can become serious issues when there is a primary employer within a town, and little or no coordination between the employment agency and the volunteer organizations in the area. The problem is also manifested in a calculation of the resources in the area. On our case study, most of the cities had volunteer fire departments, yet the large petro-chemical companies also maintained a professional fire-fighting staff which could assist in any disaster scenario. The problem being that the fire-fighters for the petro-chemical companies where the same men and women who served on the volunteer fire departments. In essence, the human resource for the area was being counted twice, once as part of the private sector, and again as a community fire-fighting force.

This variable is scored very simply, a city gets a score of "1" for each category of jurisdictional overlap that occurs within its immediate area, and a "0" if there are no overlaps (see table 9). In short, we realize that there will always be overlapping jurisdictions of some types that can complicate planning and response efforts in the face of disasters, but many of the potential problems which arise from this situation can be addressed and worked out through our next variable, Planning Integration.

Table 9

COUNTY	CITY	INDEX	Gov't	Local	National/ regional	volunteer	private	POP
GALVESTON	Clear Lake Shore	2	0	1	0	1	0	1,205
GALVESTON	Dickinson	1	0	0	0	1	0	17,093
GALVESTON	Friendswood	3	1	1	0	1	0	21,237
GALVESTON	Galveston	3	0	1	1	1	0	57,247
GALVESTON	Kemah	2	0	0	1	1	0	2,330
GALVESTON	La Marque	2	0	1	0	1	0	13,682
GALVESTON	League City	2	1	0	0	1	0	45,444
GALVESTON	Texas City	3	0	0	1	1	1	41,521
HARRIS	El Largo	1	1	0	0	0	0	3,075
HARRIS	Houston	3	0	1	1	0	1	1,953,631
HARRIS	Nassau Bay	3	0	1	1	1	0	4,170
HARRIS	Seabrook	2	0	0	1	1	0	9,443
HARRIS	Shoreacres	2	1	0	1	0	0	1,488
HARRIS	Taylor Lake Village	1	1	0	0	0	0	3,694
HARRIS	Webster	2	1	0	0	1	0	9,083

Integration of the Planning Process:

Planning integration refers to the development and strengthening of horizontal ties which work towards the eventual goal of disaster preparedness. Berke, Kartez and Wenger (1993) refer to Warren's (1963) definition of horizontal integration as "the structural and functional relations among the community's various social units and subsystems." Berke, et al. (1993) emphasis that " the extent to which a strong vertical integration is beneficial is strongly related to the strength of horizontal relationships. When horizontal relationships are weak, communities are basically powerless, subordinate, and depend on outside forces. " This statement emphasizes how crucial the planning process is, since it is through this process that strong horizontal ties are developed and maintained; within the personal contacts made during the disaster planning process. Planning integrity is divided into five categories, the first four address various community players and the last one refers to the quality of the planning process: (1) non-profit organizations, (2) political or grass-root support groups, (3) special care facilities, (4) neighboring communities, and (5) the practice and rehearsal of the emergency response process. We see planning as being one of the essential phases of disaster preparedness, and a variable that is open to human control.

When examining the planning process, we are focusing on the actual production, maintenance and continuous testing of a disaster plan, not on the final development of a manuscript. In this vain, we are looking at the ongoing development of relationships, education and growth of non-emergency mangers into the disaster-planning process. The first category mentioned is the integration of non-profit organizations. This would include regular meetings or involvement in the planning process of disaster-oriented non-profit groups (non-governmental organizations) in the area. Examples of such groups would be RACES, the Red Cross, Salvation Army, and possibly inter-faith organizations. These groups often take the center stage in the sheltering and recovery process, and should be involved with emergency management teams so that recovery can proceed seamlessly, and the correct type of assistance and information is delivered to the appropriate people.

The second category refers to the integration of grass-root support into the planning process. This integration and continuous nurturing of issue backers is essential to the planning process as it may open doors to other resources and also lets citizens invested in the community stay abreast of emergency management issues. By keeping concerned citizens involved, one insures that the planning process is maintained. Additionally, it helps build a support base that is not dependent on just one person or one moment in time. In our study, on-going political pressure to pursue disaster planning was an essential element in helping to elevate disaster planning to a priority item at the county administrative level.

The third category, special care facilities, assess the level of integration between the emergency management plan of facilities and the city disaster management plan. In particular, such facilities as hospitals, schools, elder-care, prisons; and other places that have an immobile population are the topic of this variable. Coordination with these facilities needs to be included in all phases of disaster planning, from the siting of such institutions, to their evacuation (should the need arise), to their potential use in the response and recovery phase of a disaster. Planning integration with such facilities needs to go beyond having a copy of their emergency plan at the emergency operations center; it needs to include their participation in the planning process. In this way key players will be identified, as will any limitations and available resources. The fourth category, planning integration, is crucial when there is heavy reliance on mutual-aid agreements and/or communities in close proximity to one and other. By working with neighboring communities, emergency managers get to know one and other and what can be expected in times of need. Drabek (1987) identifies this need when he states that one of the most important axioms for emergency managers is their formation and maintenance of interagency relationships.

The fifth and last category is probably one of the most important ones, and the one that brings meaning to the previously mentioned categories. Without practicing and continually updating ones emergency plan, there is no feed-back loop to bring in new information or circumstances into the planning process, nor is their an effective way to evaluate the work that has been done to that point. The practice and rehearsal of disaster planning includes regular meetings with concerned groups and individuals to arrive at a standard of quality that will ensure proper orientation and continuous development of disaster planning, not only for one's own agency, but also for all the various players involved in the mitigation, planning, rescue and recovery phases of a disaster.

Our last variable is scored similarly to the previous ones, though here there are three possible scores. A "-1" is a positive sign, showing that the community has integrated their planning efforts with the various agents in that category. A "0" means that there are no agents in that category, for a particular city. Many of the communities studied in the Clearlake area were bedroom communities and did not have the full array of facilities often found in other places. A score of "1" means that a particular facility exists within that community, but there is not adequate integration of the facility's emergency plans with the city in which it is situated. By using this scoring method, communities without some of the amenities mentioned in the variable will not be penalized for not having an integrated plan, while simultaneously accounting for these amenities in the communities where they do exist (See Table 10).

Table 10

COUNTY	CITY	INDEX	Non-profits	political	Special care	Neighbor	practice	POP
GALVESTON	Clear Lake Shore	1	0	1	0	-1	1	1,205
GALVESTON	Dickinson	-1	0	1	0	-1	-1	17,093
GALVESTON	Friendswood	-3	1	-1	-1	-1	-1	21,237
GALVESTON	Galveston	-5	-1	-1	-1	-1	-1	57,247
GALVESTON	Kemah	1	0	1	0	-1	1	2,330
GALVESTON	La Marque	-3	0	-1	0	-1	-1	13,682
GALVESTON	League City	-4	0	-1	-1	-1	-1	45,444
GALVESTON	Texas City	-4	-1	-1	0	-1	-1	41,521
HARRIS	El Largo	1	0	1	0	-1	1	3,075
HARRIS	Houston	-1	1	-1	1	-1	-1	1,953,631
HARRIS	Nassau Bay	-4	0	-1	-1	-1	-1	4,170
HARRIS	Seabrook	-3	0	-1	0	-1	-1	9,443
HARRIS	Shoreacres	1	0	1	0	-1	1	1,488
HARRIS	Taylor Lake Village	-3	0	-1	0	-1	-1	3,694
HARRIS	Webster	-3	0	-1	0	-1	-1	9,083

Conclusion:

The approach to risk analysis set forth in this paper is an attempt to provide an inclusive assessment of risk for a city which incorporates many aspects of disaster planning. In doing so it sets a framework that incorporates geographical, industrial, social, cultural, and demographic features into the planning process. However, many nuances and details are glossed over while arriving at the risk index. The aim of this index is not to provide a detailed assessment of risk for any individual, but instead to allow those individuals who are concerned about disaster risk to quickly compare the relative risk in their area, with others. If further information is required, one can then ask for greater details on how the risk index was obtained. Additionally, an aspect that is appealing about this method of analysis is that scores on many of the variable can be addressed through a comprehensive planning process. This risk analysis index can then be used by many different groups to advance disaster planning and increase awareness of emergency management issues. Among the different potential uses of this risk assessment are its use by emergency mangers in their attempts to lobby for greater support of the disaster planning process; city councils can attempt to promote their cities with it (if they have a good rating), and insurance companies can give additional credits to cites that rate well on the index.

In conclusion, we are providing a risk comparison of the various cities within the Clearlake region (see table 11). To arrive at the final risk index, we calculated the sum of the indices for all variables and then divided by ten, to reach a mean index for each city studied. As we stated earlier, this is not a comprehensive detailed analysis of risk for each city, but is instead an attempt to take into account the relationship between human organizations and environmental factors as they relate to disaster risk.

Table 11

CITY	MEAN INDEX	VAR.1	VAR.2	VAR.3	VAR.4	VAR.5	VAR.6	VAR.7	VAR.8	VAR.9	VAR.10	POP
Clear Lake Shore	2.21	4	4	5.0	3.09	4	-1	-1	1	2	1	1,205
Dickinson	1.52	4	2	3.0	1.237	3	-1	0	3	1	-1	17,093
Friendswood	.43	4	1	0.6	1.732	1	-3	0	-1	3	-3	21,237
Galveston	1.22	4	5	4.5	2.692	4	-1	-2	-3	3	-5	57,247
Kemah	2.21	4	3	3.9	2.226	3	1	-1	3	2	1	2,330
La Marque	1.78	4	3	2.8	3.015	3	1	-1	3	2	-3	13,682
League City	.69	4	2	3.0	1.942	3	-3	-1	-1	2	-4	45,444
Texas City	.99	4	4	3.0	2.917	4	-3	-1	-3	3	-4	41,521
El Largo	2.62	4	2	5.0	3.175	4	1	0	5	1	1	3,075
Houston	.79	4	1	0.0	2.952	4	-1	-4	-1	3	-1	1,953,631
Nassau Bay	1.37	4	3	4.9	3.749	4	-3	-3	1	3	-4	4,170
Seabrook	1.72	4	3	5.0	3.243	4	-3	-1	3	2	-3	9,443
Shoreacres	2.55	4	4	2.7	3.782	4	-1	0	5	2	1	1,488
Taylor Lake Village	1.87	4	2	4.5	3.171	4	-1	-1	5	1	-3	3,694
Webster	1.58	4	0	3.2	2.594	2	1	-1	5	2	-3	9,083

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Kim Galindo was born in Houston, Texas in July of 1965, but raised in Bolivia, South America. She moved back to Texas with her parents in the mid seventies. Kim has extensive experience in international travel and development issues since she spent much of her life visiting family and friends in Europe and South America. She has lived briefly in France, and Denmark and for extended periods in the United States and Bolivia. She received her B.S. in Sociology and a B.A. in Modern Languages from the University of Texas A&M in College Station. Her masters degree was conferred to her from the University of Texas in Austin in 1993, from the department of Social Work, with an emphasis on administration and planning. She is presently working on her Ph.D. in Urban and Regional Sciences, at the University of Texas A&M, College Station,. During the summer of 2000, she interned at NASA, Johnson Space Center in Houston, Texas to help them assess the planning process of the communities in the area. Currently, she is working on her dissertation which examines the recovery process and organizational development of local non-profits in a rural, Texas community following a flood. Her interests are in disaster recovery issues and how culture impacts the disaster recovery and planning process.

THE SYSTEMS APPROACH IMPLEMENTATION IN EMERGENCY MANAGEMENT FOR FLOODS, TRANSPORT AND TERRORISM PROBLEMS[1]

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Keywords: Decision support systems, emergency situations, Web based, system approach.

Abstract

Technology of using of the systems approach is considered in relation to emergency management processes. The systems approach is concluded in complex analysis of emergency situations, with provision for technical, physical, psychological and social-economic factors. The possibilities of the systems approach are analyzed for decision support with provision for all factors.

The specific feature of the proposed technologies is an interdisciplinary approach to development of intellectual decision support systems, providing efficient methods for exhibits in the field of emergency management problems, which are characterized by greater volume of analyzed information, bad formalized procedure decision making and difficulty in the use of traditional methods of the multi-criteria optimization.

The discussed problems cannot be solved without the use of methods of artificial intelligence and integrations of GIS, mathematical modeling and DSS [1]. The systems approach usage allows development of methods for integer of the class of the uniform problems in emergency management.

A suggested methodology is considered in an example of emergency management, in such situations as floods problems, transport emergency situations, including terrorism accidents and others.

Introduction

Urgency of the problem, regrettably, does not cause doubts. The emergency situations caused by natural and anthropogenous reasons, including terrorism, become ordinary in our lives. The typical particularity of the studies presented in this report is a system approach to consider the problem, under which is researched a whole cycle information handling, from input flow to finishing decision making. The last achievements of the informatics, including development of knowledge based systems (the artificial intelligence systems, expert systems) and decision making computer methods, have set the problem making the systems. Thus allowing redution in the consequences of

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[1] The research of this paper was carried out under support of the Russian Foundation for Basic Research (Grant N 00-01-00534)

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miscellaneous sorts of emergency situations, and integration of the experience of decision making, management and undertaking action in emergency situations.

This paper considers methods of decision making system development, founded on knowledge for use in emergency situations. Specific proposed methodologies are concluded in a multidisciplinary approach to the creation of an intellectual decision support system [2], allowing efficient methods for exhibits in the field of emergency management, characterized by greater volume of analyzed information, poor formalized procedure of the inference for decision making and difficulty in the use of traditional multucriterial methods to optimization. The emergency situations which have recently created the most problems, including terrorism, high water and floods, require the development of existing methods of decision making and management [3-4].

Considered in the report is a methodology that can be considered as a continuation effort on system integration of the computer products and verbal methods on new modern level. The methods have an importance to system integration, which will allow uniting the efforts between the developers of different systems. On-persisting efficient systems appear then, when there is a possibility for integration of decision appearing problems of the subsystem created in miscellaneous time, different specialists on different programme bases. In this case the systems are founded on the knowledge of the various people and different scientific disciplines. Herewith, as a result of using the system approach, appears the multidisciplinary knowledge [5-6], and the same as in the traditional scientific world, appears the problem of the general use of different languages of descriptions, differing methods of the decision of the problems etc. [7].

The Group, which includes the author, has a significant length of service in the area of informatics, in accordance with decision making, processing the greater volumes to bad outline information, methods of making the intellectual information systems, and study of the processes of the natural ambience. They were designed row of the applied systems in this area. The problem is considered of integrations of different aspect of buildings decision support systems in row of the application domains.

The methods have great importance to system integration, which allow uniting the efforts of different system developers [8-9]. On-persisting efficient systems appear then, when there is a possibility to integrate decision appearing problems of the subsystem created in miscellaneous time, different specialists in the field of informatics, decision-making, hydrology, economy, social sciences, and transport, on different programmed bases. In this case the systems are founded on the knowledge of the various people and different scientific discipline. Herewith as a result of using the system approach, appear the междисциплинарные of the knowledge, and in the same way as in traditional scientific world appears the problem of the general use of the different languages of the descriptions, different methods of the decision of the problems etc.

Modern information technology and decision making in emergency situations

Management in emergency situations and methods of decision making has recently become a much more fruitful area of exhibit of the modern methods of informatics [11]. The actual problem is an integration of the facilities telecommunication, founded on knowledge (the artificial intelligence) and computer methods of support decision making (Decision Support Systems - DSS). The system approach to making identical methods of the decision of the problems, choice corresponding to technical facilities and organizing decisions allow hope for a qualitative jump result in this area [12].

On this background by exception is a scientific problem "Decision making in exceeding situations". This area is solely fruitful for using the complex of the modern methods of informatics and, primarily, methods of artificial intelligence. There are many events when it is necessary to come to a conclusion in a short time period (from several minutes to several days). This range of time, makes it difficult, and sometimes impossible, to invite the consultant, collect the specialist, conduct the consultation or council-boards and etc. In this case, it happens to rely upon opinion of the computer, though this is sometimes fraught with unpredictable consequences. It should be emphasized that in these situations (and in many others too) computer systems decision making is not wanted by choice, but becomes the necessary variant in decision making in conditions limited by resources.

In the opinion of authors, the system approach to a given problem means the analysis of all aspects of the considered problem, продумывание and modeling of the full technological cycle of information handling, commencing from entering and receptions to information before decision making. The Main idea is concluded in agglomeration of the knowledge in computer form knowledgebase, thus allowing their use for decision-making.

We shall consider that there exists a certain application domain, in which knowledge (in the manner of recommended decisions and the sequences action) is accumulated on the basis of consideration of emergency situations of a certain frequency. Industrial damages pertain to such situations, and natural disasters (the high water, tsunami, earthquakes). In this case the frequency of the event was not so great as was a real possibility to train and drill the personnel and persons responsible for decision-making, but consequences non-optimal decisions can be significant.

For considered problems telecommunication possibilities systems, founded on knowledge, are a principle component, since significant time can be needed for accumulation of the knowledge about action in free-lance situations on each object. However, the class uniform object exists, for instance enterprises of the certain type, seaports, populated points in places, subject to high water, and etc. In this case, it is necessary to provide the integration of the knowledge about uniform emergency situations on space portioned object of one type. One possible method of reaching a decision for this problem is the creation of a computer network for spreading knowledge on the uniform object, obtained as a result of a posteriori analysis action (or inaction) in free-lance situation. This network can work in mode "on--line'" or "off-line", be organized as uniform or hierarchical, can be in the manner of stars with analytical center and etc. This depends on the concrete sphere of exhibit, but it is important to simplify and accelerate "exchange by experience" between uniform objects.

Categorization of the functional features object management with standpoint of the formalizations of the processes of acquisition of the knowledge.

For development of technologies of acquisition and issues of the knowledge about action in free-lance situations, it is necessary to produce the categorization a knowledgebase. The Knowledgebase can be divided into the following categories:
- universal, referring to all considered areas, objects and situations;
- problem-solving, which pertains to given class objects and problem-solving situations;
- specific, which are bound concretely with data by object and particularity of its operation.

Herewith-universal knowledge is circulated on all, object, using considered methodology or is found in a certain central node. This depends on accepted computer technology. The Problem-solving knowledge, in the manner of corresponding to a knowledgebase, is circulated on an object of one class. The Specific knowledge, therefore, is only one object in the computer.

The General can be knowledge about social-economic law, principle of the spreading of contamination, or another disaster. In ditto time this "knowledge", referred to as a fixed object, is a quotient. The same situation with knowledge, under discussion knowledgebase, are structurized in the form of the info logical models. Accordingly, models can be universal, problem solving and specific. In the structure of each models, there are also included simulation and other computing models, in the manner of computing procedures.

In general type, knowledge, including models, can be presented as quadruplets of the type:

M=<S,R,I,K>

Where:
S - a base of the simulation models;
R - a base of the rule-oriented rules, which is renewed as a result of analysis decision making in emergency situation;
I - an information base;
K - a base of the general knowledge.

After emergency situations have occurred, it is necessary to produce analysis of decisions taken and not taken, their consequence, production of the rules and writing the optimum decisions in the base of the rule-oriented rules, accordingly global or local (universal, problem-solving or specific). For shaping the rules base it is necessary to have participation of a knowledge engineer, though in most cases it is enough to have a specialized program of the extraction of the knowledge.

Data mining technology usage in emergency management

The key factor in emergency management is an operative taking of efficient decisions. However natural is the longing to improve the process of decision making, it quite often comes across on enormous volume and complex structure data, requiring processing in emergency situations.

Practically, the database executes the function to memories, access of the user to vault data provides only an extraction of a small part from prelimanary stored information in response to clearly assigned questions. Yet, when we have an enormous flow of information, we will get up the task greatly reasonable to use this information to extract hidden data knowledge for the reason to optimize control of the process of emergency management. This task cannot be solved by the power of only one person on the strength of gigantic volume of given economic inefficacy of such a decision. Besides, analyst results are not alwarys objective since people follow some considerations, a priori beliefs about the study subject that are reflected on the objectivity of results.

The methods of “data mining” allow a reduction of this problem. Using promoted analytical methods in the field of mining the knowledge from source, "damp" data, many organizations have increased profits, raised power, lessened expenses and enlarged client base. The methods already are actively used at analysis market, marketing, forecast of the stock quoting and other business-applications. But in the first place these methods today must interest the commercial enterprises, unfolding projects on base information vault given (Data Warehousing).

The correlations of the volume and speeds define the possible use of the artificial intelligence systems KDD (Knowledge Discovery in Databases) - a system of the extraction of the knowledge from database.

Using the systems KDD requires the known art of the director of the exploratory tasks since their decision must ultimately match logic with his intuitive analysis. The Key to successful using of the methods of KDD involves not only the choice of one or several algorithms KDD, but also the skill of the analyst. Data Mining does not exclude the need for the knowledge of specifics of the application domain and understanding of data or analytical methods.

Knowledge discovery in databases is an analytical process of the study of the large volume of information with attraction of the facilities of the automatic study given for the reason finding hidden in structure data or dependencies. It is expected to obtain full or partial absence of the a priori beliefs about nature of the hidden structures and dependencies. KDD includes the preliminary comprehension and incomplete wording of the task (in term target variable), transformation given to available automated analysis format and their preprocessing, finding the facility of automatic study given (data mining) hidden structures or dependencies, approbation of the discovered models on new, not used for building of the models data and interpreting the person of the discovered models.

Data mining ("development given") - a study and finding "machine" (algorithm, facility of the artificial intelligence) in damp given hidden structures or dependencies, which
- earlier were not known,
- not trivial,
- practically useful,
- available to interpreting the person.

As a whole technology, data mining is defined by Gregory Piateckiy-Shapiro - one of the founders of this direction: data mining - a process of the finding in damp given earlier unknown, нетривиальных, practically useful and available interpreting the knowledge required for decision making in different spheres of human activity Any cognition presents itself for modeling. The Model - artificially created system, in which is reflected resemblance of the structure and functions with system-original. Exist two types of the models: предсказательные and descriptive. The First one set given with the known result for building of the models, which obviously predicts the results for the other set data, but the second describes the dependencies in existing data. The revealed model will not be able to pretend on absolute knowledge, but will give the analyst certain advantages to alternative statistical significant model.

The task of the model building can be divided into two important subranges. First, the task to categorize - referring the new object to some class from their ensemble on base already available, given about the other object of these classes. The other subrange form the tasks of the forecast of some unceasing numeric parameter.

Case study 1. An emergency management in flood hazards.

Recently in Russia and all over the world, there have been sharply increased losses from different disasters, in particular from high water and floods such as on river Lena and in other Russian regions. This report considers the possibility of the use of the achievements of scientific and other organization on basis of the system approach, mathematical modeling (including economic and social aspects), and integrations of other scientific and engineering decisions, could greatly reduce the losses from, or prevent, these disasterst. Amongst the organizations whose results are used in the development of the project are: The Institutes to Russian Academy of Sciences - Institute for system analysis, Institute of the water problems, Computing center, Institute of the problems of management, VNIIGMI-MCD of Rosgidromet, Faculty on surrounding ambience of the University Waterloo in Ontario (Canada) and Exploratory Center on floods in Great Britain (Flood Hazard Research Centre, Middlesex, UK).

The existing system of the measures and decision making appear, on glance of the authors, to suffer from the absence of systems approach, insufficient scientific investigations, lack of the different factors accounted, and not taking into account social-economic aspects.

Floods are one of the most serious natural disasters, and annually are occurring in many countries of the world. In spite of all undertaken preventive measures they are vastly overtaking, in terms of victims and material damage, such disastrous phenomena as earthquakes. In the year 1999 for example:
- of the total number of 130 large natural disasters (including earthquakes, storms, droughts and etc) that occurred this year, nearly half - 60 - were for floods;
- victims (perished) of floods (55360) far overtake earthquakes (24964);

- in terms of number of disasters, floods (60) are closely approached by only storms (47)

The countries most subject to floods are situated basically in southeast Asia (India, Indonesia, Philippines, China, Bangladesh, Nepal), and then in Latin America (Venezuela, Columbia, Peru), from they vastly lag behind the Africa (Sudan, is Extinguished).

From European countries, floods most often in Switzerland, Germany (Bavaria), and Austria. The number of victims in these countries is small, but material damage is compensated by a developed system of insurance.

The main reasons of the floods in most cases are driving rains, sea waves, sometimes destructions or breakout of the dams. The Floods basically strike the developing countries that are explained not only by their geographical position (the regions rainstorm, location territory at a rate of epidemic deaths and etc), but also their heavy economic position, preventing separation of the significant funding on undertaking corresponding preventive work.

Last year, for the first time, question about floods turned out to be in the public eye in the entire country. This is explained by not only the scale of the disasters, but also by statements of the president of the country and EMERCOM minister, and the lack of well-timed and necessary measures on protection of large populated points, in particular in some regions of Siberia from - follows specifically to emphasize - from annually reiterative large floods (before this let and smaller scale). As is well known, warning of exceeding situation or disaster dispenses usually are cheaper than removal of their negative consequence. What can be said about effieciency in cases such as the building of the defensive sandy dams, when flooding has already exceeded critical mark and a thousand of the constructions turned out to be under water?

Meantime, corresponding to models of possible disasters, scale and negative consequence for concrete river pool could greatly relieve the development of scientifically motivated systems of efficient action and buildings while avoiding dangerous disasters, that in any event greatly reduce costs, which this year practically carried the whole country.

The system approach is offered to planning and control water resource pool of the rivers: system hydrodynamic models of the processes - currents of water, spreading the contamination, economic - an accommodations production, co-ordinations interest branches, developments fish population, production to electric powers expert estimation restrictions of the depths for navigation. The simulation system calculation of the controller rules is considered in purpose of the rational satisfaction request water customers.

Case study 2. A Terrorism Crisis Management in Transport.

One of the very important problems for emergency management is to increase the capacity of their communities to survive and recover from terrorist attacks by building an enlarged set of risk-management decision support tools and procedures for standardized evaluation and mitigation of the consequences of a terrorist attack on critical transportation infrastructure. The project will emphasize (1) the use of a Geographic Information System to create a notional port city with air, rail and marine transportation facilities and demonstrate the notional relative proximity of critical infrastructure, (2) identification of hazard simulation and modeling tools to both superimpose damage footprints across critical infrastructure and demonstrate potential consequences to the community, and (3) demonstration and econometric model evaluation of alternative mitigation and causal chain intervention strategies that are proposed by various economies. To facilitate collaboration among a maximum number of economies, high bandwidth video teleconferencing with streaming video will be used to minimize transportation costs of participants and mutually demonstrate web-accessible mapping, simulation and modeling techniques currently used by various economies.

The task is to assemble a web-accessible toolbox of hazard models and decision support simulations with use of GIS notional port communities with critical infrastructure and cross-linked hazards.

It is very important to develop econometric models that can be used as decision-support tools in evaluating the relative merit of alternative strategies of mitigation, response and recovery from various types of terrorist attacks.

The next feature for this case study is collaboration over a high-bandwidth video-teleconference system.

As an overall objective, analysis tools and procedures would be exportable and adaptable for mutual use by any individual economy in assessing their own economy's vulnerabilities, conducting their own terrorist attack consequence mitigation program and increasing the abilities of their own communities to survive and recover from terrorist attacks. A list would also be compiled of sources for GIS hazard mapping products and video-telecommunication sites among the various economies, encouraging mutual assistance and continued collaboration.

Conclusion

In the report the part of problems arising at practical mining, tracking, actualization and usage of the information from computer intelligence systems is affected. Behind frameworks of a material there were a number of other problems, such as a filtration of input information, principles and methods of activity with the inexact information, interaction of the initial and aggregated information. The statement of these problems is connected, first of all, to practical activity with intelligence systems. Many from these problems arise from concrete experience and hardly can be put beforehand. The solution of these problems is very important and allows to be advanced to successful usage of intelligence systems for decision-making in composite situations.

As display researches put within the framework of creation universal EMS a problem, have not the shelf solutions on the majority of the considered problems. The existing methodologies of designing and creation of the integrated intelligence systems are calculated on much more formalized objects, which are not unique and envision duplicating.

Conclusion about necessity of constant methodological tracking of development of the project, acceptance both implementation of the "soft" solutions and floppy approaches from here follows, which will allow to acceptance of new technological and system solutions appearing during existence of the project.

For usage of extended possibilities of data management systems, means of the analysis and submission of the information, inclusion in program systems of the statistical analysis, classification and recognition, methods of an artificial intelligence for the analysis and interpretation of results of processing is necessary. There is basis to expect that the further development of geo information systems will occur just in this direction.

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UNDERSTANDING AND CONTROLLING CASCADING FAILURE: A SYSTEMS APPROACH TO MULTI-HAZARD MITIGATION

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Keywords: hazard mitigation, infrastructure protection, building security, risk management

Abstract

Civil infrastructures (including buildings) are vital elements of a nation's economy and quality of life. They represent a massive capital investment, and, at the same time, are an economic engine of enormous power. Modern economies rely on the ability to move goods, people, and information safely and reliably. Consequently, it is of the utmost importance to government, business, and the public at-large that the flow of services provided by a nation's infrastructure continues unimpeded in the face of a broad range of natural and manmade hazards. The built environment must be designed to resist a formidable array of natural and man-made hazards over its lifetime. In the natural realm, earthquakes, extreme winds, floods, snow and ice, volcanic activity, landslides, tsunamis, and wildfires all pose some degree of risk to infrastructure systems. To this list of natural hazards, we must add terrorist acts, errors in design, construction, or operation, excessively prolonged service lives of materials and components, and inadequate maintenance. In a continuous search for increased efficiency, our way of life has become dependent on tightly coupled, highly sophisticated networks of transportation, electric power, and telecommunications systems from which essentially all redundancy has been removed. These systems become vulnerable to failure simply through their inherent complexity—and although failure may be predictable—its mode and mechanisms are not. The terrorist attacks of September 11 provided ample and horrific evidence of a previously unimaginable complex system failure. The seemingly unrelated issues of passenger throughput and airport security were critical in producing the most devastating structural failure in history. Therefore, from a comprehensive hazard mitigation standpoint, it is always necessary to look beyond the first-order effects of an event and instead seek to understand the perturbed behaviors of a complex, "system of systems". Making these systems inherently safer will require more than just improved engineering and technology. Complex systems also have a critical human component that needs to be integrated into design and operational procedures.

Introduction

Civil infrastructures (including buildings) are vital elements of a nation's economy and quality of life. They represent a massive capital investment, and, at the same time, are an economic engine of enormous power. Modern economies rely on the ability to move goods, people, and information safely and reliably. Consequently, it is of the utmost importance to government, business, and the

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public at-large that the flow of services provided by a nation's infrastructure continues unimpeded in the face of a broad range of natural and manmade hazards.

This linkage between systems and services is critical to any discussion of infrastructure. Although it may be the hardware (i.e., the highways, pipes, transmission lines, communication satellites, and network servers) that initially focuses discussions of infrastructure, it is actually the services that these systems provide that are of real value to the public (Little, 1999). Therefore, high among the concerns in protecting these systems from harm is ensuring the continuity (or at least the rapid restoration) of service.

Causes and Consequences of Infrastructure Failure

The built environment must be designed to resist a formidable array of natural and man-made hazards over its lifetime. In the natural realm, earthquakes, extreme winds, floods, snow and ice, volcanic activity, landslides, tsunamis, and wildfires all pose some degree of risk to infrastructure systems. To this list of natural hazards, we must add terrorist acts, errors in design, construction, or operation, excessively prolonged service lives of materials and components, and inadequate maintenance. Although our knowledge of how and why these systems fail has improved, and engineering approaches to design infrastructure systems to withstand natural hazards have been developed, crippling failures continue to occur (Mileti, 1999).

The consequences of infrastructure failure can range from the benign to the catastrophic. For example, whereas a power outage or water main break may be cause for only minor annoyance, a street closure due to the formation of a sinkhole may cause major disruption. If the same sinkhole were to cause simultaneous failures in the water and natural gas systems, and resultant fires could not be fought effectively due to inadequate water supply or pressure, possible loss of life and property damage could far exceed expectations from the initial cause. For example, the B-25 airplane that struck the Empire State Building in 1945 caused relatively minor structural damage and little loss of life and was the genesis of the design scenario of a Boeing 707 striking one of the World Trade Center towers (Robertson, 2002). However, the actual attacks on the World Trade Center on September 11 precipitated total structural failure and were truly cataclysmic in both the extent of the physical damage and the number of casualties.

Although hazard mitigation has moved beyond purely life safety issues, the protection of lifeline infrastructures has generally focused on first order effects—designing systems to resist the loads imparted by extreme natural events, and more recently, malevolent acts such as sabotage and terrorism. However, as these systems become increasingly complex and interdependent, hazard mitigation must also be concerned with secondary and tertiary effects.

Interdependent Infrastructures

Mitigating damage to infrastructure and ensuring continuity of service is complicated by the interdependent nature of these systems. For example, although the interdependence of many systems is straightforward (e.g., the role played by electric power in providing other services is obvious), the interdependencies of other systems are no less real if not as visible.

Interdependent effects occur when an infrastructure disruption spreads beyond itself to cause appreciable impact on other infrastructures, which in turn cause more effects on still other infrastructures. When an infrastructure system suffers an outage, it is often possible to estimate the impact of that outage on service delivery. These are the "directly dependent effects" of the outage. However, that outage may also diminish the ability of other infrastructures, through no malfunction of their own, to deliver the level of services that they normally provide. These indirect effects make up a first-order interdependent effect.

The impact of the outage may not stop at these first-order effects. They may go on to adversely affect still other critical infrastructure components, including even the infrastructure that was the original source of the problem, further aggravating the situation. These effects become second-order effects, which can propagate still further, causing yet another round of effects. How far these effects propagate, and how serious they become, depends on how tightly coupled the infrastructure components are, how potent the effects are, and whether or not countermeasures such as redundant capacity are in place. Either the outage effects will die out as they move further away from the base outage, limiting overall damage, or they will gather force in successively stronger waves of cascading effects until part or all of the infrastructure network breaks down. In the latter case, losing a key component creates a much broader failure that is out of proportion to the original failure. Infrastructure failures may be broadly described in three categories:

- Cascading failure – a disruption in one infrastructure causes a disruption in a second infrastructure
- Escalating failure – a disruption in one infrastructure exacerbates an independent disruption of a second infrastructure (e.g., the time for recovery or restoration of an infrastructure increases because another infrastructure is not available)
- Common cause failure – a disruption of two or more infrastructures at the same time because of a common cause (e.g., natural disaster, right-of-way corridor)

The interdependency problem is further compounded by the extensive linkage of physical infrastructure with information technology systems. Communication and information technologies are already affecting infrastructure system design, construction, maintenance, operations, and control and more change appears inevitable. Potential applications include coupled sensing, monitoring, and management systems, distributed and remote wireless control devices, Internet-based data systems, and multimedia information systems. Although the coupling of physical infrastructure with information technology promises improved reliability and efficiency at reduced cost, there is surprisingly little known about the behavior of these coupled systems and thus, their potential for cataclysmic failure is high.

Although long recognized as a serious concern, the issue of infrastructure interdependency has only recently begun to receive serious attention. The potential for failures in one infrastructure system to cause disruptions in others that could ultimately cascade to still other systems with unanticipated consequences is very real. In truth, beyond a certain rudimentary level, the linkages between infrastructures, their interdependencies, and possible failure mechanisms are not well understood.

Closely Coupled Complex Systems

In his book, *Normal Accidents* (Perrow, 1999a), Charles Perrow described numerous failures of tightly coupled, complex systems.[2] In our search for speed, volume, efficiency, and the ability to operate in hostile environments, he maintains that we have neglected the kind of system designs that provide reliability and security (Perrow, 1999b). A particularly troubling characteristic of these tightly-coupled, complex systems is that although failure is predictable the mode is not (in other words, they will predictably fail but in unpredictable ways). Similar chains of events do not always produce the same phenomena, but system level or "normal" accidents of major consequence continuously recur.

The catastrophic system failures that Perrow calls normal accidents cannot be dismissed as statistical anomalies—unique intersections of random events—but rather as the expected behavior

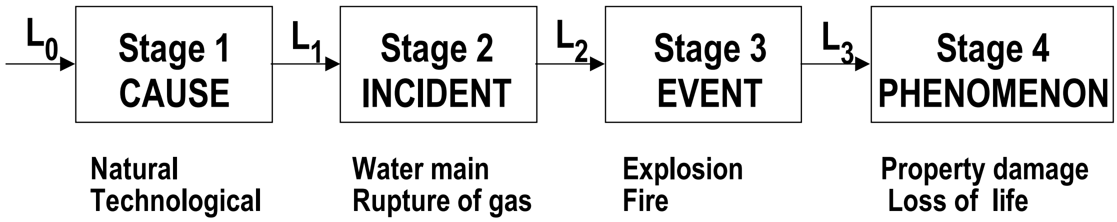
[2] These occur where the systems involved are sufficiently complex to allow unexpected interactions of failures to occur such that safety systems are defeated, and sufficiently tightly coupled to allow a cascade of increasingly serious failures ending in disaster.

of closely-coupled, complex systems. This supports a discomforting premise that although it may not be possible to predict the precise nature of the next Chernobyl, Bhopal, or major terrorist attack, a system failure of a similar cascading nature is destined to occur if we continue to rely on the types of critical-state systems underlying these disasters.

Understanding Interdependency

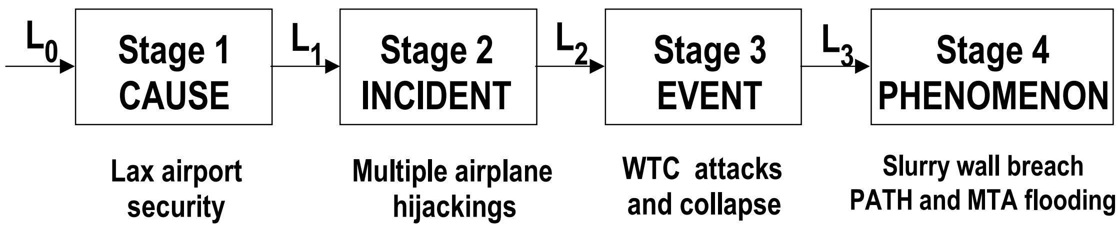
Baisuck and Wallace have developed a probabilistic model to analyze marine accidents (Baisuck and Wallace, 1979) and the multi-ordered implications of infrastructure failure can be generalized using a similar approach. As depicted in Figure 1, the first stage, or CAUSE, could be a natural hazard such as an earthquake or a technological hazard such as equipment or material failure. This is followed by the INCIDENT, in the examples above, the actual failure of the infrastructure with loss of water pressure and venting of natural gas. Stage 3, the EVENT, would be the resultant fires leading to Stage 4 PHENOMENON with property damage and loss of life.

Figure 1: A model for depicting the linked relationships between hazards and their ultimate outcomes (after Baisuck and Wallace, 1979).



Each stage in the process link is connected to the preceding and following stages by a probabilistic function based on the frequency of occurrence for any two linked stages. Thus, gas line ruptures in certain soil types (INCIDENT) can be linked to earthquakes of a certain magnitude (CAUSE) by obtaining the frequency with which gas line ruptures occurred as a result of an earthquake. If sufficient data exist, similar probabilistic analyses can be carried through the entire chain of events. A potential, but fortunately unrealized, outcome of the events of September 11 was the possible flooding and subsequent disruption of a large portion of New York's underground commuter rail system on which the City depends so heavily. Tamaro has described the damage to the slurry wall or "bathtub" that surrounded the deep basements of the World Trade Center and the extent of flooding (Tamaro, 2002). Had the slurry wall been extensively breached, it is possible that water from the Hudson River could have entered the MTA tunnels, flooded the system as far north as 34th Street, and subsequently spilled over to flood other parts of the system through their interconnected tunnels. Figure 2 is a useful logic model for depicting how a breakdown in one infrastructure system (passenger air travel) could have had unforeseen and devastating (but fortunately, unrealized) consequences for another (urban transit).

Figure 2: Logic model of an unrealized outcome of the events of September 11



The Human Element

Three Mile Island and Chernobyl provide useful case studies for understanding how systems might be designed to lessen the frequency and impact of cascading failures. In both cases, it was the intersection of concurrent failures in technology and human performance that was the key factor because neither failure alone would have produced the ultimate disastrous outcome (Perrow, 1999a; Chiles, 2001). Perrow believes that such failures are the inevitable consequence of closely-coupled complex systems and argues for what amount to safety valves and circuit breakers in terms of redundant technology and improved operator training and performance. At both Three Mile Island and Chernobyl, commonly held views of the situation were uniformly wrong and ultimately contributed to the system breakdowns. Fortunately, in the case of Three Mile Island, an outside agent who had not been influenced by observing the emerging events, was able intervene before total failure of the system (Chiles, 2001). None of the workers at Three Mile Island had been trained to expect anything resembling the types of problems that they actually had to confront. They had no successful patterns or strategies to call upon and were unable to adapt to the rapidly changing conditions.

Other Infrastructure Failures

Disastrous infrastructure failures with similar but subtler links between technology and human performance abound in the literature. The collapse of the Mianus River, Schoharie Creek, and Hatchie River Bridges and the Hyatt Regency Skywalk are illustrative in this regard. The Mianus River Bridge in the State of Connecticut carried Interstate 95. In 1983 a rusted hanger pin and hanger failed and caused a two-lane section of the roadway to fall into the river below resulting in the loss of three lives. Excessive rust had developed due to paved-over road drains and went unobserved because of poor inspection practices (NTSB, 1984). The Schoharie Creek Bridge, which carried the New York State Thruway, failed in 1987 after a pier was undercut by scour and fell into the creek. The bridge girders slipped off their supports and caused a section of the roadway to fall into the creek, killing ten people. Despite a report almost ten years earlier calling for replacement of missing riprap around the failed pier, the work was deleted from a maintenance contract (NTSB, 1988). In 1989, an 85-foot section of the bridge carrying U.S. Route 51 over the Hatchie River in Tennessee fell into the river after 2 columns supporting 3 bridge spans collapsed. Eight people were killed in an accident whose primary causes were a lack of redundancy in design and poor inspection and maintenance practices that failed to detect a developing problem (NTSB, 1990).

In 1981 a failure occurred that was described at that time as “the worst structural disaster in the United States” (Levy and Salvadori, 1992). The Skywalk at the Hyatt Regency Hotel in Kansas City, Missouri collapsed, killing 114 people and injuring more than 200. Through an unfortunate and bizarre sequence of events, a design that did not meet the applicable building code was produced by the structural engineer and was subsequently modified and *made weaker* by the contractor. The contractor’s shop drawings were later approved by the structural engineer and the effects of the change were never noticed (although it was never clear whether they were actually reviewed). The walkway was opened for use despite several instances during construction of the hotel when deficiencies were noted but were not acted upon (Petroski, 1992). Although not on the scale of a Three Mile Island or Chernobyl, what arguably places these four examples in the same context is the recurring intersection of technical faults and human performance failure. The critical role played by the human component of technological systems needs to be far better understood in the context of managing interdependent infrastructures in times of stress or crises.

Learning from Failure

Some form of structural failure analysis has probably existed since the time of Hammurabi if not before. Contract disputes over shoddy work or construction failures required that someone conduct an investigation and determine, as best they were able, the cause of failure and who was at fault. Forensic engineering is now a healthy, mature discipline and much knowledge has been gained, and advances made, from the study of engineering failures (Petroski, 1992, 1994). Engineering approaches to hazard-resistant design for structures and lifeline systems have improved continuously from the observation of past failures, assessment of their causes, and improvements in techniques and materials (Mileti, 1999; NRC, 1994). However, despite the value of forensic engineering to the advancement of engineering practice, the system is far from ideal. Much work of value exists only in court records, sealed by litigation settlements. Nothing analogous to the Air Safety Reporting System[3] exists for engineering practice although the Near-Miss Project at the Wharton School of the University of Pennsylvania is an attempt to develop a similar reporting framework for other industries (Phimister, et al., 2000). There are also conceptual concerns with commonly used forensic techniques. In its study of errors in the health care industry, *To Err Is Human*, the Institute of Medicine noted that:

> The complex coincidences that cause systems to fail could rarely have been foreseen by the people involved. As a result, they are reviewed only in hindsight; however, knowing the outcome of an event influences how we assess past events. *Hindsight bias* means that things that were not seen or understood at the time of the accident seem obvious in retrospect. Hindsight bias also misleads a reviewer into simplifying the causes of an accident, highlighting a single element as the cause and overlooking its multiple contributing factors. Given that the information about an accident is spread over many participants, none of whom may have complete information, hindsight bias makes it easy to arrive at a simple solution or to blame an individual, but difficult to determine what really went wrong. (IOM, 2000).

In light of this, care needs to be taken so that lessons learned programs (or other forms of adaptive learning for understanding the failure mechanisms of interdependent infrastructures) are designed to capture the influence of all contributing factors, not merely the obvious or easy.

Understanding Building Failure

At the conclusion of their 1992 book, *Why Buildings Fall Down*, Matthys Levy and Mario Salvadori posed the question of whether progress in the field of structures would reduce the number of failures (Levy and Salvadori, 1992). In light of the devastating collapse of the World Trade Center towers, this question is certainly as relevant today as when first posed a decade ago. However, a series of other structural failures through the 1990's raises the more compelling question of whether the overall state of knowledge regarding the interplay of risk factors in design and construction is adequate to ensure the integrity and safety of buildings and those who inhabit them. For example, the progressive collapse of the Alfred P. Murrah Federal Building in Oklahoma City in the aftermath of the 1995 bombing; extensive and costly damage to steel-frame buildings following the 1994 Northridge earthquake; damage to buildings due to snow loadings in Washington, Oregon and California caused by winter storms in 1996 are examples of failed designs employing what might be reasonably judged to be the best available practice or technology of the time. However, when subjected to extreme loading conditions, the designs proved inadequate.

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[3] The ASRS is a voluntary program administered by NASA wherein air safety-related incidents and near accidents can be reported without fear of self-incrimination. The program is credited with facilitating beneficial change throughout the airline industry (Perrow, 1999).

As isolated events, these examples would traditionally warrant a comprehensive but narrowly focused forensic investigation of the failure modes, their likely causes, and possible remedial actions (Feld and Carper, 1997). However, when considered together, these and other structural failures worldwide suggest the need for a broader, systematic contemplation of structural design and the degree to which the ultimate safety of a building's occupants depends on design assumptions that may or may not be valid under extreme loading conditions. This was dramatically demonstrated by the World Trade Center and is particularly critical in light of continuing emphasis on taller and lighter buildings (often in areas of high seismic and extreme wind risk) and the desire to accelerate the deployment of new materials and technologies into building construction.

Progressive Collapse

Progressive structural collapse occurs when the loss of load-bearing capacity (for example, through the destruction of one or more columns, or of load-bearing walls) results in localized structural failure that leads to further loss of support and, ultimately, collapse of all or part of the structure. The extent of total damage is disproportionate to the original cause. Redundancy in the design can provide multiple load paths to the ground so that if one or more load-bearing elements are compromised, sufficient capacity remains to support the structure. Better continuity in structural joints between beams, columns, and floor slabs by means of increased reinforcement is one means of ensuring redundant load paths. Although there are ways to reduce the tendency of a building to undergo progressive collapse, there is no uniform, straightforward solution to this problem, because our current knowledge of the mechanisms of progressive collapse is incomplete. Following the collapse of the Ronan Point apartment building in Great Britain as the result of a gas explosion in 1968, there was considerable interest in progressive collapse. Although some advances were made in the 1970s, research funding waned in the absence of continuing public concern.

Progressive collapse is a principal, if not the leading, cause of injury and death in building failures, regardless of the source of the loading (e.g., bomb, earthquake, internal explosion) (NRC, 2000). For this reason, predicting and designing to prevent the progressive collapse of a building for various terrorist attack scenarios is a high priority for structural engineering research. Further increasing our understanding of progressive collapse will require both physical testing of structures at full and partial scales, coupled with advanced computer modeling. However, because buildings are complex systems that can have large variances between design specifications and as-built conditions, a test structure may not accurately mimic the progressive failure of a real building. Although an experienced engineer can often estimate the likelihood that a specific building will collapse by superimposing a damage scenario on the design, because of the variances described above, the actual progress of a collapse is essentially a chaotic process. For example, following major earthquakes, nonstructural building components, such as mechanical piping, partition walls, equipment, heavy-duty storage facilities (shelving and file cabinets), and curtain walls that can transfer some of the dead load to lower levels, have been observed to keep buildings standing that would otherwise have been expected to fail (NRC, 2000). This phenomenon, (i.e., a complete progressive failure that is just barely contained) has been observed in Mexico, California, Japan, Guam, and more recently in Turkey and Taiwan. Unfortunately, although nonstructural elements obviously have an important role to play in determining individual outcomes, their random contribution to preventing a collapse cannot be easily included in structural models.

Protecting People and Buildings from Terrorism

Protecting buildings and those they shelter from terrorist acts may be viewed within a basic systems framework that seeks to prevent, mitigate, and respond to future attacks (Sevin and Little, 1998). This may be achieved through the integration of four fundamental security design objectives:

(1) denying the means of attack
(2) maintaining safe separation of attackers and targets through good planning and architectural practice
(3) providing strong, resilient construction to protect people and key building assets
(4) facilitating rescue and recovery operations in the event an attack occurs.

As demonstrated by the terrorist attacks of September 11, the first line of defense must be to identify and apprehend potential perpetrators before they can act. They must also be denied access to the means of attack such as explosives and delivery vehicles. This encompasses a broad range of primarily security-related activities such as domestic and international intelligence and surveillance, domestic law enforcement, enhanced airport security, and improved explosive-detection devices.

The second and third objectives require the active collaboration of engineers, architects, landscape architects, security specialists, and others to ensure the attractive integration of site and structure in a manner that minimizes the opportunity for attackers to approach or enter a building. They include such features as landscaping and earthworks that can function both as blast barriers and vehicle controls and appropriately designed street furniture such as planter boxes and bollards that prevent vehicular access. The building itself may have a range of blast-resistant features such as additional reinforcing details, composite fiber wraps to strengthen columns and slabs, and high-performance glazing materials. The structure's electrical and utility systems may be placed in protected raceways, critical facilities or operations housed in specially hardened areas or underground, and primary and backup systems located in different parts of the building.

As the tragic events of September 11 made abundantly clear, it is difficult if not impossible to prevent destructive acts by persons unconcerned with their own safety or survival. Therefore, facilitating rapid rescue and recovery of victims in the aftermath of an attack is a key component of a building protection strategy. The speed with which rescue personnel can safely enter and secure a damaged building can reduce the loss of life, mitigate injuries, prevent further damage to the structure, and help restore the building to productive use.

Assessing and Managing Infrastructure Risk

Risk gives meaning to things, forces, or circumstances that pose danger to people or what they value (NRC, 1996). Descriptions of risk are typically stated in terms of the likelihood of harm or loss from a hazard and usually include an identification of what is "at risk" and may be harmed or lost; the hazard that may occasion this loss; and a judgment about the likelihood that harm will occur. In the context of physical infrastructure, *risk* connotes the likelihood and level of failure of a critical physical or operational system that would prevent an infrastructure element from fulfilling its primary mission, i.e., providing services. To assess these risks, systemic quantitative risk assessment and management is necessary.

In the context of building security and hazard mitigation, *risk* connotes the likelihood and level of failure of a critical physical or operational system that would prevent the building from fulfilling its primary mission, i.e., protecting the people within. To assess these risks, systemic quantitative risk assessment and management is necessary.

In *risk assessment,* three questions must be answered (Kaplin and Garrick, 1981):

- *What can go wrong*?
- *What is the likelihood that it would go wrong*?
- *What are the consequences of failure*?

Risk management builds on the risk-assessment process by seeking answers to a second set of questions (Haimes, 2002):

- *What can be done and what options are available*? (What is the mix of site selection and configuration, building features, and management practices that will provide the desired level of protection?)
- *What are the associated trade-offs in terms of all costs, benefits, and risks*? (For example, increased cost would be traded off with reduced risk and improved confidence in the system.)
- *What are the impacts of current management decisions on future options*? (Policy options that seem cost-effective at present must be evaluated under plausible future changing conditions. For example, providing certain physical hardening may preclude building modifications to increase functionality in the future.).

Any actions taken to develop and implement comprehensive hazard mitigation strategies for buildings and infrastructure must be based on a balanced assessment of all risks confronting the systems and the possible consequences of their failure, either singly or in combination with other, interconnected systems. These strategies must be informed by the best available information and carried out by people knowledgeable about the systems, their possible failure modes, the implications of concurrent system failures, and possible interventions that would allow systems to degrade gracefully and avoid catastrophic, multi-system failure.

Conclusions

Although recent events have focused on malevolent acts and how to prevent them, infrastructure faces other equally serious threats. In addition to natural hazards, the literature demonstrates that excessively prolonged service lives, aging materials, and inadequate maintenance all negatively affect infrastructure. Although, there is strong capability within the hazard community for identifying and assessing these vulnerabilities, without a better understanding of the overall context in which they need to be applied, vulnerability assessment represents only part of a total systems solution. Infrastructure and building protection is not seen as a purely developmental problem but one in which basic research is necessary and, to date, insufficient. Research needs run the gamut from a better understanding of networks and interconnections, to the mechanism and prevention of progressive collapse, to improved operational guidance for emergency responders.

A Closing Caution

In *Betrayal of Trust*, (Garrett, 2000), Laurie Garrett paints a grim picture of how in the 20th century the public health infrastructure in the United States deteriorated from a formidable first-line defense against infectious disease to a struggling, under-funded, and under-appreciated appendage. Today's concerns with bio-terrorism have the public and policy makers alike wondering if the U.S. is capable of dealing with deliberately induced outbreaks of infectious disease. However, terrorism may not be the real threat. The global economy and worldwide air transportation network have created a closely-coupled system that make it possible, and even likely, that someone infected with a highly contagious disease unwittingly will spread the infection far beyond their borders. In the absence of a global public health infrastructure, the potential consequences are grim. As she points out:

> High-tech solutions, devices to "sniff out" nasty microbes in the air or detect them in the water supply are a technological solution to a public health threat. Were a biological attack to occur, or a naturally arising epidemic, the public would have only one viable direction in which to place its trust: with its local, national, and global public health infrastructure. If such an interlaced system did not exist at a time of grave need it would constitute an egregious betrayal of trust.

Hopefully, no bio-disasters or further acts of terrorism will come to pass. But those concerned with physical infrastructure should take careful note of the warning implied. Our basic systems are at risk from threats we may not yet foresee. We need to anticipate these threats to our physical infrastructures, design systems that are inherently safer and more robust, and be prepared to restore them when they fail. As Leslie Robertson has recently written about the failure of structures that he designed,

> Surely, we have all learned the most important lesson—that the sanctity of human life rises far above all other values (Robertson, 2002).

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SECTION 3:

ORGANIZATIONAL AND INSTITUTIONAL ASPECTS OF CRISIS MANAGEMENT AND MITIGATION

IS THE EMERGENCE OF ORGANIZATIONAL PATTERNS A SUCCESS FACTOR OF CRISIS MANAGEMENT?

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Keywords: Crisis management, resilience of organizations, oil spills.

Abstract:

On December 12, 1999 the tanker "Erika" sunk off the Brittany coast of France, pouring more than 12 000 tons of heavy fuel into Atlantic waters. A few days later, pollution reached the shore and many municipalities were confronted with a crisis that they had never experienced before. In the four municipalities that we have studied, the management of the pollution is characterized by the spontaneous emergence of efficient organizational patterns.

This paper presents an analysis of the management of this crisis, at the municipality level, based on the perceptions and actions of the many stakeholders who contributed to the resilience of organizations.

1. Introduction

In 2001, the Cindynics centre of the Ecole des Mines de Paris conducted for the French Ministry of Territorial Planning and the Environment (Ministère de l'Aménagement du Territoire et de l'Environnement) a mission concerning the analysis of the management of the Erika oil spill at the municipality level.

This mission aimed at reconstructing the history of this catastrophe for 4 coastal municipalities (Loire-Atlantique: Pornic and la Turballe; Morbihan: Belle-île en mer and Ploemeur) greatly affected by this catastrophe.

The methodology used [Wybo 2001[a]] is two fold. The first part represents the collecting of individual experiences, which aims at conserving memories of the catastrophe. The second part is represented by the sharing of experiences aimed at enabling the actors to obtain a global and detailed picture of the management of this crisis. This sharing phase is made possible by a meeting in which all the actors that participated in this management get together in order to approve the information and knowledge collected and to highlight the positive ideas in line with the will to promote a positive return on experience.

The management of this accident cannot be represented in a snapshot form, as it comprises a succession of events and decisions, the consequences of which drive the evolution of the situation. Consequently, the formalism that is used in this methodology is represented by a "string of key events" [Colardelle 2001] consisting of a group of decision cycles end events that are at the basis of

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the evolution of the situation. This formalism allows the representation of knowledge, in a way that each actor can identify his/her contribution by retrieving a reflection of his/her own experience as well as that of the totality of the actors that have participated in the management of the catastrophe.

This methodology aims at taking into account human and organizational factors and at identifying and meeting the actors who participated in the management of the crisis. In this way, in the quest for "objective truth," almost 30 people were involved in the case study of Belle-île en mer. The formalization of their experiences represents the memory of the management of this catastrophe as each actor lived or experienced it first hand.

This paper will present the elements that took part in the emergence of organizational patterns and that were identified by the analysis of the actions and the perceptions of the many stakeholders who acted in the management of this catastrophe.

2. The reasons for the emergence of organizational models?

In the Erika oil spill many factors contributed to intensifying the crisis. The Erika catastrophe may only have been an incident if it had not happened in deteriorated conditions, a phenomenon that is frequently observed for major accidents.

> *Imperceptibly or suddenly the system will pass from a normal functioning mode to a deteriorate functioning mode that could give birth to an incidental or an accidental sequence. Clearly, the system will become fragile and very sensitive from new damages and from unsuitable human behavior. The more the functioning mode becomes deteriorated, the higher the potential risk is*. [Translated from Nicolet 1998]

During the first few days of the catastrophe, people engaged in cleaning up had to deal with a violent storm that affected the whole of France. Furthermore, the French meteorology centre predicted a drift of the oil slick towards southern areas of the French Atlantic coast. Consequently, many of the resources, sent to the South, where not available, and the clean-up phase initially had to deal with the pragmatic management of all available resources.

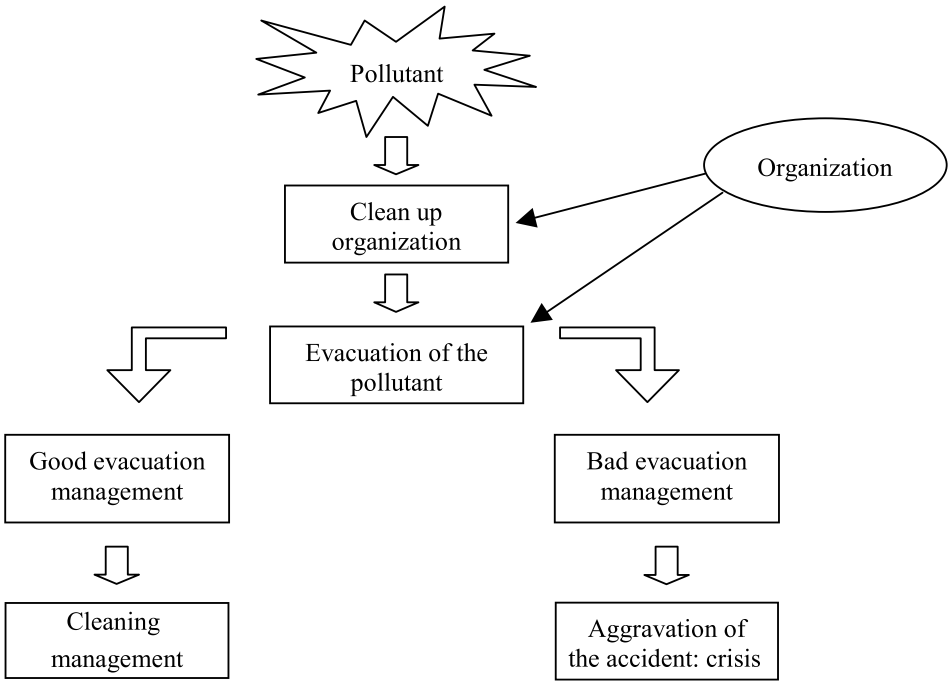
Two elements are the principal factors of the existence of a crisis situation on-land, those being the organization, particularly the entities involved in the cleaning up of the pollutant, and the quantity of pollutant. The second is directly linked to the first. If the pollutant can be gathered, stored and recycled without problem, the oil spill accident would not have evolved into a crisis situation (figure 1).

For treating marine pollution there exists in France a written emergency plan call PolMar (Marine Pollution). This emergency plan is the framework for creating an efficient organization, but this kind of organization is underestimated because few people are aware of it and these type of accidents are not frequent.

Furthermore, this emergency plan (which is specific for each administrative region) was very old and had not been updated for some regions. For example, in Loire Altlantique the last update was done in 1984. As such, many of the services of the Ministry were not aware of this plan.

The Erika pollution management situation is particularly deteriorated. This situation presents an organizational model (PolMar) which is partly unknown or unsuitable to the management of this crisis. Therefore, the majority of stakeholders, who are committed by their duties or by their convictions to overcome this catastrophe, gather their actions around a same objective: doing something efficient against the oil spill.

Figure 1: Importance of the evacuation of the pollutant in crisis management



3. The manner in which organizational patterns emerge?

The management of the crisis allowed for the implementation of immediate action on land through a process of initial improvisation. However, the allocation of roles in a participative manner rapidly took place and, over time, there was a gradual evolution of these roles and of the tasks to be accomplished. The network of actors in the municipalities that we have studied was made up of people who, for the most part, had already worked together and were already familiar with their environment.

The four municipalities are characterized by the spontaneous emergence of quite specific organizational patterns, which demonstrated a low degree of planning. But in all of these organizations, some stakeholders are or become leaders and agglomerate actors around them. Topper and Carley (1999) have studied emergence of organizations in the Exxon Valdez crisis:

> *If the Integrate crisis management units (ICMU) evolve as an emergent coordinating group, then early in the crisis response, individual organizations are disconnected. But as time progresses, organizations begin to establish relationships with their neighbors until finally, a coordinating group emerges from among participating organizations to more effectively manage their interdependencies; the ICMU network becomes connected.* [Topper 1999]

So, this emergence of organizational patterns is spontaneous but requires a kernel of actors integrated in a network of actors. Those authors represent a centralized system with a diagram organized by a pre-existing centralized group, and the structure advance by increasing centralization.

> *The large central node in the diagram represents a pre-determined coordinating organization or small group of organizations that directs the activities of other*

> *organizations. Over time, the network grows in complexity but remains highly centralized.* [Topper 1999]

In this network, the capacity domain of each stakeholder must be identified. Thus, communication around "who does what" in the first few days of the catastrophe may have limited damage to the environment.

4. Degree of complexity.

The crisis introduced a notion of uncertainty about the evolution of events and consequences. The crisis also introduced a notion of complexity:

> *The complexity (aspects linked to prevention, to aid services, legal and financial factors, to the return to a normal status) has an impact on the number and types of actors.* [Translated from Condemine 2000]

The first problem we met with when we studied the Erika oil spill is the diversity and the number of different stakeholders. The large number of parties increased the complexity of the organizations.

As we have seen, those organizations are not fixed in time; they advance in function of the behavior and the actions of the different stakeholders.

It is possible to distinguish different phases in this management situation, all characterized by ruptures with varying degrees of visibility, such as the departure of volunteers following the announcement of the toxicity of the pollutant or the transition to professional status.

> *Each crisis management has a natural dynamic, with peaceful periods and some more chaotic periods. Often the peaceful moments are favorable to re-structuring and learning from past actions whilst chaotic moments are reserved for action only.* [Translated from Colardelle 2001]

The organizations that have emerged are complex systems, and for each municipality present specific characteristics.

5. Is the emergence of organizational patterns a factor of success in crisis management ?

The complexity of these organizational patterns is one "key" to the management success. This success is imputed to a certain number of factors such as the implication of local political systems, the desire of the crisis unit to communicate with the inhabitants of the municipalities, the actions of local associations in their transmission of information, the quality and technical assistance given by the Centre of Documentation and Research and Experimentation on accidental water pollution (*Cedre*), or the roles of individuals that emerged during the catastrophe. These examples are integrated in the complexity and in the reflection of the image of the ecosystem and thus make it difficult to determine the degree of implication of each individual actor because of the diversity and sometimes non-visibility of the interrelations.

In all the organizational models we have studied, there is more communication between the different hierarchical levels than in a normal situation.

> *Unfortunately, communication difficulties arise when organizations deal with industrial incidents and accidents. Most of these result from the fact that management doesn't communicate enough on the "why" (why procedures are established as they are, why action is dangerous) while staff does not communicate enough on the "how" (how they manage the process, how they undertake an activity)* [Wybo 2001[b]].

In deteriorated situations, the communication is also deteriorated. But, emergence of organizational models allow emergence of new forms of communication.

Organizations that emerged show the importance of communication during an emergency, but also in normal situations because communication deteriorates during the development of an accident. These organizational models constitute frameworks that support crisis management in becoming more resilient to new perturbations.

6. Conclusion

The return on experience has allowed for the conservation of a memory of this accident before it is erased from all minds. The return on experience method also permitted an analysis of the management of the Erika catastrophe as well as an individual and collective learning experience of the stakeholders that struggled against this pollution.

The analysis of this complexity has revealed the factors that contributed to the resilience of organizations in dealing with this catastrophe. For the municipalities that we have studied, the emergence of organizations took an important part in the success of crisis management.

Sharing experiences also participates in learning lessons from crisis management in order to improve prevention and protection against these type of catastrophes, and reduce coastal pollution and damage.

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BRINGING RISK ASSESSMENT INTO URBAN PLANNING

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Keywords: *Risk assessment, vulnerability assessment, disaster mitigation*

Abstract

The rapidly increasing costs of natural disaster response and the prospects of even larger natural disasters have gained government interest in the last half decade. The terrorism that destroyed the World trade Centre on September 11, 2001 exacerbated government concern to move beyond response and recovery to mitigation. Planners will now need to address mitigation in many aspects of their work. This requires the planner to study a broad base of possible hazards and quantify the associated risks. In turn, this requires a new approach to looking at information resources and systems, and the planning and plan review process.

Introduction:

Urban communities experience a range of disasters that are due to natural or man made causes. The range and magnitude of such events have been increasing rapidly in the last decade (Newkirk, 2001). For example since 1996, Canada experienced three of its most devastating natural disasters: the 1996 Saguenay flood, the 1997 Red River flood, and the 1998 Ice Storms. Just these 3 events alone resulted in an estimated $7.8 billion direct cost to governments, private and voluntary sectors (OCIPEP, 2002). This sum does not include any estimates for environmental impact or any indirect costs. The unprecedented act of terrorism on the World Trade Center on September 11, 2001, in which a number of Canadians died, demonstrated a degree of vulnerability to manmade disasters that transcended anything previously considered likely. This has added great urgency to the desire of the Canadian government to move forward with a National Disaster Mitigation Strategy. No doubt this initiative and the consultations being held with the provinces will lead to a requirement for urban areas to conduct risk assessment studies and to file plans to show how the urban area would respond to disasters and mitigate against them. Certainly it is worthwhile to identify the potential risks from natural disasters. However there are a number of other areas where urban risk assessment should be considered. Since planners are directly involved in development approvals, plans that define hazard lands, plans the provide community health, safety, and educational resources, it is important for them to become involved in risk and vulnerability analysis on a much broader bases than just those associated with disasters. We consider some of these here with the intention of beginning an agenda for bringing risk assessment into urban planning.

Context:

It can be argued that risk and vulnerability are naturally occurring components of everyday life. Risk is defined: "risk: *n*. chance or possibility of loss or bad consequence." And "vulnerable: a. that may be wounded or harmed, exposed to damage" (Oxford, 1994) Thus risk and vulnerability assessment is simply aimed at understanding possible negative outcomes. Of course it is desirable to take steps to reduce the possibilities and magnitudes of risk or vulnerability. But it may often be impossible to reduce all or even a significant part of every risk. Whether risk reduction is partial or complete, it is called mitigation. "Mitigation - sustained actions to reduce or eliminate the long-term impacts and risks associated with natural and human-induced disasters." (OCIPEP, 2002) This means that urban areas need to develop a well documented understanding of the range of hazards that could face the community so that risk assessment can proceed. The definitions do not restrict the consideration to disasters. There are a number of examples of significant hazards that can be found in urban areas. For example, contaminated lands, run down or dilapidated areas, industrial areas, major transportation corridors, flood prone lands, and poor air quality may be just some of the hazards in a community. The public is aware of some of these hazards. There are increased views that urban areas are really not working well since there is often continual traffic grid lock, air quality so poor that small children and the elderly must stay indoors a number of times in the summer, and people are prohibited from swimming in the lakes due to pollution. This indicates that the public has an operational sense of hazards. Planners are being called upon to develop ways of reducing the risks associated with these and other hazards. This requires extensive analysis.

OCIPEP (2002) recognizes that Hazard Identification and Risk Assessment should be broad based. "To be effective, any measures to reduce the impact of probable disasters should be taken based on sound risk assessment and hazard identification. Conducting risk assessments can be complex, but they are an essential undertaking. Comprehensive approaches in this area involve historical research, data gathering and scientific estimations about hazard frequency, magnitude, damage potential, and vulnerability of potentially affected peoples and communities."

It is not sufficient to conduct risk assessments simply as background studies. Communities and political decision-makers must be made aware of risk levels and the possibilities of mitigating them. Ontario has achieved good success in some aspects of risk reduction in the area of flood hazards partially because the discussion of flood hazards and the formal mapping of flood plane lands has long been in the public domain. OCIPEP (2002) observes "A comparative study of Ontario and Michigan following a severe rainfall event in 1986 concluded that damage in Ontario, from the same storm, was less severe than in Michigan due to Ontario's policies that limited development in floodplains." Planners need to build community risk and vulnerability analysis into fundamental planning instruments. An obvious place to begin is with Official Plans.

Risk Considerations in Official Plans:

The Official Plan is an overall strategic document that lays out the context within which urban development, services, and activities will take place. Site plans and zoning bylaws must conform to the provisions of the Official Plan. This is also the place where the urban area's priorities can be clearly laid out. Thus, it is recommended that sections be added in each theme area of Official plans (e.g., housing, environment, industrial development, transportation, etc.) that sets out the known state of risks and vulnerabilities in those areas. The section would conclude with statements of objectives to mitigate (reduce) selected risks in specified ways. This process will require background studies and the development of risk assessment databases (Newkirk, 1993). A very important aspect of associating urban risk and vulnerability assessment reports in official plans is the fact that such plans are usually reviewed on a rolling 5-year basis. This would mean that the risk and vulnerability assessment and mitigation strategies would be reassessed on a regular cycle. Some risks are very theme specific. These should be subject to separate detailed reports. Examples discussed briefly here include Hazard Lands, Water Supply, and Industrial Development.

Risk Considerations in Identification of Hazard Lands

Hazard lands include those areas where there may be exposure to risk from natural or man-made activities. Natural hazard lands clearly include flood plane identification. The associated flood risk mitigation strategies would also be stated. This provides an opportunity for planners to directly address the cumulative impacts of land development on the watershed as proposed by Newkirk (2000, 2001) or could also include plans for physical alterations to floodways, dams and reservoirs, etc. Similar broad-based studies of the implications of other natural hazards and associated development would also be included. For some regions this would include areas prone to earthquake, subsidence, landslides, etc. The evaluation of risks from abandoned industrial land might be included here until suitably decontaminated.

Risk Considerations in Water Supply

A safe and reliable municipal water supply is critical to community health, safety, and for economic development. A detailed discussion of a planning related approach to this area can be found in Newkirk (2002) It is proposed that a broad based risk analysis is required that expands beyond just an engineering approach to water systems. This includes consideration of source of supply protection, protection of bulk transmission rights of way, risk reduction in water treatment and distribution.

Risk Considerations in Industrial Development

Many planning departments are also directly involved with business and industrial development. Most planning statements regarding business and industrial development focus on strategies for expanding such developments and addressing the various servicing needs. Analysis of associated risks and the appropriate mitigation approaches need to be added to these industrial development strategies.

Summary:

The increasing interest in mitigating risks and vulnerability will require planners to become directly engaged in risk and vulnerability studies. These should factor into the development of regional planning databases (Newkirk, 1993). A broader based assessment of risks associated with storm water impacts of development (Newkirk, 1996, 1997, 1999b, 2000, 2001) should be brought into urban development planning. This will go some way toward helping planners to be more strategic in emergency mitigation and preparedness (Newkirk, 1999a), and will be essential if they are going to be able to assist their community participate in a National Disaster Mitigation Strategy (OCIPEP, 2002)

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SECTION 4:

DISASTER RESPONSE AND MANAGEMENT

DATA COLLECTION IN RESCUE OPERATIONS

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Keywords: rescue operations, data collection, debriefing, AAR, learning

Abstract

Rescue operations are complex distributed activities. First response, incident command and rear support have to be coordinated under time pressure and safety critical conditions. Analysing an operation and learning from the experience is problematic because spatially separated units, heterogeneous systems and fragmentary information make it difficult for participants, managers and researchers to grasp the ramifications of a complex scenario. In training, multimedia representations of rescue operations support after-action reviews, post-mission analyses and distance learning by providing coherent and persistent representations of exercises. In this paper we investigate how methods and tools developed in a training context can be adapted to support reconstruction and exploration of real rescue operations as a basis for experience-based learning and operational development. Specifically, we study the requirements and limitations on data collection in real rescue operations in relation to emergency-response training. We elaborate on the consequences of the differences in data collection abilities for documenting an involved scenario, analysing the facts of the event and communicating the results and findings.

Introduction

Rescue operations after catastrophic events such as train or aeroplane crashes, chemical accidents or acts of terrorism are complex and demanding tasks. First responders from different rescue organisations have to collaborate in the field to save lives and property. Command, control and communications must be performed in a temporarily composed taskforce comprising units from multiple agencies. To acquire and sustain the ability to perform joint rescue operations, the rescue agencies need to devise appropriate plans, develop standard operating procedures, and design common training programs (Jenvald, 1999). All these tasks require a fundamental understanding of the processes involved in a rescue operation and their interaction (Flanagan, 1954, Raths, 1987; Salas, Dickinson, Converse & Tannenbaum, 1992; Fredholm, 1996). To learn and improve from past experience the responders need to reflect on the rescue performance in relation to the specific incident (Lederman, 1992). Hoffman, Crandall and Shadbolt (1998) identified two reasons why participants may have difficulties learning from past experience. First, in a distributed operation, actions taken at one location may have effects at other locations, which may lead to a lack of feedback on the performance. Second, when looking back on stressful situations people may confuse similar situations in different operations.

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In 2001 we initiated a research project (Jenvald, Johansson, Nygren, Palmgren, 2001b), together with the Swedish Rescue Services Agency and the Linköping Fire Department, with the goal to increase the possibility for the responders in the rescue community to systematically learn from real operations as well as from exercises. We aim at providing the rescue forces with methods and tools appropriate for conducting constructive after-action reviews (AAR) (Rankin, Gentner & Crissey, 1995; Gentner, Cameron, & Crissey, 1997; Morrison & Meliza, 1999) with all personnel participating in an incident. The goal is to devise instruments that the responders can use to document rescue operations as a basis for reflection and learning. We adopt a bottom-up approach by supporting the responders with procedures for automated registration of operational activities. The recorded data are combined with a conceptual model of the rescue organisation to form a dynamic computer model of each operation (Morin, Jenvald & Thorstensson, 2000). The rescue personnel can review these models using the MIND visualisation framework (Morin, 2001) to examine the various phases of the operation.

In this paper, we present means of recording the activities of real rescue operations with the goal to provide feedback to the responders after each incident. Ideally, the quality of the feedback should be the same as during full-scale emergency response training (Morin, Jenvald & Worm, 1998; Jenvald, 1999; Crissey, Morin & Jenvald, 2001; Thorstensson, Björneberg, Tingland, & Tirmén Carelius, 2001). However, a real operation sets certain demands on data collection methods. Bearing this in mind, we study the requirements and limitations on data collection in real rescue operations in relation to emergency-response training. Finally, we elaborate on the consequences of the differences in data collection abilities for documenting different rescue activities and present our findings.

From training to real operations

Methods and tools for supporting training of emergency response have been reported by Jenvald and his colleagues (Jenvald, 1999; Morin et al., 1998; Crissey et al., 2001). Based on these results we ask whether it is possible to support constructive AAR after real operations in a similar manner. To this end, we explore the differences between live operations and training exercises. We have identified the following differences:

- *Observers cannot be used*. In a training situation we can use observers to collect data. In a live operation all available personnel will be handling the emergency.
- *Absence of trainers*. In live operations there are no trainers available to provide feedback on performance and instruction to correct behaviour.
- *No control of the emergency.* In a training situation trainers can control the evolving situation and adapt it to training needs and unit performance. This option is not available in live operations.
- *Intrusive methods for registration are not viable*. All data collection, automated or manual, that limits unit performance must not be used.
- *Stress and danger*. In live operations there are always elements of stress and danger that influence the outcome of the operation.

Nevertheless, a realistic exercise resembles a real operation in many respects. The following factors are similar in training exercises and real operations:

- *Operational success factors*. A realistic exercise is constructed to reflect the factors for operational success that are valid in the real operation.
- *Organisation*. A live exercise is performed with the same organisation that would respond to a real emergency.
- *Command and control structure*. The command and control (C2) structure in an exercise is supposed to be the same as in a live operation.

- *Standard operational procedures.* The procedures trained in an exercise are to be used in live emergencies.
- *Equipment.* The same equipment is used in training as in live operations.
- *Problems.* The purpose of most training scenarios is to emphasize the problems encountered in real operations to help commanders and response personnel to acquire knowledge and experience.

In the light of the differences and similarities listed, we argue that the core methods and tools developed for training can be adapted to support real operations as well. However, in real operations, data collection methods and tools must be seamlessly integrated in operational procedures. They must be devised to be automatic and robust.

Reconstruction and exploration

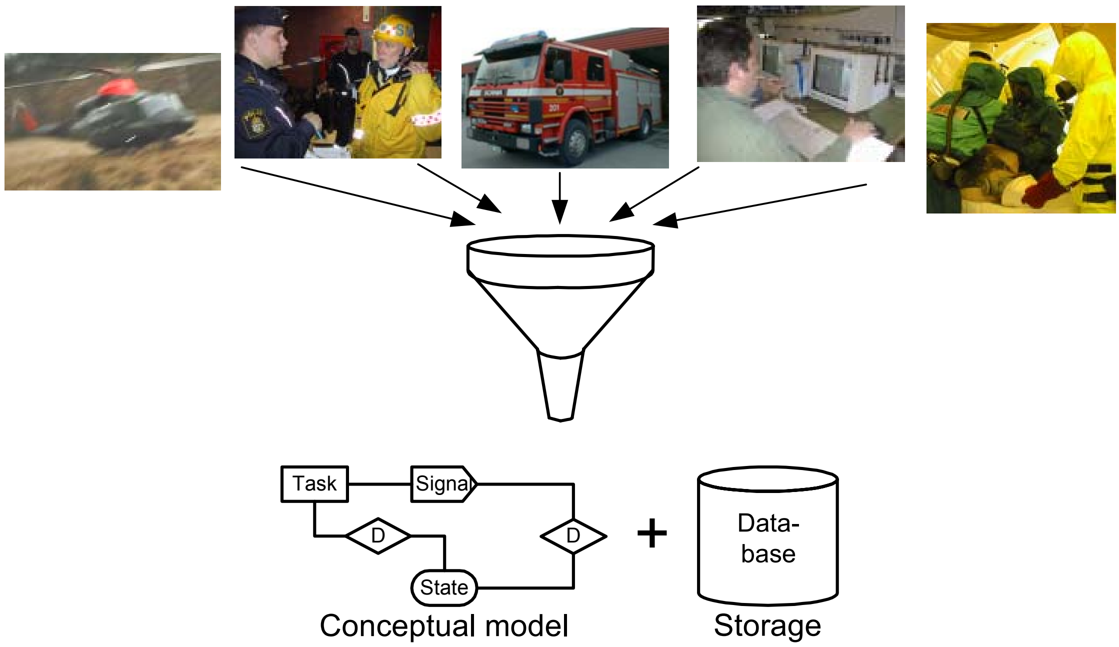
Our method addresses the problem of how to transform operational objectives into goals for the visualisation of the operation, and how these goals direct the modelling of the operation (Morin et al., 2000). The end result of this undertaking is a *mission history* (Morin et al., 1998), which is an executable, discrete-event model of the rescue operation. A mission history is made up of hierarchical object models, representing the units participating, and a sequence of events that represents the state transitions that take place in those objects. Each event is marked with the time when it occurred during the operation. Mission histories are similar to behavioural protocols (Woods, 1993) in that they include data from a variety of sources about the behaviour of people in relation to changes in an underlying process—in this case, a rescue operation.

Construction and visualisation of a mission history rely on the methods and tools to collect data from a rescue operation, to compile and appropriately organise these data and to present them using comprehensible displays and views, such as digital maps and diagrams. These tasks are performed by an *instrumentation system*. For our field experiments we have used the MIND system (Jenvald & Morin, 1998; Thorstensson, Morin & Jenvald, 1999; Jenvald, 1999). MIND is an adaptive and flexible research framework with integrated presentation components, which includes displays for tactical maps, annotated photographs from the operation, recorded tactical radio communications, command and control (C2) system logs and compiled statistics about unit performance. Figure 1 gives an overview of the process constructing a mission-history.

The method for constructing a mission history includes the following steps:

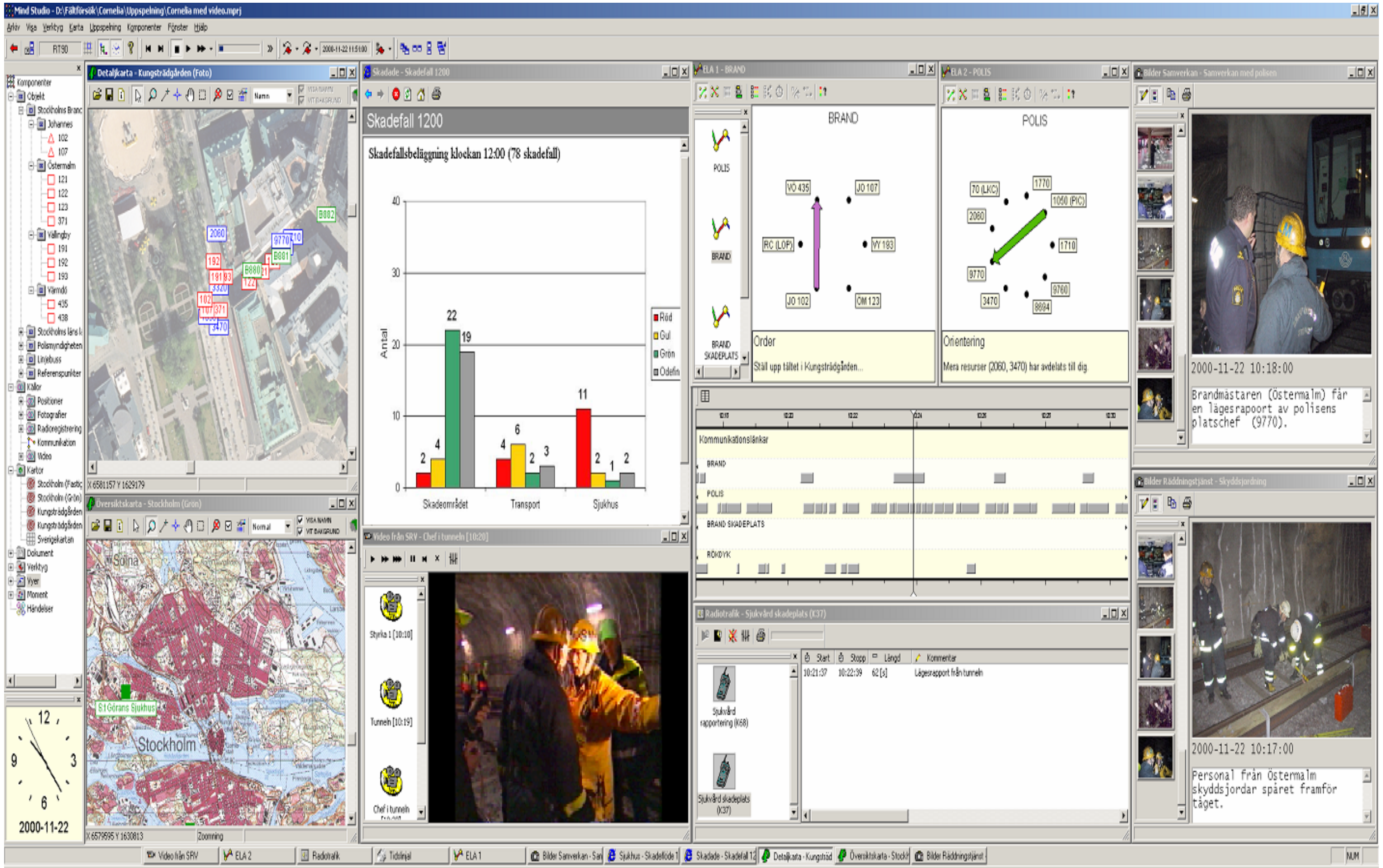
- Identify crucial objects and procedures which must be represented
- Model each object with respect to relevant parameters regarding what needs to be known and what can be measured
- Apply methods and equipment for data collection
- Record data from the operation
- Compile data in an executable mission history
- Visualize the model for the specific need

Figure 1: The process of modelling a rescue operation to construct a mission history. A conceptual model of objects and procedures in the operational domain is combined with data collected during the operation to form an executable model of the operation for subsequent exploration.



The mission history can be used for different purposes over time (Jenvald, Morin & Kincaid, 2001). Immediately after the operation an AAR supports debriefing of participants. After some time a post-mission in-depth analysis can facilitate the evaluation of unit performance and the development of tactics and plans (Jenvald, Rejnus, Morin & Thorstensson, 1998; Rejnus, Jenvald & Morin, 1998). All documented operations can also be used for training purposes (Murray, 1994) in classroom teaching and as multimedia sets for individual studies (Jenvald, Morin & Rejnus, 2000). Figure 2 shows a screen shot from the MIND system executing a mission history from a rescue operation exercise in the Stockholm underground (Thorstensson et al., 2001b).

Figure 2: A screen shot from the MIND system displaying a mission history from a rescue operation exercise in the Stockholm underground. The incident included the derailment of a train in a tunnel in the Stockholm subway. Some 80 casualties and 200 responders took part in the live exercise.



Data collection

Data collection is the process of gathering the data needed to build the mission history. It takes place during an operation and is implemented as a collection of manual or automatic procedures. The most fundamental strategy to use when recording sensor information is to use sensors with a built-in accurate clock to be able to meet the requirements of the discrete event model.

Ideally, all data can be acquired through automatic procedures, either from existing systems or from data-collection devices attached to the units in the operation. In the training settings, specially assigned and trained observers may collect data manually (Thorstensson, 1997). In general, we can choose between different available data sources. Data sources have different properties both in technical terms (for example concerning resolution and accuracy) and in economical terms (the cost in relation to the amount and quality of data provided). In some cases it might even be justifiable to modify existing methods and techniques to meet particular operational requirements.

The emergency personnel are important sources of information in a rescue operation, but there are some aspects that must be considered. First responders in a time-critical operation in a hazardous environment must not be diverted from their primary objectives. Resource demanding data-collection tasks are impropriate. However, there are methods that can be used in retrospect. The critical incident technique (CIT) (Flanagan, 1954) and the derivate critical decision method (CDM) (Hoffman, Crandall & Shadbolt, 1998; Klein, Calderwood & MacGregor, 1989) are interview-based post operation methods for extracting information from participating personnel. Using these methods we must be aware that in general people are bad at verbalizing their behavior (Woods, 1993). Furthermore, in environments where multiple distributed tasks are performed it can be difficult to recall critical events due to lack of feedback from specific actions and to separate different actions from each other and order them in time (Hoffman et al., 1998). Nevertheless, important information from an operation can be retrieved from participating personnel, though it is resource demanding to acquire.

Table 1: Example of analysis topics and corresponding means of data collection.

		Means of Data Collection	
Topic	*Method*	*Automatic*	*Manual*
Taskforce organisation	*Documentation*	-	*Copy documents*
Operation plan	*Documentation*	-	*Copy documents*
Weather conditions	*Observations and measurements*	*Weather station*	*Observers*
Geographical information	*Access geographical information system used by the staff*	*Database queries, scripts*	*Copy map overlays*
Unit movements	*Position registration*	*Logging GPS*	*Observers*
Casualty treatment	*Timing the flow of casualties*	*Electronic casualty cards*	*Observers, Casualty cards*
Command and Control	*Observation of the staff*	*Video camera*	*Observers*
Command and Control Systems usage	*Log how personnel use system*	*Logging in the system*	*Observers*
Communications	*Radio and telephone recording*	*Digital/Tape recorder*	*Observers*

Table 1 lists several topics of interest in a rescue operation and gives examples of automatic and manual means of collecting data pertaining to each topic. The organisation and initial status of the units forming the taskforce will affect the outcome of the rescue operation and consequently have to be recorded. Additional information about the participants, such as their training status, is also of interest (Morin, Jenvald & Crissey, 2000).

Weather information and the light conditions are other types of information that are relevant and should be recorded regularly. These factors are essential parts of the background information that can help people to create an image of the conditions during the operation, even if they did not participate themselves.

The geographical conditions in the operation area are fundamental in any rescue operation. Geographical information systems (GIS) are becoming increasingly important in rescue operations as they help both first responders and staff members to assess terrain and infrastructure. If a geographical information system is available it can support the visualisation of important aspects of a rescue operation (Jenvald, Thorstensson, Axelsson & Morin, 1999). The use of GIS should also be monitored, and a time stamped log included in the mission history could describe how GIS-information aided command and control during the operation.

When data are recorded from multiple units operating in a large area, it is necessary to use systems and sensors that can record, position-mark and timestamp events and actions automatically. The single most important source of this type of information is the *Global Positioning System* (GPS), which provides both position data and accurate time stamps. If the GPS receiver is connected to other registration equipment it can also be used as a high quality clock or to calibrate the clock in other sensors.

Command-and-control procedures are inherently difficult to register, because deliberations and decision-making are mental processes that are hard to capture (Rouse, Cannon-Bowers & Salas, 1992). Monitoring the communications in and out of the Command Centre provide information both about what information was available at a particular point in time and about what orders were given. Video cameras and observers can add information about the internal working procedures of the command staff (Thorstensson, Axelsson, Morin & Jenvald, 2001). If a command-and-control system is used it can be monitored and the log can provide information on how the system was used with respect to the evolving situation. Post-operative interview methods like the CIT and CDM described above can be used to add information on C2 processes, keeping in mind the limitations of the methods and the resources needed to perform them.

Finally, it is essential to include the *current* plan into the documentation of the operation. After some time plans are revised and a subsequent analyses of an operation must be correlated to the plan that was valid at the time for the operation.

Crucial operational Factors

Several factors affect the outcome of an emergency-response operation. Providing relevant post operational feedback to our responders sets focus on information requirements regarding crucial operational factors. The following list includes some operational factors that can have a decisive effect on the outcome of a rescue operation:

- *Preconditions for the operation*. Organisation of participating units, available resources, existing C2 structures, accessible standard operating procedures, contingency plans, and actual weather are examples of preconditions.
- *Dispatch information*. The first information from the dispatcher contains the initial information about the reported emergency, which is the basis for how the leaders allocate initial resources.
- *Object information*. Available information about the object for the emergency, for example a real estate property or a flat, and time point for accessibility is essential, and when it was used and by whom. Certain objects, for example industrial premises, are controlled regularly and have preplans for different types of situations. Other objects are initially

unknown and responders have to depend on information given by the person who called the alarm. It is also important to relate available information to the actual facts of the object and the evolving operation.

- *Deployment of rescue units*. Initial organisation of units is decisive for achieving a suitable structure for the actual state of the emergency, but it also permits escalation of the unfolding operation.
- *Command and control structure*. An evolving operation can have a dynamic C2 structure. The rescue organisation has an initial C2 structure, but in an escalation this structure can change. How these changes are managed, communicated and perceived in the organisation affects the operational performance.
- *Communication of orders*. Orders reflect decisions, and how they are communicated and perceived is key to efficiency (Shattuck & Woods, 2000).
- *Reports to commanders*. Reports from distributed units form the basis for commanders' situation awareness (SA) (Endsley, 1995) on which all decisions depend.
- *Briefings to subordinated units*. Briefings indicate how the commander influences SA in the organisation.
- *Management of unique and limited resources*. How commanders use unique and limited resources is of utmost importance for the outcome of an operation.
- *Time aspects*. There are three important points of time related to an emergency response operation: (1) the time when the accident or emergency takes place, (2) the time for the alarm dispatch, (3) the time at which the operation is started at the incident scene. There are different measurable time requirements used as tools to shorten the time between 2 and 3, for example, connection requirements for alarm dispatches or time limits for the fire fighters to leave the station. Nevertheless, we should emphasise all aspects from 1 to 3.
- *Inter-agency cooperation*. Operations that involve multiple agencies and disciplines require close collaboration at all levels of command to achieve successful coordinated taskforce response.
- *Escalation of operation*. There are several factors of importance when a dynamically evolving operation is escalated: for example, the definition of breakpoints along approach routes, sectors, assembly points for casualties and goods, establishment of a command post and a medical transportation organisation.

Each of these factors affect the overall taskforce performance and can be matched to possible means of data-collection topics to document operations.

Initial findings at Linköping Fire Department

The opening year of our research project together with the Linköping Fire Department has come to an end and we have learned some lessons. To make the responders aware of the purpose and the goal of the project we conducted an education program for all personnel from the fire department, the police force and the ambulance units working in the Linköping area. It is very important that the responders get the opportunity to ask questions about the data collection and the monitoring of different rescue activities. We have explained how the responders can use the recorded information to improve their future responses to critical incidents. It is a prerequisite for success that the research program is anchored with the concerned personnel.

Our goal is to systematically record a set of measurable parameters using the instrumentation system and to collect additional information and data from various systems that are presently in use. Today we have research equipment following live operations in the Linköping Fire Department. Corner stones in the data collection today are:

1. Recording of the dispatch from the emergency operation centre.

2. Digital recording of communication (Axelsson, 1997) between the rescue commander, team leaders and individual fire fighters.
3. Automatic registration of unit movements with the use of GPS receivers.
4. Digital photographs from the operational use of digital cameras.
5. Video recordings from vehicle mounted cameras.

This data set enables thorough analyses of operations but further development is needed. A substantial amount of communication on the incident scene is performed face to face, not using radio, and some important C2 communication is performed using cellular telephones. Documenting these communications would strengthen analyses. Today we use the MIND instrumentation system design as a flexible research platform, which is quite complex to handle documenting data sources and building mission histories. Our goal is that the responders can operate the instrumentation system without support from engineers and that demands improve system usability. Future developments include:

1. Automatic registration of weather information.
2. Automated compilation of the mission history to support AAR.
3. Pre-definition of a set of standard replays of the mission history.
4. Automated integration of information from support systems handling operations log books, personnel and incident reports.

A goal for the future is that all rescue operations in Linköping Fire Department are evaluated in an AAR with all the responders participating directly after each operation, and that all accumulated data is used for development of tactics and standard operational procedures.

The lessons learned from Linköping demonstrate that adapted methods and techniques for data collection in the field satisfy the requirements for building a mission history from regular rescue operations, performed by an ordinary fire brigade with its present resources. Detailed recording of unit activities, communication and performance reveal shortcomings and mistakes by personnel throughout the organisation. This necessitates thorough information to all personnel about the purpose of this detailed documentation to achieve acceptance and progress for the research project.

Discussion

Our approach has been to build reconstruction ability from the lowest unit level and design data collection tools that fulfil basic operational information requirements. Methods and tools for reconstruction of rescue operations performing well in small-scale routine incidents can be utilised within the framework of larger operations, only in larger numbers. This bottom-up approach enables scaling and adaptation to large-scale special operations with multiple agency emergency response. In everyday routine accidents the basic automated data collection can be the only documentation necessary to provide a basis for subsequent AAR and analyses. Consequent documentation of everyday response over a period of time can reveal systematic issues not noticeable when analysing single events. In special operations resources can be added to collect more information using other methods, for example CIT and CDM described above.

Important issues when recording data from live rescue operations are third person privacy and ethics. Emergency operations are to a large extent related to personal integrity. Rescue personnel are professionals in aiding people in severe traumatic situations, like road accidents or residential fires. Recorded information from these types of operations must be handled with the same ethics and respects as the first responders act themselves, which must be regarded as using this material for research and development.

Summary and conclusions

Documentation, analysis and communication of activities and lessons-learned are important factors of organisational development. These factors are also essential to sustain and improve quality. In this paper we have investigated the requirements of data collection in order to be able to support documentation, analysis and distribution of the lessons learned from rescue operations.
Live rescue operations, performed by a standard fire brigade with basic resources for data collection and analysis, can be successfully documented using adapted methods and tools from the training domain. A basic documentation achieved by automated methods and techniques support detailed after action reviews, subsequent analysis of tactics and standard operational procedures and communication of lessons learned.

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Acknowledgment

This work was sponsored by the Swedish Rescue Services Agency (SRV).

Special acknowledgment to Linköping Fire Department and their Deputy Fire Chief Anders Nygren for help and support in our research.

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MANAGING THE EMOTIONS OF DISASTER RESPONSE WORKERS: A COMPUTER-BASED DEPLOYABLE RESOURCE FOR SITE WORKERS, COUNSELORS AND VOLUNTEERS

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Keywords: emotions, trauma, measurement, nonlinear, chaos

Abstract

The immediate and apparent needs of victims during disaster response efforts obscure the more widespread damage to the emotional health of a large community of disaster response workers. While victims are openly recognized and typically treated for physical injuries and related emotional distress, the mental health needs of site workers, counselors and volunteers are often ignored. The un-addressed secondary trauma of these workers results in excessive employee turnover, domestic violence, and occasional destructive behaviors. This article describes a system called Emogram that can readily measure and report the emotional state of an individual exposed to traumatic events. As a stand-alone program, it can be deployed to the target site and used to monitor and manage the emotional health of disaster response workers, volunteers, and counselors.

Introduction

Over the past three years we have developed and successfully field-tested a computer-based system that measures and interprets individual human emotions. This system has been used to provide immediate insight into the emotional health of individuals subjected to primary and secondary trauma and to treat post-traumatic stress syndrome (PTSD). It is also used to monitor coping efforts and responses to treatment over time. Our primary application for this system was in trauma centers dedicated to the treatment of rape and the prevention of secondary trauma experienced by counselors in those centers. The system has been adapted for use in the field in disaster response theatres. Below is a discussion of the essential insights about human emotions that are necessary to understand how such a system is possible. Specifically, this article provides an introduction to basic human emotions, discusses how they respond to traumatic events and coping strategies, and demonstrates how they can be effectively analyzed and reported.

Our approach integrates these concepts into a system that can perform an assessment of an individual's emotions in approximately six minutes. It produces two types of reports, a baseline report that describes each emotion and the current level of that emotion in the individual and progress reports that describe how the individual's emotions have changed since the previous assessment. These progress reports are most useful for monitoring an individual under stress and

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they contain warnings of excessive strain on the emotional health of the individual along with specific recommendations for intervention.

Understanding Human Emotions

We are all mental, physical, and emotional beings. Emotions are neurological and biochemical processes that can both *respond* to what we think and feel and *affect* what we think and feel. There is no way to separate emotions from the mental and physical processes; they constitute an essential linkage between mind and body [1]. The new found importance of this linkage has prompted the National Institute Of Health (NIH) to request research into how emotions effect aging, cancer treatment, cardiac rehabilitation and mental health issues such as depression, anxiety and substance abuse [2]. While much will be learned in the coming years by these efforts, we already know enough about emotions to measure and respond to individual's emotions in very practical ways.

Emotions are much like the keys on a piano; they are very separate and distinct. However, we don't feel them that way, what we feel is always a combination of all the basic emotions. For this reason most of us are quite unaware of the distinct and separate emotions that we sense all the time. Most people can't name the basic emotions much less recognize them when they feel them. If someone asks us how we feel, we answer with "OK" or "A little down" instead of "Pretty *angry* with a good dose of *contempt,* some *anxiety* and a whole lot of *sadness*." Except in those rare and unpleasant instances when we feel profound anger or fear, we normally sense only a blend of the basic emotions making it difficult to get to know them individually.

Darwin provided the first major contribution to the study of emotion. Though he sites earlier work by Duchenne and Bell, his 1872 book titled The Expression of Emotions in Man and Animal is an obvious beginning to the field [3]. Darwin asked the right first questions: "What are the basic emotions?" and "Are the expressions of emotions universal across the human race and across species?" The answers he received from correspondents around the world allowed him to identify and describe in detail an initial set of basic emotions. As suggested by the title, his work highlighted the way in which emotions are expressed. The differences in the expressions led to the identity of various distinct emotions. Other contributors to the field have since recognized most of the emotions first identified by Darwin.

Not only did Darwin provide an initial list of separate emotions, he provided a productive methodology for research in the field. Expressions are the useful units to define, measure and compare. Expressions define the emotions. Focusing on the facial expressions, Paul Ekman has advanced this notion to a scientific end [4]. He identified the specific muscle groups of the face that relate to selected emotions and developed a Facial Action Coding System (FACS) that allows one to objectively identify an emotion from the combination of facial muscles used to express it. Conversely, it permits one to produce the expression of a given emotion by deliberately manipulating specific muscles in the face. This direct linkage between emotions and facial expressions is important in that it provides the foundation for the method we have used to measure emotions.

An ongoing debate has centered on the list of emotions. What precisely are the basic emotions? A useful answer comes from the doctoral work of Ilan Shalif at the University of Rami Gan, Jerusalem [5]. His dissertation, originally published in Hebrew in 1991 and translated to English in 1992 addressed the question of whether emotions are more faithfully described and communicated as cognitively interpreted terms (e.g., words) or subjectively interpreted visual images of expressions (e.g., pictures). In pursuit of this question Shalif developed a defendable list of emotions supported by the prior research of Charles Darwin, Charles Izard [6] and Paul Ekman [7]. In our work we were able to add Anxiety to this list as a distinctly different emotion supported by Darwin and others (see Table 1).

Table 1: A Consolidated List of Basic Emotions

Happiness	Shame
Interest	Fear
Surprise	Anger
Contempt	Distress
Disgust	Sadness
	Anxiety

Although we are all familiar with these terms, they are used here to refer to distinct and separate emotions defined by unique sets of physiological characteristics and neurological responses. The origin of each is also thought to differ though they all have distinctive evolutionary implications. Recent work by Richard Lazarus confirms the merit of this list and adds considerably to our understanding of how they relate to each other [8]. Though distinct, these emotions are all present to some degree at all times. Our emotional state at any given moment is defined by the relative strength of these elements. Lazarus' thoughtful discussions about the interactions of emotions contributed directly to our interpretation and analysis of emotional dynamics in the Emogram system.

Measuring Emotions

Describing emotions as unique facial actions does not measure them. Toward this end, Shalif's dissertation again proved helpful. His research provides support for the use of images of expressions (e.g., pictures) rather than terms to communicate the emotions. He found that visual expressions of emotions are more reliably recognized than are common terms for emotions.

The important next step was obvious. If expressions of emotions were the most effective way to communicate emotions, perhaps individuals could indicate the extent to which they relate to any given emotional expression. If a measure of concordance between a subject and an emotional expression could be collected, then the relative weights of the basic emotions at any given moment could be measured and it would finally be possible to have metrics on emotions.

We tested the use of photographs to measure emotions by using many of the reference photographs from various sources identified by Shalif. Each photograph was incorporated into an original software program that would present an image to a subject and collect a response using a six-point Likert-type scale. We tested this approach with more than 100 clients of a rape-crisis intervention agency and found the assessment process to have real promise. Subjects reported they could easily judge the extent of concordance held with each of the photographs presented and the measures of emotions obtained corresponded to counselor assessments and case status.

Support for the phenomenon of concordance comes from the literature on attachment, which describes how non-cognitive communication between an infant and a caregiver provides a foundation for learning to identify and regulate emotions. According to Schore, attachment allows the transmission of a caregiver's "affective appraisal of objects;" later, the child develops the capacity to internally self-evaluate objects and situations [9]. Our use of photographs allowed subjects to bypass, as much as possible, cognitive processes and sense their agreement- their concordance- with multiple emotional expressions.

The success with this approach to assessment was particularly promising given the poor quality of the original photographs. Although they were considered representative of the various emotions and had been extensively used in prior research, the photographs were of poor quality and obviously dated. What we learned by experience using these images for nearly a year allowed us to formulate an approach to producing new photographs void of the many problematic features.

Our current set of images were produced under studio conditions using modern digital color photography and trained professional talents as presenters. The images represent varying degrees of expression for each emotion and each complies with the FACS. A sample of the images is provided in Figure 1 along with a general description of each emotion. In an attempt to maximize the level of concordance, we produced five sets of images representing both gender and ethnic diversity.

Figure 1: Sample Images Representing the 11 Basic Emotions

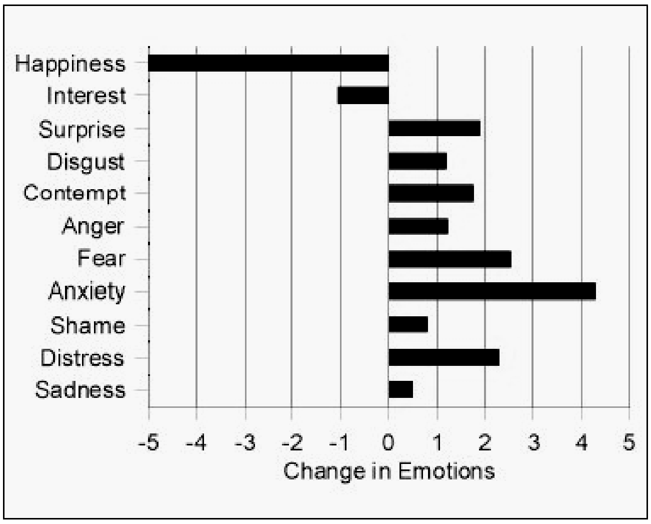
Emotional Responses and Coping

Besides the fact that we sense a blend of basic emotions, another fundamental attribute of emotions is that they are constantly changing. Referring again to the piano keyboard analogy, the combination of emotions we feel can change in an instant just as different cords can be played in any order and at any tempo. From moment to moment we can feel *anger* then *fear*, *shame* then *contempt*.

These changes in emotions are the result of *what we are thinking* and *how we are feeling physically* at any given moment. The recent terrorist events strike at some of the most fundamental beliefs we hold and they threaten us individually and directly. When we think about the threats that they represent we sense some degree of *fear*. When we think about those responsible for these acts we feel mostly *contempt*. When we think about eliminating those who threaten us we feel mostly *anger*. While all of these reactions are appropriate, we can become emotionally exhausted as our minds work through the many and varied thoughts and conversations we have about these issues. To make matters worse, the more unpleasant emotions such as anxiety, fear, and shame naturally become stronger with physical exhaustion toward the end of the day.

A specific example of how one's emotions can change immediately and dramatically is provided by the following description of a real event. Randall, a 33-year old executive, was concluding a weeklong business trip to Canada when the World Trade Centers and the Pentagon were struck. Two days later, on Saturday morning, September 15th, he had boarded a flight in Toronto for the trip home to San Antonio, Texas. At 10:30 AM he was seated on the plane at the gate in Toronto awaiting departure. In an instant four Royal Canadian Police entered the plane, two thundering down the aisle from the front and two from the back, with machine guns and pistols drawn. They violently confronted, handcuffed and arrested a Middle-Eastern man sitting just four rows behind him. A few days later we targeted this event and measured Randal's emotional response to it. Figure 2 provides the results of that assessment.

Figure 2: Emotional Response to a Selected Event



Randall response is instructive. Happiness, the sense that one is making reasonable progress toward what one desires, instantly disappeared and was replaced by anxiety because he didn't know what was going to happen. Fear emerged in response to the event and the emotion of distress, which is a call for help, increased. Note also the surprise associated with this encounter and the increases in both contempt and anger. The increase in shame is likely associated with a feeling of guilt Randall felt over having placed himself in such a risky situation; he has a wife and two kids. Randall's emotional response was the result of being placed in entirely unexpected and undesirable circumstances over which he had little information or control.

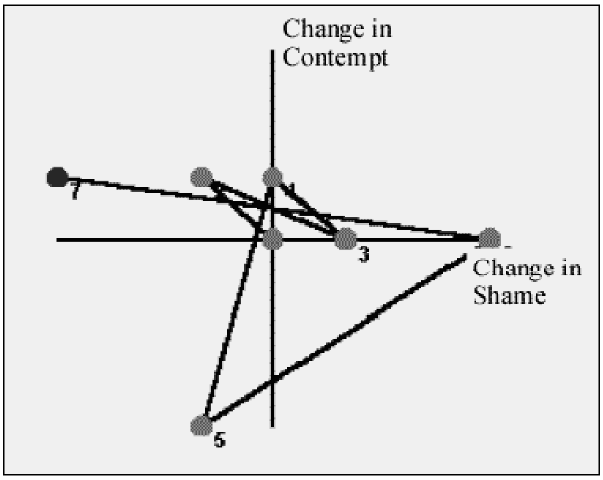
Our ability to cope is what saves us from the continuation of such emotional strain. We have all developed ways to work through the barrage of assaults we endure during the day. We have learned coping strategies that allow us to reason through conflicting issues or even temporarily disengage when things get too tough. Counselors typically classify coping strategies as either *emotion-focused* or *problem-focused*. Emotion-focused coping is an attempt to change how we *think* about a stressful issue. We attempt to change our perspective, which leads to different emotions. Problem-focused coping is an attempt to deal with matters by directly addressing and changing whatever it is that is bothersome. You cope by considering your alternatives and then taking action to change the reality you confront. The donations of blood and financial contributions subsequent to September 11, 2001 are examples of problem-focused coping behavior. Unfortunately, in the immediacy of disaster relief settings, these coping strategies are easily overwhelmed as individuals are made to endure more anger, contempt, anxiety and fear than they are adapted to handle. Typically, there is too little time to process emotional distress, the coping process is subverted and the damage to the mental health of an individual emerges only later in the form of chronic Post Traumatic Stress Disorder.

Analyzing Emotional Dynamics

Our production and use of new photographs provided a reliable means of obtaining measures for each emotion, however, an appropriate method was needed to analyze the interactions of emotions and the dynamic changes in emotions which occur over time. Recent advances in applied nonlinear systems theory provided the appropriate concepts and tools.

Nonlinear science makes use of a concept called state space that describes the current dynamic state of a system over time. From this view, an individual's emotions are seen as a collection of discrete elements changing and interacting with each other. In this application a "state" is defined as the dynamic combination of two or more emotions. For example, an increase in Contempt combined with a decrease in Shame constitutes a unique state. Similarly, a decrease in Contempt combined with an increase in Shame constitutes another entirely unique state. When expanded to include the dynamics of all eleven emotions one can see that the myriad of states rapidly increases. Though complex, the states are mutually exclusive and exhaustively finite. State space provides a means of defining the unique dynamic condition of the system at any moment and the sequence of dynamic conditions through which the system has passed [10].

Figure 3: A Phase Plane Depicting the Interaction of Emotions



The phase plane presented in Figure 3 is the most basic tool in the non-linear toolbox. It is used to reveal the dynamic behavior of a system over time. This image, relating changes in Contempt to changes in Shame, plots the attribution one applies to a particular event. Because Contempt is directed toward others and Shame is directed to the self, the dynamics of these two emotions provides an important psychological insight; it reveals the way in which an individual assigns blame.

Each axis on the phase plane measures changes in one of the two measures. The origin is coordinate 0,0 representing no change; positions to the right or upward represent increases, those to the left and downward represent decreases. Any point on the phase plane represents the state of the system at a moment in time describing precisely how the relationship between the two measures is changing. The trajectory on the phase plane is produced by plotting points at the intersections of the changes in each of the two measures over time and then tracing a line from each point to the next. The dynamic behavior of the two measures in interaction is revealed by the changing position of the trajectory on the phase plane [11].

This approach provides the necessary qualities to appropriately analyze the changes in emotions. It captures the incrementally evolving nature of emotions in that each new measure is compared to the prior measure of that same emotion for the same individual. This self-referencing approach is essential if one expects to assess a single individual. It is a fundamentally different approach than norm-based methods that apply statistics to compare an individual to a sample from a given population. By plotting the changes in two dynamic measures, the phase plane reveals an underlying interaction that is not otherwise apparent.

Phase planes are not just another way to present data. They provide a precise description of the system at each moment in time and they can be related to specific intervention strategies. For example, any point in Quadrant 2 (the upper left quadrant) reflects an *increase* in Contempt and a decrease in Shame by some specific amount. This combination of dynamic changes provides sufficient information to permit *interpretations* to be attached to the phase plane. An appropriate interpretation for Quadrant 2 may be " the individual is assigning more blame to others and less to the self."

Because interpretations can be drawn directly from positions on the phase plane, it follows that recommended *prescriptions for action* could also be attached to positions on the phase plane. Doing so does require that the context of the analysis be known. For example, if Contempt increased and Shame declined for a traumatized individual, that unique state may relate to a prescription stating "Confirm the appropriate assignment of blame to others and reinforce the realization that the individual should not blame the self." This prescribed action and the interpretation on which it is based flow directly from the changes in the underlying data. The phase plane, therefore, provides a means for converting the complex dynamics of the emotions into descriptive interpretations and recommendations for action. The method allows for the development of an extensive knowledge base that provides precise professional insight in real time. This approach, which constitutes a dynamic form of clinical pathway construction, has been successfully applied in other medical rehabilitation settings [12].

Applications

To make practical use of these concepts and methods we developed a unique software program that performs both the measurement and the analysis of emotions. With the financial assistance of the San Antonio Area Foundation we developed a demographically diverse set of validated photographs to be used to measure emotions. Then, guided by the literature and the insight of the certified counselors on this project, we developed three knowledge bases to address the unique conditions presented by trauma victims, crisis intervention volunteers, and trauma counselors. Each of these separate knowledge bases is capable of producing reports tailored to its designated audience. Each one can be used in a variety of ways from simple intake assessment to monitoring and psycho-education. The software program, the assessment images and the various knowledge bases were ultimately combined onto a single compact disk that will run on any modern Windows–based computer.

The Assessment Process

It is important to recognize that the Emogram assessment constitutes a psychoanalytic instrument and is therefore governed by the rules of conduct and ethics imposed on mental health professionals. In general, those rules dictate that any licensed professional administering a psychoanalytic instrument must be trained on that instrument or is subject to ethics violations. Our experience with Emogram has also established that it is essential that it by administered by a licensed counselor trained on the system or, at the minimum, by a counselor trained on the system and supervised by a licensed mental health professional. Additionally, a consent agreement is obtained from the client. These standards have been established because the measurement and subsequent feedback of measures of emotions can solicit candid and open responses of a personal nature from the client. The administrator must, therefore, be competent enough to address such issues productively.

The assessment process begins by entering an identifying name or number into the program. The administrator or client then selects one of the five presenters incorporated into the system. These presenters are (1) an Anglo female, (2) a Hispanic female, (3) an African-American female, (4) an Anglo male and (5) an African-American male. In general demographic matches are made with the client although there are specific exceptions to this practice.

The client is then instructed that there will be a presentation of thirty-three facial photographs depicting various emotions. The client is not to analyze the photographs cognitively, but rather, to simply answer the following question: “To what extent do you feel the way the individual in the photograph feels?” The client is presented with a data entry screen as shown in Figure 4 and responds by clicking on any one of the response bars that range from “Very Different” to “Very Similar.”

Figure 4: The Emogram Data Entry Screen

Each time a response is entered a new photograph appears on the screen depicting another emotion. There are three photographs for each emotion that differ only in degree. An important aspect of this assessment process is that it does not rely on the client knowing the names of the emotions or having any prior instruction about emotions. The response is essentially guttural rather than cognitive. When a response has been entered for each of the thirty-three photographs the system combines the scores for each emotion mathematically to derive a specific score for each emotion.

The Reports

Assessments can be made at anytime. After the initial assessment a baseline report is produced which simply identifies the strength of each emotion on Likert-type scales ranging from one through six. Subsequent assessments produce Progress Reports that include the analysis and insight from our certified counselors. The reports may also contain special "Cautions" and "Alerts" if the system detects problematic transitions in the client's emotional profile. The report also provides an Overall Emotional Quality Score (E-Quality) that is scaled from +100 to –100. A sample report is provided in Figure 5.

Figure 5: An Emogram Report

PROGRESS REPORT

Individual:	**#4345**
Knowledge Base:	**KBASE3**
Image Series:	**F1HIS**
Assessed:	**4/6/02 6:35 PM**
Previous Report:	**4/5/02 5:26 PM**

Here is an analysis of the assessment data. Consider the specified target material and the purpose of the assessment when interpreting these results.

OVERVIEW: Overall Emotional Quality decreased. The Overall Emotional Quality Score has declined to -28.09. Caution: The subject's Emotional Quality score is particularly low; the subject may not be in a safe emotional state.

ORIENTATION: This component of the emotional state refers to openness and willingness to attend to information in the environment. It examines the changes in interest and surprise.

Surprise has increased to 3.11; interest has declined from 3.94 to 2.23. The subject's openness to new insight and information has increased. CONSIDER: Using this as an opportunity to explore new perspectives on difficult material.

APPRAISAL: This section examines the way in which a subject assigns blame for negative emotions. It reflects changes in shame (blaming self) and contempt (blaming others).

The subject is assigning more blame to others than in the prior report while self-blame remains the same (the contempt score has increased from 2 to 4.47, the shame score remains constant at 2). CONSIDER: (1) Using this condition as a therapeutic opportunity to discuss responsibility and the appropriateness of blaming others for current emotions and (2) assessing the subject's potential for acting out anger on others.

COPING STRATEGY: This component refers to the subject's response tendencies. It addresses the propensity to approach (anger) or retreat (fear) in relation to the target material.

The subject is currently both more angry and more fearful than in the prior report. The anger score has increased from 2.29 to 5 and the fear score has increased from 1 to 2.52. The subject may be experiencing mixed feelings in interactions with others and may be experiencing helplessness regarding target material. CONSIDER: (1) Identifying and processing the threat that is soliciting the fear response, (2) helping the subject identify the sources of fear and anger and regain control where appropriate, and (3) assisting the subject in expressing anger in safe and appropriate ways.

ALERT: The subject's Emotional Quality score has declined significantly since the previous assessment. The subject has reported an Emotional Quality Score below –20; it is currently -28.09. Assess the client's safety. Consider seeking counsel regarding this subject.

Each report is unique in that its content is constructed from the myriad of possible state spaces defined by the eleven interacting emotions. These reports also vary in content depending on the specific application. For example, reports relating to trauma victims are directed toward the counselor and contain discussions and suggestions appropriate for a trained counselor to assist in intervention. Reports relating to counselors contain very specific coping strategies that help the counselor prevent “counselor burnout.” Those reports used to monitor volunteers and other crisis workers are phrased in language that is appropriate for both the supervising counselor and the subject.

Reports are produced instantly after each assessment and retained so that the chronological history of the individual can be referenced at any time. Each report relates specifically to the period of time since the previous assessment. Periodic assessments, therefore, provide a series of reports that reveal the continuously evolving mental health of the individual. Because the reports are based on subtle changes in the various emotions they are able to readily detect changes that call for intervention. Put simply, the reports identify changes that, if continued, would result in a deterioration of the emotional state. Editing and note-taking features are included in the system to further simplify documentation requirements.

Editions

The need to address volunteers, counselors and victims differently resulted in the development of three different editions representing the different knowledge bases. In all cases the assessment process is the same, however, because of differences in the context of the assessment and the characteristics of the clients, the reports differs greatly. All three of these editions are incorporated onto a single compact disk and can be used interchangeably on the same computer. In this way a single counselor can use the system to monitor volunteers, perform intake assessment and counseling with trauma victims and monitor his or her own response to the demands of the job.

The volunteer edition is specifically designed to support agencies placing volunteers in potentially stressful situations. Volunteer monitoring is typically required by professional and ethical codes of conduct. By administering Emogram tests at the beginning of the assignment and periodically throughout the assignment it is possible to reduce the risks to both the volunteer and the clients they serve. Our experience using the system with volunteers at a detention facility suggests that it definitely aids in debriefing the volunteer after assignment thereby reducing stress and improving the volunteer’s coping ability. It may also reduce the turnover rate and absenteeism of volunteers. An additional benefit with volunteers is that it provides an enjoyable check-in, checkout system that is both efficient and time-stamped.

The counselor burnout edition is designed to assess changes in emotion and to provide suggestions aimed at improving counseling professionals' abilities to meet the demands of emotionally taxing work, thus preventing possible burnout. Grounded in the work of major burnout theorists, this edition addresses burnout issues at the individual level by promoting awareness of stress producing situations, providing guidance for appropriate appraisal, and suggesting possible coping strategies for dealing with negative affect. Designed for counselors assumed to possess adequate coping skills, it detects early signs of job stress and provides suggestions to help counselors self-manage their emotions. Targeted emotions are assessed and emotional changes tracked in the context of the known effects of vicarious trauma and burnout. Transitions toward burnout manifest themselves as changes in orientation (surprise and interest), congruence (happiness), incongruence (anger plus contempt, disgust, shame, fear, and distress), internal blame tendencies (fear, shame, and distress), and external blame tendencies (disgust and contempt). By promoting behavior that includes engagement, change, and healthy coping skills, this edition directs counselors to manage stress and take control of their emotional lives.

The trauma edition is based on specific assumptions about the clinical population relating to the cognitive and social-interpersonal effects of trauma. These include: irrational self-blame for the trauma, a sense of helplessness and incompetence, hyper-vigilance often accompanied by inaccurate interpretation of emotional expressions and other related disorders of affect modulation, regulation, and attachment. Because of these assumptions, this edition incorporates interpretations of emotional dynamics and prescriptive comments that are extremely sensitive to issues of client safety and is most suitable for clinical users. Traumatic events have extremely powerful influences in both the cognitive and emotional development and they powerfully and negatively impact adolescents and adults with otherwise normal developmental patterns. The effects of traumatic exposure can be drastic, debilitating, and dependent on the complex interrelationships between the nature of the traumatic event and the resilience of the individual. Our experience using this edition in a large trauma treatment facility indicates that, when used as an intake assessment tool, it can greatly reduce the time required to begin effective treatment. Used as a pre-session and post-session assessment tool, it can measure the effectiveness of counselor interventions.

Training and Deployment

Training is provided in sessions usually organized by counseling and intervention agencies. The length of training varies from four hours to twelve hours depending upon which versions are addressed. Volunteer training is typically only four hours, the volunteer and counselor burnout editions can be taught in a one-day session, an additional four hours of "hands-on" training is required for those planning to use the trauma edition.

Distributing compact disks that contain the software and the relevant editions provides deployment to those counselors trained on the system. Certain features in the program make it simple to transmit reports via e-mail to counseling supervisors not on location or to share entire data sets with other counselors. Confidentiality is maintained by using either unique identification numbers or pseudonyms for clients while security over the system is maintained by either password protection or by off-loading and securing data files.

The Emogram system has been deployed to crisis intervention centers, detention centers and to more than 60 schools in the southwest. Its applications have varied from intake assessment of juvenile criminals as young as 14 years of age to use as a treatment tool for PTSD clients and individuals with multiple-personality disorder. Its primary benefits center around its ease-of-use and the accurate insight provided in the reports. Other valuable features cited by users are the fact that it is self-scoring and that the reports accomplish a major part of session documentation requirements.

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Acknowledgments

The authors wish to thank the San Antonio Area Foundation, the Semp Russ Foundation and the Franque R. and Philip H. Curtis Trust for their financial support of Emogram.

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ORGANIZATIONS, LEARNING AND RISK MANAGEMENT

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Keywords : Risk management, crisis management, organizational learning, organizational silienrece

Abstract

The management of risk, alerts and crises in the industry is a complex task, which is achieved by a large number of stakeholders. This paper presents the advantages associated with the development of organizational learning to analyze alerts and crises, which provides a better sharing of knowledge about identification of weaknesses and strengths, and a deeper involvement of people in risk management.

Introduction

The objectives of risk management are not only to suppress or to reduce hazardous events, but also to be able to react in the best ways when risk develops into accident or crisis. To reach these objectives, organizations establish means and strategies for prevention and mitigation.

If the system (technological or not) may be risky and the nature of these risks are well known, then it is possible to build strategies aiming at protecting this system against perturbations that may be at the origin of dangerous situations and crisis.

Prevention corresponds to several kinds of actions:

- Analyze potentially hazardous events and situations and study their origins and consequences.
- Analyze the system vulnerabilities: components that may be damaged, persons that may be wounded and functions of the organization that may be disturbed.
- Install technical devices or procedures to suppress hazardous events or make them harmless.
- Set up an organization that favors the integration of the notion of risk at all levels.

People achieve the management of incidents, accidents and crises through two complementary ways: application of procedures and improvisation.

If the incidental situation has been anticipated and analyzed, for instance during the system design or following a similar incident, its management will follow an incident management procedure and will be facilitated by appropriate protection devices and organization models, which are called barriers or defenses.

If the situation escapes from this framework, either because the incident was not considered and never occurred before, or because defenses have not functioned, then we turn to a type of management based on experience and improvisation of people. These people will do their best to bring the system back into a known and stable state, while limiting damage and disaster extent.

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There is an unlimited number of organization types and combinations of actions that put an end to a crisis situation, and during these situations, one may often observe the emergence of leaders and interesting organization models. The different kinds of knowledge that are used or built during the management of these situations constitute an important wealth for organizations and companies, but they are often tacit and poorly shared among people.

> *The actors involved in safety system failures are frequently the primary, sometimes the sole, source of information about what happened and why. The capacity to learn from accidents and develop preventive measures therefore depends on the ability to elicit information.* [Mc Donald 1997]

Developing this knowledge, sharing it and improving the image of people who own it are, along with prevention, the most important ways of increasing the resistance of organizations to hazardous situations.

Complexity of the problem

In the last decades, a substantial improvement in technology reliability and risk prevention has been observed, but in parallel, a steady increase of system complexity tends to create new kinds of risks.

> *The role of the human being in complex systems is essential: he must achieve programmed and complex operations, but also supervise the system as a whole. In many cases, his job goes beyond simple compliance to procedures because their only application is not enough to get the production. Moreover, if it were the case, people would be replaced by automatic devices. Quite often, he must check the relevance of the procedure in the real context of the task and, in the eventuality of a gap, he must change procedure, complete prescriptions, or even invent new organization schemes to reach the goal, despite perturbations, while respecting safety requirements.* [Translated from Leplat 1990]

This complexity is often linked to the extension of technology and automatic devices that control the system, but it results also from the increase in the number of stakeholders and relations binding them. In the same way, the development of outsourcing, which contributes to the increase of productivity, may also bring a loss of tacit knowledge belonging to key people that contribute to the organization resilience, especially if these staff categories have a high turnover ratio.

Even if a part of this complexity can be identified and allow the setting up of reliable organization models and transparent flows of information, it also promotes the emergence of drifts, differences between people and dilution of responsibilities, which are key risk factors.

Debriefing incidents and accidents is becoming de facto one of the few ways to identify what we call “traces of complexity”, that is to say to enlighten, through detailed analysis of events and decisions, the behavior of technical, human and organizational subsystems when facing unexpected situations.

The human being, the organization and the resilience

When events or conditions occur that may turn into alerts or crises, there are simultaneously strong constraints, uncertainties on the development of the situation, and a need for a structure of organization. This structure is a landmark in the unknown, an obstacle to chaos. Which are the key factors that promote the setting up of an order, an organizational structure for the response to the alert or the crisis?

As early as the activation of an alert, by analogy with crystals growing, one or several "germs" will play the role of support or guide for the development of the structure, but they will rapidly become invisible and give room to an aggregation process that will generally only keep main directions from the initial germ. We call this "germ" the *kernel* of the organizational structure.

But this kernel is insufficient, as a source of energy is also required: the set of constraints that exert on people belonging to the different groups involved in the situation, which push them to participate in the organizational structure of emergency management and which allows its development and adaptation to the context.

In the case of an organization confronted by the management of an alert or a crisis, factors that participate in the setting up of an organizational structure will be the pressure of events, the extension of the alert, the motivation of people or their willingness to limit consequences. But who plays the role of kernel?

Two kinds of germs can be observed: people and action plans. In the first case, there are one or several leaders, whose role in the organization, charisma or reputation will attract people and form the initial germ.

In the second case, there is an action plan that is known well enough (sometimes more by its name than by its exact content) to be used by a first group of people as a reference, to initiate a structure following its indications.

In both cases (leader or plan), it can be observed that the complexity of crisis situations moves rapidly away from the hypothesis of the plan or the first leader's indications. "*Procedure is weak when confronted by urgency*" [translated from De Coninck 1995]. The situation then moves to a process of evolution and developing of the organizational structure, which will develop not only from the kernel, but also and mainly from the influences and constraints of the context (dangerousness, dissemination of products, media impact, etc.).

We use the term resilience to qualify the ability of organizations to resist dangerous situations with the minimum of damage. In the domain of risk management, the resilience of a system is built up in two phases:

- At the design stage, by promoting the design of a safe system, able to resist expected hazards and be provided with efficient barriers.
- During the life span of the system, by the analysis of incidents, of their management by staff and of the behavior of barriers, in order to assess weaknesses as well as resources that have provided solutions, and to learn lessons from these analyses.

When a system (company, municipality, etc.) is confronted by a crisis, a small group of people will take the responsibility of its management, either because it corresponds to their duties, or because they feel entrusted with this mission. To identify this network of people, which constitutes what we call the "resilience kernel" of the system, it is necessary to analyze examples of alert or crisis management and to identify the parties who have played key roles.

In most cases, organizations demonstrate efficiency and resistance to stress, events and time. It is not by chance, but rather because they follow a general scheme, based on the availability of a kernel (leader or plan) and on the existence of constraints and stress around this kernel. If these constraints go beyond a given threshold, which corresponds for us to the individual or collective acceptability of risk, then a structure (or a sub-structure) will grow around this kernel. This structure of organization is a sort of buffer zone that distributes constraints by relying on these germs. The goal is to shoulder constraints while protecting the system against damage. This buffer zone may concern actions, information management or grading the problems to solve.

By this way, each incident enlightens in the general architecture of the organization, a subset of people who have been involved and their relations among themselves and with the outside world, whenever they belong to the organization or they are opinion relays. The analysis of the different networks that have "emerged" during incidents, alerts and crisis management reveals what we call "pockets of resilience", which constitute the strengths of the system, but also its weaknesses, when these organization schemes have not been able to efficiently manage the situations.

> *The level of reliability of an organized system depends on the capacity of its parties to develop cleverness clues needed to achieve informal settings in order to continuously correct and amend a set of structurally incomplete rules and devices* [translated from Bourrier 2001[a]]

Among the benefits of debriefing and analysis of alerts and crisis management unfolding, this identification of the strengths of the system that must be promoted and its weaknesses that need to be corrected, is probably one of the most promising. It provides knowledge about the behavior of the system beyond its limits and it allows the identification of key people, information flows and resources on which the system may rely to anticipate, prepare and manage hazardous situations.

The contributions of organizational learning to knowledge

Knowledge imbedded in experience of individuals is difficult to grasp because it is spread throughout the organization and it is often tacit among groups. Moreover, it can only be revealed at the time of "problems" that are often badly identified by the hierarchy and the other groups, as a consequence of an organizational culture based on the sanction of errors.

This set of knowledge, often informal, tacit and acquired through years of practice, failures and successes, constitutes individual experiences of people. But this wealth of the institution is fragile. It assists in confronting difficulties and adversity but it may vanish if the organization is not aware of it, if the owners of this knowledge, what we call the "resilience providers," are not rewarded for it, and if it is not transmitted and shared among people, hierarchies and generations.

Setting up and developing an organizational learning scheme to make this knowledge visible and formalized is crucial. But it also creates a progress dynamics based on three principles: respect of individuals; trust in their ability to manage unexpected situations; and dissemination of information. It is also a way to reinforce the feeling of belonging to the structure of the system, which is a key factor for motivating and encouraging commitment in the development of a safety culture within the institution.

> *The definition of safety culture tries to bind the sphere of individual behavior (attitudes) and human errors, objects of predilection until the eighties, to the sphere of organization, structures and social behavior, objects that were not so much tackled until now* [translated from Bourrier 2001[b]]

Recurrent incidents are signs pointing to dysfunction and should be studied carefully. It is usual to limit their analysis to the search for technical factors that will be fixed or human failures that will be sanctioned. This kind of strategy turns out to have a limited efficiency and the frequency of incidents stays at a level which cannot be lowered any further.

The introduction of more refined debriefing methods may reveal structural factors that are the roots of these incidents and by that contribute to provide more efficient solutions.

> *Organizational learning requires that event analysis traces the causal factors and determinants of an event both further back into the past, and further up the chain of management control.* [Hale 1997]

Inside a group of people, organizational learning also results in the creation of communication and sharing of knowledge among individuals, whatever their missions or level in the hierarchy are.

> *The reliability of learning of an organization is if it develops common understandings of its experience and makes its interpretation public, stable and shared.* [March 1991]

This kind of communication gives opportunities to anyone to raise the standing of his own expertise and to learn from others: "management told us the reasons why"; "operators told us the way how".

Conclusion

The main objective of the debriefing process is to understand what happened and to find ways to avoid the repetition of accidents and to limit their consequences, using the lessons learned from the analysis of incidents and crises. Enlarging this perspective to set up a real organizational learning scheme sets the path to new goals that participate in the development of a risk culture among organizations.

The experience gained by the people is, with its successes and failures, an invaluable source of improvement [Wybo 2001[b]]. Incidents, quasi-accidents and crises may become, beyond simple debriefing sessions, opportunities to reinforce the trust bindings among people, contribute to promote their skills and provide a better knowledge of the system.

The management of incidents and crises is always a matter of exceptional events in deteriorated situations. Setting up a risk culture based on a global approach needs to take into account the complexity and, notably, to master its three main aspects: technical, human and organizational.

Based on the notions that have been presented in this paper, a methodology for debriefing and organizational learning is currently under development within an interest group composed of academics, companies and public bodies [REXAO]. This methodology is applied to different kinds of hazards: natural, technological and food-related.

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[REXAO] Groupement REXAO®. French interest group for debriefing and organizational learning (Retour d'Expérience et Apprentissage Organisationnel). http://www.rexao.org

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SECTION 5:

INTERNATIONAL DISASTER RECOVERY – IS GENDER AN ISSUE?

AN EARLY APPROACH TO COMMUNITY-BASED DISASTER MANAGEMENT: PREVENTION MITIGATION AND PREPAREDNESS

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Keywords: disaster management, prevention, mitigation, preparedness, local level

Abstract

Overview of the design and implementation of a Local Accident Mitigation and Prevention (LAMP) program from its inception in 1991 to its completion in 1998. Significant elements are that it provided implementation resources for actions prescribed by an existing United Nations awareness program; it made significant strides towards determining how to build sustainability into foreign assistance programs; it took a bottom-up approach that secured local ownership and design; it made real inroads into creating and maintaining local capability to prevent, prepare for and mitigate the consequences of technological accidents and natural disasters; and it was a working example of real partnerships between government, industry and community groups.

Introduction and Summary

In 1991, while the current U.S. Agency for International Development Administrator, Andrew Natsios was Director of the U.S. Office for Foreign Disaster Assistance, he launched a novel program in partnership with the World Environment Center (WEC), an independent, non-profit organization. His goal was to anticipate and reduce the negative social and economic impacts of natural disasters in developing countries. That by itself was innovative enough but he also wanted to include local community groups, i.e. women.

OFDA had allocated funding to a new initiative called PMP - prevention, mitigation and preparedness – and asked the WEC to work with OFDA to design an effective approach. Those discussions, consultations in the field and a pilot project led to a five-year Cooperative Agreement, signed in 1992. The Agreement was for the design completion and implementation of the Local Accident Mitigation and Prevention (LAMP) program that was to incorporate a number of novel steps and work in India, Indonesia, Mexico and Thailand. (A six-minute video of the first simulation exercise in Mexico is available.)

The first innovation was that LAMP capitalized on the existing APELL program run by the United Nations Environment Programme out of the Industry and Environment Office in Paris. APELL, Awareness and Preparedness for Emergencies at the Local Level, with the support of the Canadian, U.S. and European chemical industry manufacturers associations, had a mandate to conduct high-level awareness seminars around the world but had no follow-through implementation mandate or funding. However, what APELL did do was to create a market for LAMP. This worked so well that a side activity of LAMP became the funding and sometimes the organization of APELL programs.

The second innovation was that the program looked carefully at sustainability. The fact that the USAID funding would only last five years meant that continuity of funding, i.e. sustainability, had to be built in and it was quickly recognized that that meant engaging and serving the needs of the private sector. In addition to providing a recognizably valuable service to the industrial community, a second element of sustainability was the achievement of critical mass. Making sure that the initial programs in each country were attended by officials from other jurisdictions and that, wherever possible, the materials used were all in the local language, raised the likelihood of replication. This tactic worked very well in India where one initial LAMP location in Madras quickly became six cities throughout the country.

Although the long-term goal was to deal with the impacts of natural disasters, the third strategic decision was to focus on PMP with respect to industrial accidents. This was done because it would get private sector attention and the infrastructure created could easily be used in times of natural disasters but would receive full attention, and funding, on a daily and ongoing basis

Thus, the prima facie goal of the LAMP Program was to reduce the incidence and impact of major chemical, hazardous materials transport or other technological accidents and disasters in selected high-risk locations in each selected country but it also included the mitigation of technological side-effects of natural disasters such as earthquakes and floods. Towards this end, WEC organized and implemented results-oriented accident prevention, emergency preparedness and response planning and disaster mitigation training; chemical safety education; and public awareness outreach and accident simulation (mock emergency drills) in each country.

The LAMP program brought about positive and meaningful improvements in emergency response, emergency preparedness, and emergency planning and testing through a sustained, interactive, and client-driven approach. Thus, by definition, methods of intervention varied from country to country, and within countries from site to site, according to the specific social, political, economic, and developmental conditions of each site. For that reason, LAMP had to be flexible and able to respond to the planning and training needs of the groups that engaged the LAMP process of improving industrial accident prevention and mitigation systems. Flexibility and responsiveness to the local clients were the defining characteristics of the LAMP program.

These two traits played an important role in the progression of activities that took place. Since the program was designed to respond to the unique characteristics of each site, LAMP managers relied heavily on the local representatives at each site to help define the plan of action and goals for the project. Those groups and individuals that embraced the Awareness and Preparedness for Emergencies at the Local Level (APELL) process of the Industry and Environment Office of the United Nations Environment Programme (UNEP), and the LAMP program were often key to successful implementation of the program. Thus, one of the most important responsibilities of program management was to identify organizations and individuals who believed in and would champion the APELL and/or LAMP approach. It was crucial to engage those parties, and continually work with them to ensure that objectives were well defined, in line with the conditions at each site, and likely to achieve the expected outcomes.

Under the bottom-up approach of the LAMP Program, prototype examples of improved community-based emergency preparedness were established at selected sites, which then were replicated at other sites while influencing and informing country-wide policies and institutions related to disaster prevention, response and mitigation.

Overall, the foreign exchange cost for implementing the LAMP Program was 200-250 thousand U.S. dollars per country, per year 84% of which was contributed by OFDA and the balance came from in-kind contributions from the private sector, the Canadian government and others. This figure excludes the local currency costs of seminar and training facilities, fees for local experts, expenses for participants, salaries of local APELL/LAMP coordinators and equipment, materials and supplies for emergency exercises. All these costs were borne by local governments, industries and participants. In the spirit of the LAMP Program, these expenses were seen as investments by the communities at each LAMP site to demonstrate their commitment to organizing themselves for improved safety against technological accidents and natural disasters.

Steps for Implementing LAMP Program

Since successful program implementation required flexibility and responsiveness to local conditions, there was no single approach to implementing the LAMP programs in each country. There were, however, several aspects of all LAMP programs that remained constant from one country to the next. The following section outlines aspects of the LAMP program that can be seen as the characteristics that were common to all LAMP programs. These components were the building blocks for LAMP and can be seen as the "steps" to conducting effective LAMP programs.

A particular emphasis has been to create ongoing programs in Awareness and Preparedness for Emergencies at the Local Level (APELL) at selected local sites to:

- Create and/or increase community awareness of possible hazards within the community, and
- Based on that awareness, develop an operative plan to respond to any emergencies that these hazards might present.

APELL itself uses as a model the U.S. Local Emergency Planning Committees (LEPC's), as defined and legally constituted under SARA Title 3, and the Community Awareness and Emergency Response (CAER) groups encouraged and supported by the International Association of Chemical Associations, particularly the U.S. and Canadian chemical manufacturers associations and CEFIC in Europe, which are implementing Responsible Care™. Throughout the LAMP Program, WEC and UNEP/IEO cooperated actively to jointly promote improved community-based emergency preparedness in the target countries and selected communities. In fact, in India the Program was known as "APELL/LAMP" both at the local level and the national level.

In each country, local "bonding" agents were found to help ensure that objectives were met on the local level, as well as national "nodal" organizations to help replicate LEPC's to other sites. The local "bonding" agents were typically local industry associations, Responsible Care™ groups, community service organizations, or local worker or public safety committees that had already demonstrated a shared concern about chemical safety. These "bonding" agents became major participants in a tri-partite local emergency preparedness committee comprising representatives of the local government, industry and at-risk community. The national "nodal" organization(s) were selected for a similar demonstrated concern on the national level.

In India, a National Advisory Committee (NAC) was created comprised of representatives of federal ministries (labor, health, environment, interior, etc.), national industry associations (chemical manufacturers, insurance and loss prevention, etc.) and national service and professional organizations (Rotary Clubs, industrial medicine, safety professionals, etc.). The NAC accepted an ongoing role in replicating the LAMP program at other sites in India, as well as in advising national and state governments on issues related to emergency preparedness and response and accident prevention.

Step One - Site Selection

LAMP program site selection was a critical step towards ensuring that meaningful results ensued after two to three years of locally designed interventions. LAMP relied on replication from one site to another to maximize the effectiveness of donor funding and to ensure that program initiatives continued to improve after donor funding ended. The need to replicate LAMP successes, so as to achieve a critical mass of mutually supportive of sites in each country, made the site selection process one of the most important steps in designing each LAMP program. LAMP funding was targeted on industrial areas where the chances for meaningful and lasting impact were most likely to occur and on those communities that would most likely be in a position to share their experience with other industrial sites in need of improved accident prevention, response and mitigation.

The LAMP approach worked best in those countries and/or geographic regions having a multitude of high-risk industrial sites that could benefit from the replication. The criteria for selection of potential LAMP sites were:

1. Flammable, explosive, or acutely toxic substances are produced or utilized on site and transported through the local areas;
2. A significant number of persons reside on or near the industrial site and are at risk;
3. Disaster relief institutions exist near the industrial site or can easily be created;
4. There is an expressed local concern about industrial risk and an interest in organizing more effective prevention, mitigation and preparedness (PMP) programs to counter the current risk; and
5. An established prime mover agrees to take on a leadership role.

Step Two - Recruit and Train Country Manager

Once sites were selected per the above criteria, a Country Manager was put in place to interact with the local representatives of each LAMP site and coordinate on a daily basis with industry, government and community representatives. The Country Managers played pivotal roles and had to embrace a number of diverse responsibilities. The Country Manager needed the aptitude and the skills to both engage local leaders on technical skills of emergency responders as well as display political sensitivity regarding a community's participation and "right to know". For this reason, the Country Managers had to have experience and credibility with local industries and government groups, as well as the dynamism and openness to reach out to other groups, particularly both formal and informal community interest groups, with whom no prior relationship or experience existed. In this way, the Country Managers could effectively direct program activities relevant to many groups and serve as a catalyst for the changes that needed to occur as program goals were first shaped and then realized.

The effectiveness of the Country Managers was ultimately dependent their personal understanding of the nature of the process of change, their vision of what could be accomplished at each site and the patience and skill to allow local leaders to own the process and move towards those changes. Understanding what needs to be done at each site allows the Country Manager to guide others -- plant safety managers, community group leaders, elected officials, hospital managers, and planning committee members -- towards more responsible and more effective means of preventing accidents, preparing for emergencies and mitigating disasters.

To help LAMP Country Managers develop this “vision” of what is possible, the four Managers toured prototype local emergency planning and response groups in the U.S. and Canada, witnessed emergency response exercises and visited first-responder training facilities. This exposure helped them understand community-based chemical emergency preparedness and accident prevention activities, including risk assessment, mapping of chemicals, emergency plan preparation and update and management of emergency exercises. They also visited the Chemical Manufacturing

Association's CHEMTREC that coordinates responses to hazardous materials transport accidents throughout the U.S. In addition, they visited the Federal Emergency Management Agency and the U.S. Environmental Protection Agency, Chemical Emergency Preparedness and Prevention Office (EPA/CEPPO) operations centers in Washington, DC.

Step Three - Determine Baseline Indicators

In planning a LAMP program each country and site within that country, certain baseline indicators related to accident mitigation and prevention must be assessed. Baseline indicators function as a planning tool during program implementation to determine which types of LAMP activities are appropriate. The development of a list of baseline indicators is a useful way of reviewing and documenting the conditions in LAMP countries and at selected sites. Because baseline indicators vary from site to site, planned activities and expected outcomes at each site will also vary.

Baselines are also used as a benchmark against which program outcomes can be evaluated following the completion of program activities. The indicators selected in each location will never be exhaustive but should be easily understood and accepted by all participants as being meaningful reflections of certain elements of safety and readiness. Baseline indicators may also include historical events that have a particular bearing on a site or country where the LAMP program operates. For example, the 1984 Bhopal, India accident resulted in a groundswell of concern for public safety and accident prevention at the grassroots level. Thus, this disaster and the subsequent emergence of grass-roots safety groups throughout India both serve as baseline indicators for India.

There was no single set of baseline conditions to which the LAMP programs had to refer, however, assessment of potential LAMP sites required that baselines be determined in order to help guide LAMP activities and bring focus to long-term strategies of the project as a whole.

Step Four - Develop an Action Plan

Following site selection, choosing a Country Manager, and documenting the baseline conditions, an action plan for each site and the country as a whole was determined. The action plans were an important part of the LAMP process as they helped to set agendas and quantify constraints based on the local conditions.

Each action plan was used to define the site goals and identify the means by which these goals were to be achieved. Since the replication of LAMP activities was one of the primary objectives of the program, highly replicable activities were always central to each action plan. Action plans were also flexible and allowed for changes in conditions at a site. Action plans also defined, as priorities, activities that were most likely to succeed and result in improvements at the local level. The action plan was a guide that helped project management define and achieve realistic goals.

Step Five - Select and train local LAMP Site Coordinators

Consistent with the model promoted by initial APELL seminar/workshops, a local coordinating committee for improved chemical safety was formed and began by assessing chemical risks and formulating emergency response plans to mitigate that risk. Often, a natural leader emerged as a local person motivated and committed to helping the community achieve greater safety for its citizens, through improved cooperation of the tri-partite partners (industry, government and community organizations).

Step Six - Plan and Implement Activities

Site selection, choosing a Country Manager, determining baseline indicators, developing an action plan and selecting and training local LAMP Coordinators were the principle steps to beginning a LAMP program. Once these steps accomplished, program activities were designed and implemented in relation to specific goals and objectives at each site.

The LAMP programs worked with local and visiting experts from the public and private sectors to accomplish priority goals. Local participants, a local advisory board and WEC/LAMP staff determined the goals. Building on the core of a well-established APELL Seminar/Workshop used to initiate the APELL/LAMP process, other programs of particular concern at each location were added as required. These include training of local experts and citizens on hazard and risk assessment, formulating an emergency plan to respond to that risk, plan evaluation and the organizing of mock emergency drills to test the efficacy of emergency preparedness plans.

Simultaneously, local emergency first responders were trained in industrial fire safety, containment and clean-up of hazardous materials incidents and medical response to chemical accidents and disasters, including treatment of the types of medical wounds and injuries that might result in the event of particular accidental releases or spills in that community. Finally, WEC worked with local industry to organize effective accident prevention programs and to reduce the threat to public health and safety from chronic and catastrophic chemical risks.

In addition to working closely with UNEP/IEO to organize and implement APELL Seminar/Workshops as a normal first-step to acquaint a particular community with the concepts and practice of chemical disaster preparedness, other partners provided critical assistance. The USEPA Chemical Emergency Preparedness and Prevention Office (CEPPO) and the Atlanta-based Center for Disease Control's Center for Environmental Health, Division of Environmental Hazards and Health Effects (DEHHE) provided *pro bono* support and personnel. Both of these organizations, as well as private sector companies loaned key personnel to implement various APELL-related seminars and training programs, chemical risk assessments and training in medical response to toxic exposure. In addition, CEPPO, DEHHE and Transport Canada graciously provided various technical references and chemical safety training programs at no cost.

The LAMP approach to environmental disaster mitigation and prevention had several unique aspects, namely:

- A broad-based approach that mobilized private sector resources and equipment to complement the normal public sector responsibilities for fire safety, hazmat handling and medical response;
- Involvement of the medical community in emergency response planning and training for medical personnel in industrial accident response and materials safety data sheet use;
- A proven success in communication of risk and mobilizing community participation in emergency preparedness and response exercises;
- The establishment of prototype programs at the local level that serve as operating examples to guide policy and programs at the national level in each country, and
- Involvement of the insurance industry in risk assessment and the linkage between improved accident mitigation and prevention and reduced catastrophic risk exposure on-site and off-site.

<u>Step Seven - Choose More Sites and Replicate Programs</u>

LAMP relied on replication from one site to another to ensure that donor funding is maximized and that program initiatives continue to improve safety conditions once a program has been completed. This replication typically utilized key persons from the initial LAMP sites to instill new site leaders with enthusiasm and confidence that they could effectively take charge of their own safety, even in a complex technical arena involving toxic or explosive chemicals.

<u>Step Eight - Review, Revise, and Redirect activities</u>

Over the course of a multi-year LAMP program, changes inevitably affected the course of program events. Elected officials changed. Industry leaders came and went also, requiring amendments to the action plans for each LAMP site. All of this was a natural part of the process of implementing LAMP and underlined the need for flexibility from the start. In spite of external changes that may occurred, LAMP remained effective by continuing to work with motivated groups, focusing on the ultimate goals of the program, and adapting these goals to conditions at the local level.

Observations in the Four Countries

Each LAMP program worked towards its objectives and outcomes through a number of different activities designed to increase industrial and community awareness of chemical risks, to develop prototype industrial emergency response plans, and to improve response capabilities to technological emergencies and natural disasters. By working with the community as a whole, LAMP programs fostered greater involvement of local government, industry, and community leaders in accident mitigation and prevention activities. In this way, the LAMP program achieved a catalytic effect by bringing groups together in support of the goals and objectives of the program, strengthening existing ties between these groups, and developing new ties to improve emergency response and planning capabilities.

LAMP program activities included the following range of initiatives:

- Awareness & Preparedness for Emergencies and Local Level (APELL) workshop/seminar to bring industry/local government/community groups together;
- Chemical emergency preparedness and accident prevention training;
- Risk assessment in process industries training;
- Workshops in communicating risk to the public and preparing the community for chemical emergencies;
- Periodic emergency response exercises involving local government, industry and community;
- Specific skill training for first responders in industrial and chemical fire safety and control of hazardous materials incidents and spills (fire, police and medical response);
- Training on safe transportation of hazardous materials;
- Computer-aided management of emergency operations (CAMEO™) - a computer software program for emergency planning and response developed by U.S. Environmental Protection Agency (EPA) and the National Oceanic and Atmospheric Administration (NOAA); and
- Assistance in the establishing Local Emergency Planning Committees or crisis groups.
- Assistance in establishing national emergency preparedness and response networking organizations to coordinate policy and replicate APELL/LAMP sites around the country.

Altogether, LAMP utilized 54 experts in such diverse fields such as risk assessment, emergency planning, hazmat emergency response (including medical response), CAMEO™, and community outreach and education, to participate in 159 different events and activities. In addition, there were dozens of local experts utilized in the different programs in LAMP Programs in India, Indonesia, Mexico and Thailand.

In general, the lessons learned validated the bottom-up LAMP approach in establishing prototype examples of improved community-based emergency preparedness at selected sites that could be replicated at other sites while influencing and informing country-wide policies and institutions.

Impact

Good progress toward long term, effective collaboration between industry, government and local community to implement appropriate disaster prevention and mitigation measures was indicated at several high-risk sites in the four target countries. In most cases, there was good support from a national nodal agency for replication of LAMP programs at multiple sites throughout each target country.

The sites where that made the most progress were:

Mexico: Vera Cruz State (Coatzacoalcos, Vera Cruz, Orizaba & Poza Rica)

India: Madras, Mumbai, Cochin, Haldia, Kanpur and Vadodara

Thailand: Map Ta Phut and Bangpoo Industrial Estates

Indonesia: West Java State (Cilegon & Tangerang) and Gresik/Surabaya

Although the major focus on the LAMP program was in India, Indonesia, Mexico and Thailand, some LAMP and/or APELL activities were carried out in Egypt, Chile, Colombia, Costa Rica, Jamaica, Poland, Turkey and Venezuela. Between 1992 and 1998, the LAMP program was implemented in whole or in part in over 20 communities.

LAMP Program Benefits

The LAMP program focused on emergency prevention and preparedness at the local level in order to improve capabilities at selected high-risk sites in each target country. Thus, the major benefits and impacts of LAMP programs were defined by changes and improvements to emergency systems at the local level. While the major measurable impacts were at the local level, the long-term replication of activities and experience to other high-risk sites in target countries was also an important national aspect of each program.

Local Level Accomplishments

- Increased industry sensitivity to risk reduction and accident prevention and increased adoption of emergency preparedness and response plans;
- Increased coordinated disaster preparedness and prevention in high-risk communities;
- Increased number of trained technological accident responders using more advanced emergency response equipment as purchased by local industries and some local governments;
- Increased community involvement in disaster prevention and response for defined accident scenarios;
- Periodic and regular testing of local emergency preparedness and response plans; and
- Strengthened local, regional, and national technological disaster response networks.

National Level Impacts

- New legislation supporting the formation of local emergency coordination committees with representatives of the community and industry, as well as government;
- National level disaster planning and coordination committees with representation from industry associations, insurance groups, government ministries and national service organizations; and
- Resources made available for purchase of emergency response equipment and replication of program to more sites.

International Level Impacts

- Other countries have adopted a community-based emergency preparedness approach to empower local communities to take charge of their own safety from the risk of toxic and hazardous chemicals; and
- Recognition of accomplishments from international agencies.

Funding

Foreign Exchange Costs

OFDA contributed U.S. $3.5 million over five years, an average of $219,000 per country per year and an average implementation period of three years in each of the four countries. In-kind Contributions amounted to some U.S.$650,000.

Local Costs

Unfortunately, there was no mechanism set up for tracking local contributions for seminar and training facilities, fees for local experts, expenses for participants, salaries of local APELL/LAMP coordinators and equipment, materials and supplies for emergency exercises. All of these expenses were borne by local governments, industries and participants.

Authors' Biographies

Antony Marcil is the 2001-2002 Planner in Residence, School of Planning, Faculty of Environmental Studies, University of Waterloo. He has an MBA (finance/accounting) from Concordia University and a Bachelor of Mechanical Engineering from Sir George Williams University. He is also the senior policy advisor to Dr. Carolyn Bennett, M.P., Toronto St. Paul's. Previously, he was President and Chief Executive Officer for the last 10 of his 15 years with the World Environment Center. WEC is an independent, non-profit, non-advocacy organization founded with a 1974 United Nations grant. The Center develops and manages industry-government partnerships worldwide and designs professional development programs for corporate environment, health and safety executives. While at WEC, his work ranged from assessing mercury pollution due to small-scale gold mining and the formulation of market-based preventive strategies in The Philippines to establishing a 270-hour environmental consulting engineer's training course that certified 180 engineers in Mexico. He has lectured on pollution prevention and eco-efficiency in academic, government and industry settings around the world. In 1997, he was included in the first, worldwide Top 100 Figures in Environment, Sustainable Development and Social Issues, by The Earth Times of New York and Geneva.

Richard Williams holds a Bachelor of Industrial Engineering from Montana State University and a Masters in the same discipline from Columbia University. He first worked in industrial engineering for Merck Pharmaceuticals, General Electric and then the Franklin Research Institute, where he specialized in the human aspects of operations analysis and training. He then joined the U. S. Peace Corps where he designed training courses and techniques for volunteers in the U.S. and then served in India. He then spent 11 years designing and implementing training programs for the electric power and the telecommunications industries in Iran, leaving just days before the Islamic Revolution in 1979. From there, he joined the U.S, Agency for International Development in Egypt and then in Washington, D.C. before finishing up his government service with the U.S. Trade Development Agency. In 1990, he was named Senior Fellow and he opened the Washington, D.C. office of the World Environment Center from which he retired eight years later. In the interim, he managed the logistics for the establishment of the Regional Environmental Center in Budapest, managed the Local Accident Mitigation and Prevention (LAMP) program from inception to final report and oversaw industrial eco-efficiency programs in Latin America.

The International Emergency Management Society
9th Annual Conference Proceedings
University of Waterloo, Canada, May 14-17, 2002

WHAT'S THE BIG DEAL ABOUT TEMPORARY HOUSING?

Types of temporary accommodation after disasters: example of the 1999 Turkish earthquake[1]

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Keywords: temporary housing, temporary accommodation, planning, recovery, disasters, Turkey

Abstract

In this paper the author describes nine types of temporary accommodation that are commonly used after disasters. This description includes: the physical characteristics of each type, its effect on family recovery, and its function in the reconstruction continuum. Information is drawn from the author's field research in Turkey after the 1999 earthquakes in the Marmara and Bolu regions, as well as from other published case studies. Temporary accommodation refers to lodging provided for, or built by, the affected population as a place to stay in the interim between the immediate relief phase and the later reconstruction phase. It serves as a safe, private place where the family can begin to recover and go about their daily activities sooner, rather than later, after the disaster. This paper emphasizes how different types of temporary accommodation can be the best-fit option, depending on the particularities of the specific disaster and the timeline for permanent reconstruction. It is Part 1 of a 2-part series on temporary accommodation after disaster. The second paper, Part 2, is titled "Planning considerations for temporary accommodation," and examines the issues that providers, such as governments, non-governmental organisations (NGOs) and aid organisations, need to look at before deciding on a strategy for post-disaster temporary accommodation.

1. Introduction: Filling the Gap

In 2001, 256 million people were affected by disasters, well above the previous decade's average of 211 million people per year. While the number of deaths attributed to disasters has decreased in the last twenty years, the number of people *affected* by disasters has increased quite substantially. Relief and reconstruction for these populations after disaster is an on-going concern of many governments, non-governmental organisations (NGOs) and international agencies. However, the Red Cross World Disaster Report 2001 points out the need for research into managing the 'gap' in time that exists between the relief period and the reconstruction: "There is gap: the relief stops…often a year or more goes by between the disaster and [the start of] reconstruction. People can't wait that long…they begin rebuilding their lives hours after disaster strikes. They aren't interested in relief—they are interested in recovering. That is when people need technical

[1] This paper is Part 1 of a 2-part series on temporary accommodation after disasters. Part 2, titled "Planning Considerations for Temporary Housing" is available on the I-Rec website at www.grif.umontreal.ca

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assistance to reduce future risk" (IFRC 2001). Technical assistance is a complex process that includes, among others, financial aid or incentives, mobilization of resources, social programs and physical construction.

One of the key aspects to filling this gap is finding a suitable lodging solution that allows the affected population to begin rebuilding their lives and to do so quickly. There are many types of *temporary accommodation* that can be implemented after a disaster to fill the housing gap between the immediate relief phase and the results of the permanent reconstruction. Types of temporary accommodation include, but are not limited to, tents, prefabricated temporary housing, shelters in public facilities, homes of family or friends, self-built shelters, or rented apartments. Usually several types of temporary accommodation are used concurrently to fill the housing need of the entire affected population. In some cases, temporary accommodation can be used as an effective housing solution not just to fill the gap, but can continue to be used through more than one phase of the post-disaster rehabilitation process.

Each type of temporary accommodation has its own set of short-term and long-term implications, and some types are more suitable than others, depending on the particular disaster situation. Therefore, the decision to implement a particular temporary accommodation strategy or strategies must be based on knowledge of the short-term and long-term implications of each and an understanding of the particular characteristics of the disaster situation.

After a disaster, families are in need of a place to live, a place to restart, a place to take responsibility for what they have, a place to regain control over their lives for their economic, physical and emotional well-being. If temporary accommodation does not promote this process of reestablishment at the household level, it can hinder the overall recovery of the population and of the region as a whole. It is for this reason that temporary accommodation, and the chosen type of accommodation, is of particular concern after a disaster. In fact, temporary accommodation is inevitably an integral part of a family's recovery process after a disaster, and the type and availability of temporary accommodation can contribute to or hinder the recovery process.

The temporary accommodation used after the devastating 1999 earthquakes in Turkey illustrate the possible types that can be used after a disaster (Johnson 2000). This paper, which is part 1 of a 2-part series, describes the types of temporary accommodation used in Turkey. The paper considers both the short-term and long-term implications of each type. The second paper, part 2, "Planning considerations for temporary accommodation," specifies what planning issues need to be considered before governments, NGOs and aid organisations reach a decision as to the type of temporary accommodation that is necessary or the most appropriate[2].

Incidentally, I would like to point out that one should not look at the question of temporary accommodation without considering that the provision of aid after disasters is a political process. International organisations, NGOs and governments are subject to their political agenda and strategies, which unfortunately can have the tendency to override humanitarian concerns. Although it may often be the case that temporary accommodation decisions are politically biased, in this paper I take a politically unbiased view of its provision; specifically, that the decision as to the type of temporary accommodation to provide after a disaster is or should be based on the best-fit solution and not on political agendas.

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[2] This second paper, part 2, "Planning considerations for temporary accommodation" is available on the I-Rec website at www.grif.umontreal.ca

2. Material and methods

This paper (Part 1) describes the types of temporary accommodation commonly used after a disaster, taking the Turkish example as a case in point.

To define where temporary accommodation lies on the reconstruction continuum, in this paper I begin with an explanation of the stages of post-disaster housing as they are defined by Quarantelli (1995). This is followed by a short description of the 1999 earthquake disaster in Turkey. The next section describes the types of temporary accommodation used, firstly in Turkey and secondly, in other disasters. The last section draws conclusions and highlights the most important points.

There are nine types of temporary accommodation used after disasters, as found in Turkey and elsewhere. While doing field research in Turkey, there were five main types of temporary accommodation I observed and recorded. These were: prefabricated temporary houses, wooden temporary houses, paper temporary houses, winterised tents, and self-built shelters. There are four types of other temporary accommodation referred to in other case studies, which are mobile homes, public facilities retrofitted as lodging, homes of family or friends, and rented apartments.

This paper describes the physical characteristics of each type, its effect on family recovery, and its function in the reconstruction continuum. The information presented here is derived partly from my field research in the earthquake-affected region of Turkey in June and July 2000, approximately ten months after two devastating earthquakes in the Marmara and Bolu regions of Turkey in 1999 (Johnson 2000). Additional information is also taken from other published case studies on temporary accommodation from various disasters in the United States; the 1995 earthquake in Kobe, Japan; the 1999 floods in Venezuela; and elsewhere.

3. Definition of Terms: Stages of Post Disaster Housing

In disaster research the terms "housing" and "sheltering" are often used interchangeably, with little distinction between the terms. The vagueness apparent in these terms must be clarified to precisely define the phenomena of housing after a disaster. Quarantelli (1995) situates the concept of ideal: "In social science, the ideal does not refer to [what is] desirable, but how the phenomena would look like if it existed in a pure form. Thus, the [ideals] we advance are not intended to be exact descriptions of social reality but as ways of thinking about such realities." Quarantelli then defines the four stages of housing after a disaster as:

1. Emergency sheltering
2. Temporary sheltering
3. Temporary housing
4. Permanent housing

Actual or potential populations seeking quarters outside of their own permanent homes for short periods utilize *emergency sheltering*. Emergency shelters are typically used for a few hours or possibly for a one-night stay. This stage does not require the arrangement of food for the affected people since the stay is so short. *Temporary sheltering* refers to the populations' temporary displacement into other quarters with an expected short stay. This could take the form of a tent, a second home, a family member's/friend's house, a motel, or a public facility where people will stay for more time than just the height of an emergency. There is no attempt to re-establish household routines; however, there must be an arrangement for the provision of food. The distinction between *housing* and *sheltering* is made on the basis that *housing* involves the resumption of household responsibilities and activities in the new living quarters, whereas during *sheltering*, normal daily activities are put on hold.

In addition to the four terms, as defined above by Quarantelli, in this paper I also use the term *temporary accommodation.* The term *temporary accommodation* is used to refer to the all the different types of temporary lodging commonly utilised after a disaster. It is important to distinguish between *temporary accommodation* and *temporary housing*, as *temporary housing* usually refers only to very specific types of *temporary accommodation* i.e. dwellings clustered in settlements and built by organisations using industrialised components and standardised designs. But *temporary accommodation* can also take the form of tents, self-built shelters, mobile homes, homes of family or friends' homes, or apartments, where the family will resume their household responsibilities and activities in a location that is intended to be temporary.

Permanent housing refers to the affected population returning to their repaired or rebuilt houses, or moving into new quarters in the community. In most disaster situations in developed countries there is a sharp distinction between temporary and permanent housing. However, in less developed countries this distinction can be blurred: what is initially intended as temporary housing can become permanent housing over the long-term, particularly of none or insufficient formal permanent housing is constructed.

4. Turkey: The 1999 Earthquakes in the Marmara and Bolu Regions

In the latter half of 1999, two devastating earthquakes shook the Marmara and Bolu regions of Turkey, the industrial heartland of the country to the east of Istanbul. The first and larger earthquake on August 17th (M7.4) caused widespread damage to the towns of Gölcük, Yalova and Adapazari as well as the industrial town of Izmit (population 1 million) and eastern parts of Istanbul. The second earthquake on November 12th (M7.2) largely affected the mountainous towns of Düzce and Bolu, about 100 kilometres to the east of Izmit (fig. 1). It is estimated that, in total, 380,000 buildings were damaged or had collapsed. A total of 120,000 dwellings were damaged beyond repair leaving more than 250,000 people in need of housing. The combined death toll from both earthquakes is recognized as being around 18,000.

Fig. 1: Towns in Turkey affected by the 1999 earthquakes (IFRC 2000)

The Turkish government instigated a three step accommodation strategy for those affected by the earthquake, beginning with the provision of temporary shelter, then temporary housing and later permanent housing. Tents were provided as temporary shelter for earthquake survivors throughout the affected areas immediately following both earthquakes. Since the winter after the earthquake was quite severe, relief organizations distributed as many winterised tents as possible. During the first winter, as many as 135,000 people stayed in 109 tent camps established both inside and on the outskirts of the cities and towns in the affected region. Many people were also living in small self-provided tent camps set up near their destroyed homes or they constructed self-made structures to serve as temporary lodging.

In October 1999 the Turkish Ministry of Housing announced plans to provide approximately 47,000 prefabricated temporary houses to accommodate up to 151,000 people affected by the August earthquake. This plan was extended after the November earthquake to include survivors in need of housing in the newly affected areas. In August 2000, the first anniversary of the earthquake, governments and NGOs had provided 42,000 prefabricated houses, housing a total of 150,000 people. By then, the majority of the population were set up in temporary housing, but approximately 30,000 people were still living in tents and 70,000 people had secured their own temporary accommodation.

5. Types of Temporary Accommodation

The following descriptions of the types of temporary accommodation often used after disasters is based on what I observed in Turkey, as well as types of accommodation documented by other researchers in their case studies of other recent disasters. Based on my field research, several types of temporary accommodation were provided, i.e. built, by governments, NGOs and aid organisations for the affected population, though the families may work with the agencies in the design process or the construction of the temporary accommodation. Other types of temporary accommodation necessitate that the users take a more active role in securing their own lodging. However, governments, NGOs and aid organisations have an organisational, managerial and provisional role to play in all types of temporary accommodation.

Before beginning an examination of the nine types of temporary accommodation, I would like to remind the reader that in this paper, I make a distinction between *temporary accommodation* and *temporary housing*. I use *temporary accommodation* to refer to all types of temporary lodging after disasters. *Temporary housing* specifically refers to housing provided by governments, NGOs and aid organisations that are usually constructed with industrialised components and standardised designs and commonly grouped together in settlements that include services and infrastructure.

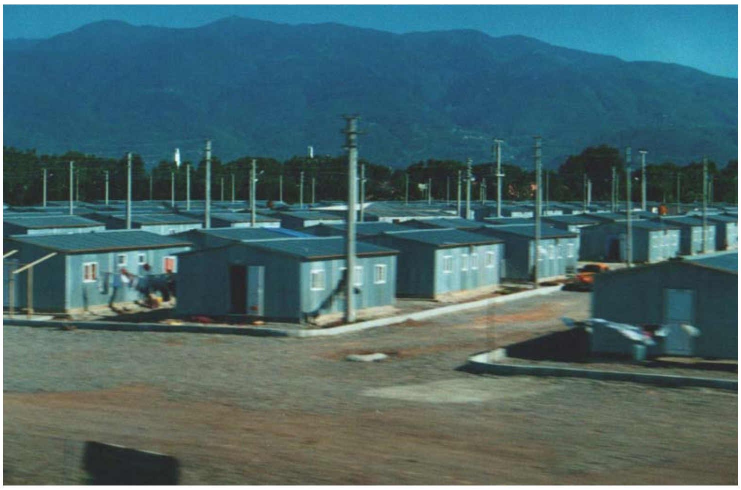
<u>Turkey case study: prefabricated temporary houses, wooden temporary houses and paper temporary houses</u>

Temporary housing refers to accommodation provided by governments or NGOs to house the affected population for the interim period between the disaster and the reconstruction of permanent housing. This housing is provided as soon as possible after the disaster—yet because of procurement, planning, and construction delays temporary housing can take up to a year to be built. The housing is built using industrialised components and standardised designs. Infrastructure—running water, sewage, electricity, and roads—are included in the settlement and dwelling design. The houses are grouped together in settlements that are serviced by public transportation routes, local businesses, garbage collection services and community centres. Large settlements are managed locally, although overseen by higher management. Governments or NGOs own the land or it is leased by these organisations from private landowners. The housing is then rented or leased to the inhabitant either free of charge or for a fee. Families qualify for temporary housing depending on the amount of damage to their former home and their possibilities of obtaining other types of housing. Temporary housing is intended to serve as a place for the families to resume their household responsibilities and activities for a duration of two or more years after the disaster. The longevity of the housing largely depends on the quality of the materials used and the quality of the infrastructure. Typical prefabricated metal or fibreglass houses, or quality wood or vinyl houses can endure several years while cardboard or low-quality wood houses may only last two or three years.

All villages, towns and cities in Turkey that were affected by the 1999 earthquakes participated, in collaboration with the federal government and NGOs, in constructing temporary housing settlements. The settlements are located both inside the urban areas and on the peripheries. They include basic infrastructure for water, electricity and sewage. While smaller settlements within the urban areas have as little as ten houses, larger settlements on the periphery contain up to 1400 units. Larger settlements include amenities such as central squares, play areas, shops, cafés, restaurants, community centres, daycares, medical units, and bus service. Most of the temporary houses have an adequate plot space around them so that the families can make additions to the house as needed, plant a garden, or generally personalize their home.

I found three major types of temporary housing constructed in the earthquake area: prefabricated, wood, and paper. All the units provided by the Turkish federal government are prefabricated (fig. 2). The prefabricated units vary slightly depending on the manufacturer, however they are all built on concrete slab foundations with plumbing and electricity. The units vary in size from 25 m² to 35 m². Units are comprised of one large multipurpose room, a kitchen and bathroom plus one or two bedrooms. Most of the units were manufactured in Turkey, though some were imported from other countries. Each unit was manufactured at a factory and brought to the site for assembly. Although the systems are similar, they vary slightly in size, layout and type of fixtures. In each building, there are two, three or four units back-to-back or side-by side. Kitchens are supplied with a sink, fridge and stove. Bathrooms include a toilet, sink, shower, and in many cases a washing machine.

Fig. 2: Prefabricated temporary houses in Turkey[3]



Some of the other units, such as those provided by various NGOs, are constructed on-site with wood (fig. 3). Each dwelling unit is either a freestanding structure, or a two or four-unit building.

[3] All photos included in this paper are from my field research in Turkey, referenced as Johnson (2000).

The wood frame units vary in size from 20 m² to 30 m². Each unit is outfitted with a kitchen area and a bathroom.

Another settlement, of particular interest, is constructed using paper tubes (fig. 4). These paper tube houses were also used after the 1995 earthquake in Kobe, Japan. Designed by Japanese architect Shigeru Ban, these structures are one-room freestanding units without plumbing. The buildings stand on a foundation of beer crates covered with plywood. The walls are constructed solely of paper tubes lined up vertically and supported laterally with steel rebar. The paper tubes act as outer walls and insulation; the inside walls are covered in cardboard sheets. The roof structure is constructed using a wood frame and paper tubes, then covered with canvas sheeting. Some inhabitants have fastened tarpaulins to the outside on the paper tube walls to protect the tubes from rain and snow. Makeshift kitchens have been added or constructed inside the buildings by the inhabitants. Two semi-public prefabricated bathroom units service the twenty-unit settlement.

Fig. 3: Wooden temporary houses in Turkey

Fig 4: Paper temporary houses in Turkey

It is apparent that these examples of temporary housing in Turkey positively influences the interim recovery of the population. Each family in temporary housing has a private place where family members can resume their household responsibilities. The plot allows for additions to the house and personalization of space. The temporary housing is located, for the most part, in a convenient location—close to work, schools, transportation and services—so the families are more easily able to resume their daily activities.

The life expectancy of the units depends on the type of materials used in the construction and this is reflected in the initial cost. The prefabricated units are expected to endure several years with proper maintenance. The wood units will endure less time and the quality of the building will decrease more rapidly. Although the paper tube houses are expected to be inhabitable for up to five years, I suspect that their quality will deteriorate within two to three years. The life expectancy of the building should be relative to the amount of time they are expected to be inhabited. Therefore, governments, NGOs and aid organisations may choose the type—and hence cost expenditure—of temporary housing based on the amount of time they expect the houses to be inhabited for.

It is ideal if the life expectancy of the housing matches the length of tenure available for the land the housing is built on. For the most part, the longer-lasting prefabricated units are located on government-owned land on the periphery of the city. The shorter-life wood units and paper units are located within the city limits and are built on land leased from private landowners. As one might expect, I found that the families living in the paper units made less permanent-looking additions and spent less time and money on the beautification and personalization of their property. The reason for this was that they were likely to be forced to move to a new location in the near future. Therefore, if the tenure at a certain location is intended to be for less time, for example, because of land ownership reasons, the expenditure on temporary housing at that location should be less than the expenditure at a location that is available for a longer-term—such as government-owned land. This is true both for governments, NGOs and aid organisations planning temporary housing and for families inhabiting the housing.

The use of temporary housing results in at least a three-stage housing process after the disaster—temporary shelter, temporary housing and permanent housing. It takes several months (and even up to a year) for the process of procurement, planning, and construction of temporary housing, so the population will need to reside in temporary shelter in the meantime. Once living in the temporary housing, the population will need a permanent housing solution before they can vacate the temporary housing. From the perspective of recovery, this three-stage strategy is beneficial because families have the best housing solution possible throughout the various stages of the recovery process. However, it is expensive. As the United Nations (1982) points out, temporary housing amounts to rebuilding twice over: the construction of the temporary housing plus the later construction of permanent housing. Depending on the disaster-stricken country, the quality of the temporary house may exceed or be equal to the quality of the pre-disaster housing. In these cases, often the temporary housing becomes permanent housing because there is insufficient money or resources to build enough permanent housing for everyone. If this 'permanency' of temporary housing is foreseen and planned for, it is not necessarily negative. However, the quality of the house and the infrastructure, as well as the location and placement of services must be planned from the outset with the inevitable possibility of permanency in mind.

Also, temporary housing can delay the permanent reconstruction because the process of temporary housing consumes the money, resources and time of the organisations assigned to the local disaster-affected region. Yet, if too much time passes before the reconstruction process is completed and people are forced to live in dilapidated temporary housing, this can negatively affect their recovery process (United Nations 1982).

Turkey case study: winterised tents

Winterised tents, although typically thought of as *temporary sheltering*, can be used over the longer term as *temporary accommodation*. Governments, NGOs and aid organisations provide them for disaster situations where the climate dictates the need for more protection from the elements than just regular relief tents. In Turkey, relief tents were provided immediately after the earthquake. These were replaced a few months later by winterized tents, which offered a warm shelter from the elements the first winter after the earthquakes. In the spring, as temporary housing became available, the majority of the winterised tent residents were moved into temporary housing. However, during my field visit ten months after the earthquake, many settlements of winterised tents still existed and were being inhabited by those who had not yet secured temporary housing (fig. 5).

Winterised tents are made with waterproof fabric and metal structure with a floor and insulation. They usually have a few soft plastic windows and regular framed door. The winterised tents in Turkey were provided by the Turkish military, and therefore resembled military tents. This type of accommodation does not include a kitchen or a bathroom, but they may be connected to electricity. They are erected in settlements or distributed to families who may erect them near their damaged home. In Turkey, most of the winterised tents were constructed in settlement clusters, however some were distributed to families who erected them on or near their property. Many of the families in the settlements built a simple kitchen addition for home cooking (fig. 6). Semi-public prefabricated bathroom units were provided, and one bathroom unit would serve several families.

Fig. 5: Winterised tent settlement in Turkey

Fig. 6: Winterised tent additions

From the perspective of recovery, the winterised tents in Turkey allowed the families a moderately comfortable private space where they could resume their daily activities. With the addition of a kitchen, the families could prepare their own food and no longer had to rely on aid organisations for meals. I visited many families who were still living in the winterised tents during the summer when I was there. Ventilation in the tents was not the best, so families spent much of their time outside under makeshift covered verandas near the tent. The families, who erected tents on or near their property, would use their damaged home for living and cooking and would sleep in the tent, where they felt it was secure from the potential danger of another earthquake.

In the reconstruction continuum, winterised tents can serve as what Quarantelli (1995) refers to as both *sheltering* and *housing*. In Turkey, winterised tents were erected to serve only as temporary shelter before the temporary housing was built. If they have been stockpiled, they are relatively quick to arrive and easy to set up. Families can take part in erecting their tent. If there is enough space around the tent to build a simple kitchen and a veranda, the winterised tent can serve as temporary housing. Of course, the winterised tent will not work as well if it is to be a temporary housing solution over the medium to long-term, like two to ten years. However, I observed that these tents could suffice as temporary housing in a situation where the permanent reconstruction takes place soon after the disaster—within one to two years. If permanent housing will be available quickly, the population can stay in winterised tents, since it is less costly and resource-consuming than temporary housing, yet they allow the families to shelter from the elements and to have a private place to resume their daily activities.

Turkey case study: user-built shelters

There are many examples of user-built shelters that serve as temporary accommodation. Families erect user-built shelters using recycled materials or materials distributed by NGOs and aid organisations, such as wood, plastic sheeting and corrugated metal sheets (fig. 7). Usually there is no infrastructure—electricity or running water—unless the family is able to connect them somehow.

In Turkey, many families built shelters on their property on near their former home (fig. 8). The shelter serves mainly as a place for sleeping while other household activities take place inside the damaged home. Families did not want to sleep in their damaged home because they feared another earthquake would come at night and harm them when they were sleeping. The first earthquake on August 17th occurred at night and many thousands of people died because they were sleeping and therefore did not feel the first smaller tremors that occurred before the large one. Had the earthquake come during the day, many people would have felt the pre-shocks and they would have left their home to a safer location. Because of this, families felt it was safe to be in their home during waking hours, but preferred to sleep in the self-built shelter, where they believed they were out of harm's way.

User-built shelters are inexpensive from the perspective of provision because governments, NGOs and aid organisations may only need to provide materials. There is no cost or time associated with procurement, planning and construction. Families must have land available near their former homes to build the shelters. Because families are located helter-skelter and are not organized in settlements, it may be harder, however, to deliver other types of aid, such as food and hygiene kits, medical and psychological support and social programs.

Fig. 7: User-built shelters in Turkey

Fig. 8: User-built shelters near damaged apartment buildings in Turkey

Like winterised tents, user-built shelters serve as temporary shelter and can serve as temporary accommodation if the reconstruction process occurs soon after the disaster. Leaving temporary shelter and accommodation up to the people allows governments, NGOs and aid organisations to dedicate more time and resources to permanent reconstruction. But, if the reconstruction process lags for whatever reason, there is a risk that the shelters may remain too long and develop into slums, which may hinder recovery in the long-term.

Other case studies: mobile homes

The examples of mobile homes as temporary accommodation come from case studies of American disasters (Bolin 1982 and Bolin and Stanford 1991, 1990). The United States Federal Emergency Management Association (FEMA) provides mobile homes or trailers as temporary housing if the disaster is declared as a national emergency. Typically the families are loaned the units for six months while they rebuild their permanent home, however this may be extended if the situation warrants. After the loan period, the units are reclaimed by FEMA, stored, and re-used for the next disaster.

The mobile home units include a kitchen, bathroom, common area and one to three bedrooms. They are heated and have running water as long as they are connected to an infrastructure system. In the case of the likelihood of high winds, the units must be secured to the ground. If the recipients are landowners, the mobile homes are placed on the family's property. If the family does not have land, the units are placed on leased or government-owned land in settlement clusters or in existing trailer parks. FEMA provides the unit, and it is the responsibility of the local government or family to secure infrastructure for electricity and water.

From the perspective of recovery, the mobile homes allow a private place for the family to resume their household responsibilities. If the unit is located on the family's property, the family does not suffer from any relocation inconveniences, and they can oversee the reconstruction of their home.

On the reconstruction continuum, mobile homes serve the purpose of temporary accommodation only. The mobile homes are quick to arrive and install in the needed location. Depending on the locale of the disaster in relation to the storage location, the units can be made available within a couple of weeks after the disaster. The provision of mobile homes does not hinder the reconstruction process because they arrive as self-contained units; they do not drain construction, management or planning resources in the disaster-affected area. In the American example, there is little risk of mobile homes becoming permanent, since FEMA has a strict policy of reclaiming the units as soon as possible. FEMA's strict reclamation policy pressures the families to find a permanent housing solution quickly. In past cases, it was found that families who had less money to build their permanent home inhabited the mobile units longer. If the family had to rebuild their home themselves or rely on kin or friends to help them, it generally took longer to rebuild than if the family was able to hire contractors to rebuild their home. Therefore, they would end up living in the temporary mobile home units longer.

<u>Other case studies: public facilities retrofitted as lodging</u>

In many disaster situations, public facilities, such as schools, community centres and hospitals are used as *emergency* and *temporary shelter* immediately after the disaster. Families are given floor space in a public facility to sleep and to keep their belongings. Governments, NGOs and aid organisations look after the management of the facilities as well as the provision of food and other aid. In some cases, families with no other place to go will stay in the public facility well into the *temporary accommodation* phase. That is, they will begin working, going to school and generally resuming their daily activities while still residing in the public facility. Harada (2000) documents the use of public facilities as lodging after the 1995 earthquake in Kobe, Japan.

Public facilities retrofitted as lodging work well as emergency or temporary shelter; however, they have serious drawbacks as temporary accommodation. Public facilities do not offer a great deal of privacy for the families, even though as time passes, families will make adjustments to their space, such as hanging curtains, to create more privacy (Harada 2000). Management often imposes curfews for the residents to maintain calm at night. Since families do not have a place to prepare meals, the management organisation must provide meals for the residents. Meals are usually served at specific times and people must be available to eat at those times. While this is considered normal behaviour for a short while during the temporary sheltering stage, it can become a problem during the temporary accommodation stage, since it does not allow the families to regain responsibility for their daily life. It has been found that the longer people must rely on outside aid, the more difficult it is for them to be rehabilitated (Ellis and Barakat 1996). Over time, people lose their drive and tend to become despondent if they do not have control over basic things such as meals and the time to return home. In extreme cases, such as after the 1999 floods in Venezuela, this can lead to violence and even to drug abuse (IFRC 2001).

The benefit of using public facilities as temporary accommodation is that it pressures governments, NGOs, aid organisations and families to find a more permanent housing solution quickly. The families will either pressure the agencies to help them or they will take care of the situation as best they can themselves. It is, however, dangerous when people are left in public facilities without prospects of finding other housing, or with no voice to influence those agencies that can help them.

<u>Other case studies: homes of family and friends</u>

Little formal documentation exists as to the use of family or friends' homes as temporary accommodation. While we know that many families often stay with other family members or friends after a disaster, it is difficult to estimate how many people do this and for how long. However, Bolin (1982), in a study on long-term family recovery from disaster, finds that while people will often stay with friends or family for emergency and temporary sheltering, they prefer to have their own dwelling during the temporary accommodation stage. He interviewed people living in FEMA-provided mobile homes in the United States and found that they were relieved to have the mobile home because it meant that they didn't have to impose on someone or depend on others for their accommodation. While this may be true in the post-disaster situation in America, this may not be true in other countries i.e. people may feel more comfortable staying with family or friends than living in another type of temporary accommodation. However, this is point is uncertain.

From the perspective of provision, staying with family or friends is certainly inexpensive. It also allows governments, NGOs and aid organisations to concentrate funds and resources toward reconstruction activities.

Other case studies: rented apartments

If, after a disaster, there remains an undamaged stock of apartment housing that is available, governments, NGOs and aid organisations may lease the apartments and offer them to the families whose homes were damaged. Usually families will be given an allowance by these organisations to offset the cost of the rental while their damaged home is being rebuilt. This is an ideal situation; families have a private place to reside while they recover and it does not necessitate the construction of temporary accommodation. Therefore, families and agencies can focus on reconstruction activities.

6. Conclusions

To conclude, I would like to reiterate the important points covered in this paper. These are: the 'gap' of time between relief and reconstruction; the role of temporary housing in the post-disaster recovery process; the different amounts of durability of different types of temporary accommodation; the role of governments, NGOs and aid organisations in the process of temporary accommodation; and the temporary accommodation types in Turkey.

After many disasters, there exists a 'gap' between the immediate relief phase and the later reconstruction phase. In the immediate aftermath of a disaster, relief aid is poured into the affected region to help people cope with the crisis. Later, post-disaster reconstruction programs help to rebuild the communities and ultimately increase the level of development in the region. However, in many cases, families affected by disaster do not receive proper support in the interim between these two phases; they effectively fall into the 'gap' between relief and reconstruction. I illustrate this point by using a quote from the Red Cross World Disaster Report 2001: "There is a financial gap in international aid. Relief funds need to be spent within three months, pressuring agencies to pursue short-term projects. Emergency aid has media impact and quick, tangible results—therefore attracting funds rapidly. Later on, long-term recovery projects bring measurable development and lucrative contracts. But transitional aid had less appeal, more complications and therefore attracts less funding" (IFRC 2001).

Temporary accommodation is an integral part of the recovery process. It gives families a safe and private place from which to resume their daily activities and to so quickly after the disaster. It is a place for families to restart their lives and ultimately benefit the recovery of their economic, physical and emotional well-being. If families do not have access to adequate temporary accommodation—accommodation that allows them to resume their daily activities—it may affect their recovery in the long-term and therefore the recovery of the region as a whole.

There are at least nine different types of temporary accommodation that are commonly used after disasters. Each type differs in physical form, in cost, in ability to aid recovery, and in procurement, planning, and construction time. Types of temporary accommodation will vary in their appropriateness depending on the particular disaster's characteristics.[4]

Different types of temporary accommodation have different levels of durability, i.e. some types will endure longer than others. It is ideal if the durability of the temporary accommodation matches the amount of time that it is needed for. For example, if the temporary accommodation will only be needed for two years because permanent housing will be available within that two

[4] Please see part 2 "Planning considerations for temporary housing," for a more detailed explanation. This paper is available on the I-Rec website at www.grif.umontreal.ca

years, there is no need to build temporary housing that will endure five to ten years. On other hand, if adequate numbers of permanent housing will not be completed until five to ten years after the disaster, the temporary accommodation must offer decent shelter until that time. Matching the durability of temporary accommodation to the amount of time it will be needed helps to maximize the time and monetary resources of governments, NGOs, aid organisations, and the affected families.

Governments, NGOs and aid organisations have an organisational, managerial and provisional role to play in all types of temporary accommodation. Some types of temporary accommodation, like temporary housing, winterised tents, mobile homes, and public facilities retrofitted as lodging, are almost completely provided by governments, NGOs or aid organisations i.e. they are funded, planned and constructed *by* these organisations *for* the affected population. However, the families may work with the agencies in the design process or the construction of the temporary accommodation. Other types of temporary accommodation, such as user-built shelters or homes of family and friends are found or built by the families themselves. Here, the families take a more active role in securing their own temporary accommodation. However, agencies can take a role in helping families to build or find a place to stay. For user-built shelters, they can provide families with construction materials and help them to learn safe methods for construction.

The agencies in Turkey opted for a three-part housing strategy to house the more than a quarter of a million people made homeless from the 1999 earthquake disaster. This strategy included temporary shelter in the form of tents, temporary accommodation in the form of temporary houses and winterised tents, and permanent reconstruction. During my field research in Turkey, I found several types of temporary accommodation. Some, such as prefabricated temporary houses, wood temporary houses, paper temporary houses and winterised tents, were provided in settlements by the government, NGOs and aid organisations for the affected population. Other types of accommodation, such as self-built shelters, were constructed by the families next to or near their damaged home.

As this paper constitutes Part 1 of a 2-part series, the above conclusions are linked to a detailed analysis of planning considerations and to an overall conclusion.

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WOMEN'S ROLES IN THE 1998 CENTRAL FLORIDA TORNADO DISASTER RESPONSE AND RECOVERY[*]

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Abstract

This paper explores women's roles in Osceola County, Florida's response to and recovery from the community's worst documented tornado outbreak of February 1998. Six women were prominent in the community tornado response and recovery out of approximately 30 key players. Five of the six women performed traditional female work roles such as human services (coordinating personnel, feeding, and sheltering) and clerical duties. We found no evidence of formation of emergent organizations following the tornado disaster due in part to women's presence in the disaster response and recovery processes and the many innovative techniques that the community employed during response and recovery including free bus transit to the Disaster Relief Center and insurance coverage for volunteer workers. We foresee that the incorporation of more women and minorities into disaster management is likely to sensitize disaster practitioners' awareness of the disaster needs of varying groups and to satisfy the needs and concerns of all members of an affected community. Therefore, no needs of disaster victims will go unmet and thus no emergent groups will be necessary. We recommend more detailed research of women's contributions to innovative approaches to disaster management as well as further analysis of the relationship between a diverse disaster management structure and unmet disaster needs in a community resulting in emergent organizations.

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[*] This research was supported by the Natural Hazards Research and Applications Information Center at the University of Colorado-Boulder through the Quick Response Grant Program, which is supported by the National Science Foundation under Grant No. CMS-9632458. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the Natural Hazards Research and Applications Information Center or the National Science Foundation.

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Conceptual Framework

Disasters do not affect everyone equally—such phenomena are discriminatory (Blaikie et al. 1994, Neal and Phillips 1990, White and Haas 1975, Oyola-Yemaiel and Wilson 2000). An individual's place within the social structure determines the likelihood of he or she becoming a disaster victim. Vulnerability to such events differs between social groups with disaster victims more likely to be groups of individuals who have the least amount of power and resources in the social system to recover or escape from natural or technological hazards. Additionally, disaster victims who belong to one or more of these less-powerful groups will have more difficulty in the recovery process. Researchers have also found that traditionally less-powerful groups are less likely to be part of existing disaster planning, response, and recovery efforts (Enarson and Morrow 1998a, Peacock, et al. 1997, Neal and Phillips 1995, Phillips 1990, Bolin and Bolton 1986).

For example, the elderly are more apt to lack the physical and economic resources necessary for effective response, are more likely to suffer health-related consequences, and will be slower to recover from the impacts of the disaster (Morrow 1998, Tobin and Ollenburger 1992). Poorer households more often live in sub-standard and inadequately maintained housing, increasing their vulnerability to hazards (Peacock, Morrow and Gladwin 1997, Phillips 1993, Bolin 1982, Bates 1982). And, while the economic losses of the poor will be less in absolute terms, even minor losses can be devastating, relative to a household's stock of resources and assets. Ethnic differences have been found to affect ways in which people process warnings and respond to disasters (Perry and Mushkatel 1986). Language barriers often limit the access of minority groups to disaster warnings and disaster information such as that related to the government aid process (Aguirre 1988, Bolin and Bolton 1986). Worldwide, the population most at risk to disaster events is women (Enarson and Morrow 1998a, Blaikie, et al. 1994). Women typically have fewer resources, less autonomy, and greater caregiving responsibilities which serve to accentuate their hazard vulnerability and victimize them disproportionately at all stages of disaster (Morrow 1998, Enarson and Morrow1998a, Blaikie, et al. 1994).

Within the limited literature addressing women's roles in disaster preparedness, response, recovery, and mitigation, women have been found in several roles within "the gendered terrain of disasters"(Enarson and Morrow 1998a). The most commonly discussed role of women in disaster thus far is that of victim (Wilson 1999). Indeed, women are vulnerable to disaster impacts due to cultural norms and traditional gender responsibilities that give them little social influence or visibility in organizational and community decision- and policymaking. Because women are outside of the formal disaster planning, response, and recovery network, they may not have their voices heard or needs met.

In addition, women victims may often be considered dependents in need of saving by others rather than capable of participating in the disaster response and recovery. But many times these women who are victims do indeed help themselves to respond to and recover from disaster (e.g., Akhter 1992). There is significant evidence that groups of affected people who do not have their needs met through pre-existing social (organizational) means will organize among themselves in some fashion to satisfy them. Emergent or ad hoc organizations then arise (see Dynes' [1970] typology of organizational behavior in disaster) which form outside the structure of the official disaster relief network and are aimed to link with the "insiders" in order to acquire a fair share of the means for recovery. While commonly called emergent organizations, these groups often draw upon existing networks for labor and resources.

Gillespie (1992) discusses how network structures in already existing organizations can shift their functions and modify their goals during disaster in adaptation to the new environment. This arrangement is more efficient and cost-effective than the formation of entirely new organizations. Bates and Harvey (1978) have labeled groups that form between existing organizations and play coordinative roles to pool resources from many different sources coordinative interstitial groups. These groups serve to link the various social units that participate in a goal-oriented exchange relationship. An exchange interstitial group may or may not continue to exist contingent upon attainment of goals, expectations, and needs of the participants involved (Peacock 1991) as well as the scope of work, jurisdiction, and/or financial limitations of the parent organizations (Oyola-Yemaiel 2000). Following this concept, pre-existing women's groups or networks may be a source for leadership in such interstitial groups.

Women do indeed become actively involved in their communities and neighborhoods during disaster situations and have been key participants or leaders in emergent citizen groups in disaster-affected communities (Cox 1998, Viñas 1998, Neal and Phillips 1990, Massolo and Schteingart 1987). The emergent citizen groups fit into this traditional and local pattern of women's activism where women view their cause as an extension of their traditional gender role, as family caregiver (Poniatowska 1995). Enarson and Morrow (1998b), for example, found that women's formal and informal networks were central to both household and community recovery after Hurricane Andrew in 1992 where women's experience as community workers, informal neighborhood leaders, and social activists propelled them to take the initiative in organizing a disaster response coalition. Other women are highly involved as community workers and organizers in disaster-prone areas (Eade and Williams 1995), including neighborhood-based household preparedness programs (e.g., Faupel and Styles 1993).

Increasingly, women are becoming incorporated into the official disaster relief network as disaster volunteers, temporary relief workers, and permanent employees (e.g., Barnecut 1998, Robertson 1998). Due in part to professionalization, women are now more often found in official emergency management positions at the federal, state and local level (Wilson 1999, Enarson and Morrow 1998a, Enarson 1997, Drabek 1986). Women also continue to enter other emergency response organizations such as the police and fire departments in greater numbers (Chetkovich 1997, Martin 1980). These trends together with the fact that women traditionally participate in human service agencies such as the American Red Cross make their presence more prevalent in the emergency operations center (EOC) as representatives of important functional areas. Women's greater participation in the interstitial group of the EOC may provide less reason for outside ad hoc groups to form. Thus, women's needs may increasingly be met through existing organizations.

This phenomenon is not exclusive to emergency management. Increasingly, women participate in other arenas where interstitial groups are a key element of stakeholder participation. For example, the Florida Ecosystem (Everglades) Restoration Initiative utilized what Oyola-Yemaiel (2000) has described as network management coordinative interstitial groups (NetMIG). In these settings women contribute to the advancement of the greater goals, providing gender-specific expertise and reducing external pressures (Oyola-Yemaiel 2000).

In order to explore further the complex issues of women's roles in disaster recovery as well as in disaster-related emergent organizations, we examined a disaster-affected community to assess where women were located within the disaster response including emergent, ad hoc groups. Hence, the research question was: *What roles do women play in community disaster response activities?* Several sub-questions included: What roles did women have in the existing organizations?; Did emergent organizations form?; Were women involved in the emergent organizations?

Setting

Located adjacent to south Orange County (city of Orlando), Osceola County has a population of approximately 130,000 (Pierce 1995). Geographically the county contains two large lakes, West Lake Tohopekaliga and East Lake Tohopekaliga that rim the county's two largest cities, Kissimmee and St. Cloud. The two large lakes and many smaller lakes to the south comprise the

Upper Kissimmee Waterway Basin. Because of the many lakes, conservation areas and farmland in the southern part of the county, the population is small outside of the cities of Kissimmee and St. Cloud. Osceola County also contains half of Walt Disney World theme park, (the other half being in Orange County) located directly west of the city of Kissimmee.

Storms that swept across Central Florida in the early morning hours of Monday, February 23, 1998, spawned the deadliest round of tornadoes on record in Florida. Historically, ninety percent of Florida's tornadoes have winds under 72 miles per hour (Table 1). According to the National Weather Service, the several tornadoes that struck Florida on February 23, contained wind speeds ranging from 210 mph to 260 mph, due largely to the effects of El Niño atmospheric disturbances. According to Jim Lushine, a Miami-based National Weather Service warning meteorologist, in only two other instances has Florida been hit by tornadoes with wind speeds of more than 206 miles per hour: one in 1958 and the other in 1966. Both were El Niño years, and both times the storms hit Central Florida (*Sun-Sentinel* Feb. 24, 1998).

Table 1: Osceola County, Florida Tornadoes 1950-1995*
All times are Central Standard Time; add one hour for Eastern Standard Time

Date	Event #	Time	Dead	Injured	F** Scale	County Number(s)
JUN 08, 1960	017	1730	0	1	F1	097
APR 12, 1961	008	1515	0	1	F1	097
APR 04, 1966	001	0900	0	0	F3	097
APR 04, 1966	002	0715	0	0	F2	097
JUN 28, 1971	031	1430	0	0	F0	097
AUG 24, 1971	045	1630	0	0	F1	097
JAN 28, 1973	006	1115	0	7	F2	097
APR 15, 1975	036	0515	0	0	F0	097
APR 15, 1975	037	0850	0	0	F0	097
MAY 14, 1975	042	1850	0	0	F1	097
MAY 13, 1976	022	1800	0	0	F0	097
JAN 10, 1977	002	0550	0	0	F1	097
FEB 24, 1977	004	0804	0	0	F0	097
MAY 04, 1978	039	1350	0	1	F0	097
MAR 19, 1981	008	0100	0	11	F2	097
MAR 24, 1983	030	0510	0	0	F2	097
MAR 24, 1983	031	0550	0	0	F1	097
SEP 01, 1987	040	1440	0	3	F1	097
AUG 02, 1995	041	0304	0	0	F1	097

* Source: Tornado Project Web Link
http://www.tornadoproject.com/fujitascale/fscale.htm#top
** Scaling of event based on Fujita Tornado Scale

Florida is far from "Tornado Alley" where the nation's most severe tornadoes usually occur, yet is among the most tornado prone states. Unfortunately, Florida does not have tornado sirens such as those found in Texas, Oklahoma and Kansas, which sound to warn sleeping citizens of approaching tornadoes. Despite tornado watches and warnings all day and throughout the evening of February 23, many Central Floridians went to sleep on Sunday night with apparently little concern for such extreme weather.

Early the next day, tornadoes touched down in Brevard, Dixie, Manatee, Nassau, Orange, Osceola, Seminole, Sumter, and Volusia Counties. Forty-two people were killed and more than 250 were injured throughout the Central Florida area (*St. Petersburg Times* Feb. 24, 1998). Osceola County experienced the most severe impact of the tornadoes where 25 people were killed and 148 injured. Osceola County Office of Emergency Management estimated that the county sustained more than $37 million in severe damage to 150 homes, 200 mobile homes, 15 recreational vehicles, a strip mall, and about 30 businesses. Some damage was inflicted upon an additional 225 homes, 60 apartments, and 25 mobile homes (*The Osceola Sentinel*, March 6, 1998).

The path of the storm traveled from southwest to northeast crossing the mid-section of Osceola County. The tornado first passed over a restricted elders-only subdivision near the Poinciana Office and Industrial Park causing minor damage to some homes. It then proceeded to damage a few homes in the Campbell area southwest of Kissimmee proper. The tornado continued northeast heavily damaging The Shops at Kissimmee strip shopping mall with one entire wing completely collapsing. At that point the tornado passed over the northern tip of West Lake Tohopekaliga causing the heaviest damage to a neighborhood of lakeside homes as it reached the opposite shore.

After crossing an open field, then Highway 441, and leaving the Osceola County Stadium and Sports Complex unscathed, the tornado touched down around 2:00 a.m. at the Ponderosa Pines mobile home park near Boggy Creek Road where it caused the highest number of fatalities. Amidst virtually complete devastation, rescue workers recovered 10 bodies in the park. Nearly all of the community's 200 mobile homes and recreational vehicles were destroyed. The tornado then moved northeast crossing the Florida turnpike and touched down in the Lakeside Estates subdivision of single-family homes in the Buena Ventura Lakes area damaging about 400 homes and the Cypress Creek Elementary School. Rescuers and residents awoke to find flattened cars, wrecked homes, and aluminum siding embedded in trees.

Methodology

We visited Osceola County, Florida, on four different occasions for two days each on March 13-14, 21-22, 27-28, and April 3-4, 1998 in order to study this community's response to and short-term recovery from the tornado disaster. The research for this project was qualitative in design including interviewing, document analysis, and participant observation. Qualitative methods allow social scientists to learn by observing as they participate in a natural setting because many features of the social world are difficult to investigate with experiments or surveys. Rather some of the greatest insights into social processes can result from what appear to be very ordinary activities: observing, participating, listening, and talking (Schutt 1999).

Data were primarily collected through semi-structured, open-ended, face-to-face interviews. We sought to hear the answers to our questions in the respondents' own words. Thus, we did not ask standard questions in a fixed order but allowed the specific content and order of questions to vary from one interviewee to another. We employed snowball and purposive sampling techniques to gather interview data. We began by interviewing some customary leaders in the community (purposive sampling) such as the county emergency manager, the heads of the local Salvation Army and American Red Cross, other local volunteer organization leaders, and the police chief. During each interview, we asked the respondent if he/she thought there was someone else in the community that would be important for us to talk to (snowball sampling) regarding coordination of the community's tornado response. Our interviews included emergency management organization personnel, government and non-profit disaster relief organization personnel, as well as citizen/victims. In total, we conducted ten interviews. During our interviews we observed social interactions at the Disaster Relief Center (DRC) and at the Emergency Operations Center (EOC).

In order to avoid biasing our respondents, we did not reveal that we were primarily interested in women's roles in Osceola County's disaster response. Rather, we only asked our respondents whom they thought were the key individuals involved in the community's response. As expected, our respondents suggested more women participants in human services and more men participants in response activities, confirming the traditional division of labor patterns in disaster that has been documented elsewhere (Wilson 1999, Enarson and Morrow 1998a, Enarson 1997, Phillips 1990).

To supplement and further establish credibility and trustworthiness of ethnographic data (Erlandson, et al. 1993, Lincoln and Guba 1985), we gathered documents such as emergency management organizational reports, media accounts, census data, weather reports, some informational documents printed by volunteer organizations for citizen/victims, and other useful materials (Plummer 1983, Webb, et al. 1981). These documents illustrate the use of triangulation in support of the primary data source (e.g., interviews). Triangulation is the use of a number of different types of data gathering approaches in the study of the same phenomenon to corroborate, elaborate or illuminate the research (Erlandson, et. al 1993, Marshall and Rossman 1989, Kirk and Miller 1986, Lincoln and Guba 1985). In cases where we used news accounts, notoriously unreliable in disasters (Fischer 1994), we compared them to our interview data to assess their accuracy.

Findings

We found no evidence of formation of emergent organizations in Osceola County, Florida following the February tornado disaster. The response was handled using pre-established organizational channels. Conditions for the formation of emergent organizations were not present, thus, the opportunity for women to participate in these groups was nonexistent.

Why were there no emergent groups?

The Osceola County emergency operations center (EOC) Operations Manager stated: "Initially it was overwhelming. The sheer volume of…needs was tremendous…This county has never experienced anything like this…Were we prepared? No, we weren't." However, all indications from other respondents were that the official response was immediate and thorough. Victims with whom we informally interacted during our observations at the Disaster Relief Center were highly satisfied. Furthermore, the Salvation Army and the American Red Cross respondents believed that the response went extremely well, despite the lack of preparation.

Although historically this county has rarely experienced a disaster of this proportion, there were some very innovative techniques utilized during the response. For example, the Osceola County Office of Emergency Management (OEM) established a storeroom for citizens whose homes were destroyed to stow their possessions until they could find replacement housing. In addition, the OEM established two warehouses--one for incoming donations and one for outgoing donations. Osceola OEM was aware that the county would receive large amounts of unusable donations that could then be forwarded to other agencies that would be glad to have them. The OEM Operations Manager who was in charge of the activated EOC said that, "at one point we had nearly twenty semi's coming in and twenty semi's going out each day" with donations received and then subsequently forwarded.

Another unique or unusual response by Osceola County OEM was the coordination of volunteers. The OEM arranged to have photo identification badges made for each volunteer. This was accomplished through the development of a database, which kept track of volunteers' names, what skills and/or equipment they were able to provide, and their assignments. The database also tracked the volunteer needs within the community. In addition, the OEM covered volunteers with accident insurance and workman's compensation insurance during their volunteer work. According to the

Operations Manager of Osceola County OEM, there were close to 3000 volunteers who did 19,000 hours of work in the county in response to the tornado disaster.

In all, respondents had very few negative remarks concerning the response to the tornadoes. Rather, the respondents to whom we spoke praised the coordinated efforts among the community's organizations. Indeed, according to our respondents there was a high amount of coordination among existing agencies or organizations. For example, "town meetings" jointly organized by the city and county were instituted immediately after the event (the next day) in order to facilitate communication among all the agencies and organizations involved. Respondents reported that there were only minor communication problems that were resolved quickly. This may be due to the fact that the EOC was expressly utilized for coordination purposes among the victims, volunteers, and response organizations.

Coordination was further facilitated because most of the Osceola County departments and offices were involved in the response in some way. These departments included human resources, parks and recreation, road and bridge, collections, solid waste, billing office, and others. These offices provided labor, equipment, and communication to the response effort.

Another reason for the quick and thorough response is the fact that several of the key response agencies had members of their regional and state offices come into the county in order to facilitate the response. The Florida State Department of Emergency Management had a representative come in "almost immediately" after the tornadoes to work with Osceola County OEM in instituting the state-designed response plan. This same procedure occurred at the American Red Cross and the Salvation Army that both had members of their regional disaster response teams arrive within twelve to thirty-six hours of the tornado disaster. These teams' expertise in disaster response and their assistance in Osceola County were evident in the coordinated and swift response of these organizations for sheltering and donations (American Red Cross) and feeding (Salvation Army).

There was substantial evidence that the responders were concerned with making recovery from the disaster as easy as possible for individual victims in the community. One way in which this was accomplished was through the local bus system, LYNX, which established separate routes to transport tornado victims to the Disaster Relief Center (DRC). In addition, the DRC contained representatives from the Red Cross, the Salvation Army, Federal Emergency Management Agency (FEMA), Small Business Administration (SBA), some state agencies such as the Insurance Department, and United Methodist Disaster Relief (UMCorp) all in the same building. Such integrated and localized coordination of relief is significant in improving community recovery because it allows 'one-stop shopping'. In other words, cooperation and communication between agency members in the same location resolves victims' problems and requirements in a timely and convenient fashion. In this particular case, it was possible to coordinate in such a way because of the localized nature of the damage whereas in other disaster events the magnitude of damage may require relief efforts over an extended impacted area. In other cases, lack of space and/or unwillingness to work so closely together hinders this type of integrated relief coordination (Wilson, Neal and Phillips 1998).

Furthermore, 'coordination' took on a new meaning when most of the local social service agencies decided to set up a disaster relief fund for the donations they received. Every agency was then able to draw from this fund to practice their individual disaster relief work (e.g., mental health, food bank). This procedure was taken in order to balance the amount of disaster relief donations received by individual agencies since some received large amounts of funds and some received little or no donations. This is a significant component of the coordinative effort as non-profit agencies often have difficulty obtaining adequate operating funds.

As evidenced in the foregoing, the need for emergent groups did not exist in the aftermath of the tornado disaster in Osceola County due to the high degree of coordinated recovery efforts including town meetings among the participating agencies, quick regional and state assistance, and innovative techniques for meeting victim's recovery needs. Further, women played a part in the tornado disaster response and recovery possibly contributing to the non-necessity for emergent groups, which is described in the next section.

The role of women

Following Gillespie's (1992) thesis, a few women in the 1998 Central Florida tornado disaster became key participants within their existing organizational positions. For example, the director of the county personnel office was key in organizing the county's volunteer program. Kissimmee's assistant city manager was essential in facilitating the working relationship between city workers and the Osceola County Office of Emergency Management's response plans. In addition, the director of the local American Red Cross played an integral part in shelter provision. One of the co-directors of the local Salvation Army was crucial in providing food to both victims and rescuers. And, finally, the sheriff department's EOC representative served to link her department's response efforts with the OEM.

In total, six women were prominent in the community tornado response in Osceola County, Florida out of approximately 30 key players. Although the total number of important female responders is small compared to the total number of key responders, half of those six women (three) occupied non-traditional female working roles in their official positions. Three were in the more traditional female line of work of social services (director of personnel, director of the local American Red Cross, co-director of the local Salvation Army) but the remaining three occupied less-traditional female working roles: a police officer, a horticulture agent, and an assistant city manager (public official). Due to societal gender differentiation and the sexual division of labor, some kinds of work often become defined in people's minds as belonging to one sex and inappropriate for the other (Reskin and Padavic 1994, Lorber 1994). Thus certain occupations and jobs are typically performed by men and others by women. Traditionally female lines of work that employ millions of women include secretary, retail sales, food preparation, school teaching, nursing, and cashiering and bookkeeping (Reskin and Padavic 1994). Traditionally male lines of work include carpenter, automobile mechanic, truck driver, construction laborer, and firefighter (Reskin and Padavic 1994).

Even though three of the key female participants regularly occupied "less-traditional" working roles, two of them fulfilled more traditional female roles during the disaster response. One woman was responsible for coordinating volunteer workers and the second handled phone communication at the EOC. However, the third woman performed a much more substantial "non-traditional" role during the disaster response as the mediator between city workers and the county OEM response process. Thus, five of the six women performed typically traditional female roles during the disaster response. From what we know about women's participation in the formal disaster preparedness, response, recovery, and mitigation network this proportion of traditional female role performance could probably be expected. Not because women do not have the capacity to perform roles usually performed by men in disaster contexts, but rather due to lack of access to participate (Wilson 1999) because of the gender division of labor.

Women played a major part in the disaster recovery performing traditional female work roles such as human services (coordinating personnel, feeding, and sheltering) and clerical duties as an extension of their organizational positions. Conversely, none of the Osceola County emergency managers were women. Only one public official was a woman. Few public works or public safety workers were women. Thus, women did not play a major part in the disaster response and recovery performing non-traditional female work roles such as search and rescue, debris clearance, transportation problems, infrastructure repair, and public information, among others.

Discussion

Why did the majority of the women involved in the response and recovery operation in Osceola County, Florida perform traditional female work roles? For a long time a male workforce and work culture has traditionally dominated disaster management agencies (Barnecut 1998, Robertson 1998, Wraith 1997,Gibbs 1990, Phillips 1990). Thus, women have only recently begun to be involved in structurally significant disaster management roles (Wilson 1999).

Although a general pattern of underutilizing women's capacities in disaster preparedness, mitigation, response, and recovery exists, women's traditional roles in paid and unpaid labor often prepare them to be primary contributors to disaster management. Even today, women continue to do most of the household and family caregiving work so that an unequal division of domestic responsibility persists even when women participate in the formal labor force in post-industrial societies. The "second shift" occurs when working women return home after a full day in the paid labor force to begin their "second" full day of cleaning house, cooking meals, and caring for children (Hochschild 1983). Running a household with children in today's fast paced world has become a challenging activity. Motherhood is as an excellent school for management, demanding many of the same skills: organization, pacing, teaching, guiding, leading, monitoring, handling disturbances, and imparting information (Helgesen 1990). Experience in balancing work and family develops skills to deal with conflicting demands.

Similarly, women's experiences as community workers, informal neighborhood leaders, and social activists equip them to respond to community crisis (Poniatowska 1995). Enarson and Morrow (1998b) found that women's formal and informal networks were central to both household and community recovery after Hurricane Andrew in 1992.

In addition, women have been part of the paid labor force for a long time especially when their family's economic need makes it necessary for women to seek outside income (Dunn 1997). Now, women not only work in traditionally held positions such as nursing and teaching, but are increasingly gaining entry into higher paid, more prestigious public and private occupations and professions including management level positions. According to Colwil (1997), women form one third of the management work force in the United States. However, such progress does not seem to have filtered into disaster management in which we find a much lower percentage of women in high-ranking positions. For instance, the state of South Dakota only has one full-time county emergency management director in the state of 66 counties.

When women have participated in emergency management organizations, the work culture has reflected an implicit gender division of labor (Enarson and Morrow 1998a, Barnecut 1998, Robertson 1998). Most women are placed into jobs addressing special needs and mass care or human services rather than being represented throughout the entire spectrum of disaster management functions. Women may be deterred from moving into positions and developing their careers in the high priority areas that are considered "more masculine" such as radiological or other hazardous materials, terrorism, communication, transportation, and mass evacuation.

Thus, although women play crucial private and public roles managing households and as part of the paid labor force, their voices have been largely absent in organizational and community policy-making, including decisions about disaster response and recovery (Enarson and Morrow 1998a). This is in spite of the fact that the technological and managerial skills women use in their daily lives can be used in disaster management and their contribution can greatly help a community's response effort. Efficient and effective disaster management systems depend on the knowledge and skills of all those who can make a positive contribution (Robertson 1998). Utilization of women's skills and capacities throughout the disaster management network has the potential to significantly increase the efficacy of disaster preparedness, mitigation, response, and recovery.

Professionalization of emergency management, which includes improved communication and coordination practices, will likely incorporate more sensitivity to needs of all sectors of a community among disaster response practitioners. One aspect of the professionalization process of emergency management, according to Drabek (1994), is the greater linkages between researchers and practitioners due to the growing number of professional associations, publications, seminars and workshops, and advisory committees in which both practitioners and researchers are able to share ideas, practical problems, and research results. Social science research of the vulnerabilities of some groups in society, which cause them to experience greater disaster impacts (e.g., works cited in first paragraph of Conceptual Framework section), should increase disaster response practitioners' awareness of these issues.

In addition, professionalization is fostering major changes in disaster management education and training (Drabek 1994, Neal 2000, Wilson 2001,Wilson and Oyola-Yemaiel 2001). In the past, emergency managers have had little formal disaster management training. This new era of professionalism is indicated by the availability of intensive courses at the Federal Emergency Management Agency's Emergency Management Institute, by the institutionalization of emergency management certification programs, and by a growing number of degree-based university programs, both traditional (i.e., Institute of Emergency Administration and Planning at the University of North Texas) and online (i.e., the Institute of Emergency Preparedness at Jacksonville State University). Increased access to disaster management careers through formal education should increase the number of women, minorities, and other marginalized group members involved in the disaster response network. This occurrence should in turn increase the likelihood that the unique disaster needs of varying groups will not be overlooked or ignored. Therefore, no needs of disaster victims will go unmet and thus no emergent groups will be necessary.

Conclusion

In the relatively small community of Osceola County, the coordinative effort of local agencies was supported and assisted by the convergence of outside experts. The tornado, although severe and devastating for some, was localized and did not have a large magnitude catastrophic effect in which the entire social structure/institutional fabric ceased to operate (Bates 1982). In contrast, a disaster of the scope of Hurricane Andrew in 1992 caused devastation so widespread that the social-organizational structure of everyday life was virtually dismantled (Peacock, Morrow and Gladwin 1997). The 1998 Osceola County tornado left clusters of localized heavy damage, but the majority of the community was left intact and able to concentrate relief efforts on the damaged areas. This resilient community was able to respond effectively, solving problems at hand that otherwise could have created unmet needs for sectors of the population. In doing so, unmet needs and the resulting emergent organizations never appeared.

Among the reasons that emergent organizations did not form in Osceola County, is existing organizations adapted to meet the basic needs of the affected community. In short, the exchange relationship was conducted both within existing organizations and between these organizations so that outside or ad hoc groups were not needed. This type of relationship may have been accomplished in part because of a high degree of flexibility, ingenuity, cooperation, and communication by community organizations evident in such innovative practices as free bus transit to the Disaster Relief Center and insurance coverage for volunteer workers. Moreover, women adapted their organizational roles to become integral parts of the coordinative interstitial group (EOC) that handled the disaster response and recovery.

In particular, the female horticultural agent of the Department of Agriculture made a substantial contribution to the innovative techniques that the Osceola County community employed in the disaster response and recovery. She designed and maintained the computer database program that kept track of the volunteer workers' skills and assignments. This was an essential component to the management of volunteer work in the community after the tornado disaster especially in light of the implementation of workman's compensation and accident insurance coverage for the volunteers.

Yet, women's roles in disaster management activities are still largely understudied. Women's vulnerabilities that make them more likely to become disaster victims have now been well documented (e.g., Enarson and Morrow 1998a, Blaikie, et al. 1994). However, we have very little understanding of the impacts of gendered expectations, roles, and interactions on disaster management. There is still not much evidence that women's knowledge, ideas, and abilities are being integrated into disaster response and recovery. As women become incorporated into the official disaster management network due to the professionalization process, how does women's participation make a difference in disaster management practice and policy? How do gender differences affect interagency coordination? Do women perform disaster response and recovery roles differently than men? Specifically, how do women's contributions (ideas and actions) have an effect on disaster mitigation, preparedness, response, and recovery activities? We recommend more detailed research of women's contributions to innovative approaches in disaster management.

In addition, we wonder what effect professionalization of disaster management will have on the future appearance of emergent organizations after disaster. As a result of the professionalization process, we foresee that the incorporation of more diverse and adaptive disaster managers are more likely to be sensitive to and take action to satisfy the needs and concerns of all members of an affected community. The knowledge, ideas, and skills of women and minorities will renovate and improve the disaster management structure so that the disaster needs of all community groups are met. Future research should further analyze the relationship between a diverse disaster management structure and unmet disaster needs in the community resulting in emergent organizations.

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SECTION 6:

TRANSPORTATION EMERGENCIES

The International Emergency Management Society
9th Annual Conference Proceedings
University of Waterloo, Canada, May 14-17, 2002

EMERGENCY RESPONSE POSSIBILITIES AT TUNNEL ACCIDENTS

Nils Rosmuller and Roel van den Brand

Netherlands Institute for Fire Service and Disaster Management

Keywords: Accidents in rail tunnels for freight; effectiveness of response activities; lessons from accidents; expert interviews; modeling

Abstract

Recent tunnel disasters in several Western European countries such as Austria (Goddharttunnel, 2001 and Tauerntunnel, 1999), France/Italy (Mont Blanc tunnel, 1999) and Great Britain/France (Channel Tunnel, 1996) have made tunnel safety an area for special attention. In-depth investigations into these accidents focused on aspects of tunnel design and emergency response activities. As regards the latter, a major issue was the effectiveness of emergency response activities to reduce the number of victims. For rail tunnels for freight, a three-way research plan was developed to reveal the emergency response opportunities for tunnel accidents. Case studies, expert interviews and physical modeling of fires and firefighting revealed that emergency response possibilities for rescue operations in tunnels are extremely limited. This result is important for both tunnel designers and emergency responders: tunnel designers should reconsider their tunnel design principles and emergency responders should reconsider their tunnel accident strategies.

1. Introduction

As a result of recent and future economic growth, the need for high-capacity transportation facilities in the Netherlands has been increasing. In order to meet this need, additional infrastructure projects are being planned and built, which on land include roads, railways, pipelines and canals. To an increasing extent tunnels are part of these infrastructure projects. The reason for developing and building tunnels is twofold. Firstly, tunnels are built for crossing topographical barriers like rivers and mountains. Secondly, tunnels are built to preserve the built-up areas and natural environment aboveground.

A potential disadvantage of tunnels is the issue of safety. Tunnel developers and emergency response organizations negotiate on technical systems that will support emergency response, such as smoke and heat detection systems, ventilation systems and the required distances between emergency exits. It is not certain, however, whether emergency response organizations will respond to any tunnel accident. The emergency response possibilities and the extent to which technical systems enhance these possibilities are not clear. So far, little research has been done into the possibilities available to emergency response organizations for rescue operations in threatened tunnel tubes. Any research on this topic should include the main characteristics of transport mode and tunnel layout. Different transport modes and tunnel layouts result in different accident and emergency response scenarios.

In the Netherlands, a new railway called Betuweline is being built. The Betuweline connects the seaport of Rotterdam eastwards to a multimodal transfer facility at Valburg and the German industrial Ruhr area. This high-speed railway includes six tunnels of various lengths and is intended for freight transportation only.

In 2000, the organizational unit of the Dutch Ministry of Transportation and Public Works, responsible for the planning and building of the Betuweline, needed insight into the possible emergency response activities in the Betuweline tunnels. This subject for study was formulated as follows: what are the emergency response possibilities for rail tunnels intended for cargo transportation?

This paper contains the established and stated possibilities as well as the modeling of emergency response possibilities for accidents in rail tunnels for freight. First, several tunnel incidents[1] and emergency response activities are described (paragraph 2). Paragraph 3 discusses the results of the interviews with fire officers: possibilities with regard to stated emergency response activities in rail tunnels for freight. Paragraph 4 explains the physical phenomena like smoke and temperature development as time progresses as well as the emergency response activities in time. Gearing emergency response activities with the physical situation in the threatened tunnel tube will determine the possibilities for offensive tactics and entering the tunnel tube at issue. Paragraph 5 mentions the emergency response possibilities as found in this study.

2. Tunnel incidents

The Dutch Ministry of the Interior and Kingdom Relations, responsible for national fire service policies, together with Dutch Rail (NS) and regional fire chiefs, has defined plausible scenarios for tunnel incidents. These scenarios are (BZK, 1997):

1. Derailment. It is generally not expected that a train will derail on a straight section of the railway. Derailment may be a consequence of technical failure, such as broken axles. It may also occur when a train hits an object on the railway, a possible act of sabotage. Fires and leaks may be subsequent scenarios following a derailment. Derailment may lead to a collision in a two-way rail tunnel.
2. Collision. In theory, a train may collide with another train, an object, an animal or a person. The chance of collision with another train is considered negligible because modern technologies prevent trains from riding on the same track. Collisions with people include trespassers, unauthorized or maintenance personnel.
3. Fire. Fire may be a consequence of electrical failure, blocked axles and breaks, or attacks. When hazardous materials are involved, a high-energy fire may occur, like a (leaking) fuel fire. Fires involving trains or cargo are considered to be more serious than fires in tunnel cables or maintenance rooms or during maintenance operations.
4. Leaks of hazardous materials. Minor leaks will probably not be detected during the journey. When a train comes to a stop in a tunnel, the potential effects of a leak of hazardous materials is more serious. Different scenarios exist that involve flammable and/or explosive substances or toxic or radioactive chemicals. Leaks may occur as a result of derailment or collision.
5. Explosion. If an explosion occurs in a tunnel built in wet soil, infrastructure may be lost. Explosions may be caused by deliberate attacks or fire (Boiling Liquid Expanding Vapor Explosion).
6. Miscellaneous. In the Netherlands, floods constitute a specific risk that may affect tunnels. Tunnel system failure and regular transport interruptions are not considered relevant for emergency response organizations.

These scenarios are theoretic scenarios used. In order to assess emergency response possibilities, information about actual incidents and emergency response activities is additionally required. For this purpose, a selection of tunnel accidents was made. A Dutch inventory study (COB, 1997) of

[1] In this paper, the terms ‘accident’ and ‘incident’ are used as synonyms.

tunnel incidents showed that in Western Europe incidents in rail tunnels for freight have been limited to only two incidents and do not cover a wide range of scenarios (Channel Tunnel, 1996; Summit Tunnel, 1984). Therefore, the scope was broadened to incidents in road tunnels and rail tunnels for passenger trains. It was assumed that an insight into the physical mechanisms that influence emergency response possibilities could be gained from these types of tunnel incidents. Criteria used in the selection of the cases included (Nibra, 2001):

1. The incident required evident involvement of public emergency response organizations in terms of the duration of operations (over 15 hours) and the number of personnel deployed (over 100 firefighters). Major operations may reveal the possibilities as well as the limitations of emergency response.
2. The incident occurred between 1995 and 2000 (the year in which the study was carried out). The topicality of the incident is important because the state-of-the-art technical and organizational possibilities of emergency response organizations should be taken into account.
3. The incident and the emergency response activities are sufficiently documented.

These criteria led to the selection of the following cases:

1. Channel Tunnel, Great Britain-France, 18 November 1996: Fire on a Heavy Goods Vehicle shuttle (HVG).
2. Leinebusch Tunnel, Germany, 2 March 1999: Derailment of, and fire on a freight train.
3. Mont Blanc Tunnel, France-Italy, 24 March 1999: Fire in a road tunnel involving a considerable number of vehicles.
4. Tauern Tunnel, Austria, 29 May 1999: Collision and fire in a road tunnel involving a considerable number of vehicles.

The accidents and emergency response activities are described in short. The lessons learned from the incidents are summed up.

2.1 Channel Tunnel

The Channel Tunnel (rail tunnel, 50 kilometers) consists of two one-way running tunnels and a service tunnel in between. The running tunnels are connected to the service tunnel by closed cross sections at 375 meters intervals.

The start of the incident was a Heavy Goods Vehicle, consisting of 29 carriages, entering running tunnel south with a burning truck on it. Maintenance personnel detected the fire outside the tunnel but the shuttle was not stopped. Ten minutes later the driver halted the train in the tunnel because of a derailment signal on his control panel caused by burnt cables. The (natural) ventilation in the tunnel spread thick smoke over the train, including the passenger carriages. People were unable to leave the train due to the smoke.

Twenty-three minutes after the stop an emergency exit was opened by the Rail Control Center creating a 'bubble effect'. Smoke was driven out from the tunnel section making it possible to evacuate the passengers. Subsequently the fire-fighting operation began. Firefighters had trouble estimating the exact location and extent of the fire. Smoke, rubble and explosions were serious obstacles while approaching the fire. In addition, the fire damaged the tunnel water supply system.

Lessons learned from the Channel Tunnel incident, as formulated in this study:

- Smoke prevented passengers from active evacuation.
- Adequate information from the train did not reach emergency response organizations because of extremely limited visibility.
- Tunnel entrance security measures delayed the emergency response units.
- Smoke and heat limited both the approach of the fire site and the working time of firefighters.

2.2 Leinebusch Tunnel

The Leinebusch Tunnel (rail tunnel, 1740 meters) is a single-tube tunnel with separate rail tracks for both directions.

The start of the incident was the derailment of the 14th of 24 carriages of a freight train. The derailment took place 6 kilometers outside the tunnel. Because of the speed reduction the driver halted the train in the tunnel, decoupled the front carriages and drove them out of the tunnel. The cargo (paper) on the derailed carriage had started to burn.

One hour and forty-four minutes after the first alert, a special rescue train arrived at the tunnel entrance. Lacking water supply facilities hindered firefighting. The train could not be taken in tow due to the damaged rail track. For the same reason, an additional rescue train could not reach the site. Eventually, the carriage had to be cut open to extinguish the fire, resulting in heavy smoke development.

Lessons learned from the Leinebusch Tunnel incident, as formulated in this study:
- Inadequate procedures delayed the arrival of the rescue train.
- Heavy smoke filled the tunnel tube despite a relatively large tunnel diameter and an enclosed fire.
- Working conditions were harsh despite relatively large working space and a limited temperature.

2.3 Mont Blanc Tunnel

The Mont Blanc Tunnel (road tunnel, 11,6 kilometers) is a single-tube tunnel allowing two-way traffic. There are parking exits every 300 meters. Every second parking exit has an evacuation room.

The start of the incident was a truck entering the tunnel with a leaking diesel fuel tank. The tank caught fire, making oncoming traffic to alert the truck driver. The driver stopped and left the vehicle. Vehicles kept entering the tunnel on both sides while alerted drivers in the tunnel attempted to turn their vehicles.

The tunnel entrances were closed 10 minutes after the truck had entered the tunnel. At this point, when the first emergency response units entered the tunnel, it was filled with smoke over a 1500-meter distance. Four minutes later, they managed to approach the burning vehicle up to 6 meters distance and lead the way to people at the site. After this, multiple emergency response units saw themselves forced to flee into the evacuation rooms, both downwind and upwind. They were evacuated from the tunnel hours later. The entire emergency response operation took 55 hours and consisted of defensive fire-fighting tactics. Thirty-nine people died in the incident.

Lessons learned from the Mont Blanc Tunnel incident, as formulated in this study:
- Un-coordinated ventilation tactics possibly enhanced the fire.
- Limited visibility made rescue workers fail to recognize evacuation rooms.
- Due to extreme temperatures, firefighting was not possible until after most of the fire load was burnt.

2.4 Tauern Tunnel

The Tauern Tunnel (road tunnel, 6,04 kilometers) is a single-tube tunnel allowing two-way traffic. There are no evacuation rooms inside the tunnel.

The start of the incident was a truck crashing into a queue of vehicles waiting at a red traffic light inside the tunnel. Immediately after the crash, in which eight people were killed, the truck - carrying paint products and spray cans - caught fire. During the first 10 minutes after the crash, people at the site tried to extinguish the fire, without effect. People managed to evacuate, walking several hundreds of meters towards the tunnel exit. Others fled into a telephone booth.

Twenty-seven minutes after the crash the first emergency response vehicle entered the tunnel but was forced to withdraw because of heavy smoke up to two kilometers downwind. Forty-five minutes later three people were rescued from the telephone booth. After this, emergency response activities aimed at extinguishing the fire. The operation was seriously hampered by parts of the ceiling collapsing.

Lessons learned from the Tauern Tunnel Incident, as formulated in this study:

- Heat and explosions forced emergency response units to withdraw, despite effective efforts to drive out smoke by active ventilation tactics.
- Failing construction integrity resulted in immediate danger for emergency response units.

2.5 Threats for emergency response

Despite the differences between the cases regarding tunnel layout and incident scenario, the same mechanisms seem to be accountable for possible life-threatening situations for emergency response units. These mechanisms may constitute both direct and indirect threats. Direct threats result in immediate danger independent of subsequent events. Indirect threats may result in danger dependent on subsequent events (like tactical decisions). Indirect threats may be posed by inadequate situation information; inadequate communications between control centers, emergency rooms and response units; inadequate procedures; persons failing to comply with adequate procedures; and failing maintenance of technical systems. Direct physical threats are more compelling and are posed by:

1. Smoke. Smoke spreads faster and fills larger parts of the tunnel than is expected by both people inside the tunnel and emergency response organizations outside the tunnel. Several kilometers of the tube can be filled with smoke within 10 to 15 minutes. Even small fires can cause large amounts of smoke and harsh conditions. Self-rescue and external rescue are seriously hindered by limited visibility.
2. Heat. Temperatures at tunnel fires may rise to over a 1000 degrees Celsius within 10 to 15 minutes. Heat can result in extreme damage to technical systems (communications, water supply) and in lesser construction integrity.
3. Collapsing structure. Falling debris may pile up to 50 centimeters at the center of the accident site. This seriously hampers emergency response activities, even more so in conditions of limited visibility. Moreover, a constant threat of falling debris constitutes a great danger for emergency response units.

The cases reveal that offensive emergency response tactics are not to be expected in case of a tunnel fire when emergency response organizations arrive at the tunnel exit within 10 to 15 minutes. The main impediments for self-rescue and offensive tactics are smoke and heat, in that particular order. This means that rescue opportunities are extremely limited.

3. Interviews with fire officers

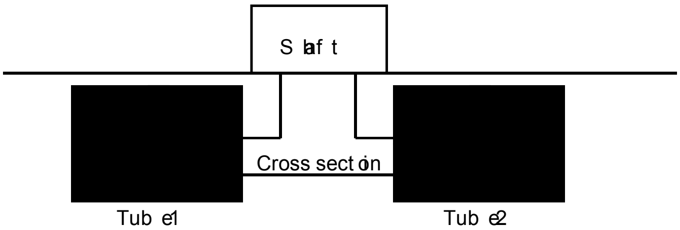
The aim of the second part of the study was to disclose emergency response possibilities in specified tunnel accidents, as perceived by Dutch fire officers. For this purpose, a method was devised for presenting accident scenarios to fire officers in a series of expert interviews. This method included a standard tunnel design, a set of accident scenarios and a selection method for the fire officers to be interviewed.

3.1 Interview structure

In order to gain reliable results it was considered necessary to use a standard tunnel layout in the interviews. Fire officers were shown the same main tunnel layout (TUDelft, 1999) that applies to the six Betuweline tunnels.

The general layout of these tunnels (figure 1) is a double-tube tunnel. Each tube contains one rail track that allows one-way traffic only. The two running tunnels are connected by cross sections at regular, and for the purpose of the interview, variable intervals up to 600 meters maximum. Shafts leading to ground level are included except where the tunnel passes under a canal.

Figure 1: General tunnel layout as used in interviews



Other features of the system are:

- Exit doors are operated by control room personnel and are fire resistant for 60 minutes.
- A permanently available water supply system (deluge system) is installed. The system is designed for extinguishing 300 MegaWatt fires. Its supply capacity is 3000 liters of water per minute for four hours. A distant operator controls it.
- An active ventilation system designed for driving out smoke in either direction is installed. The system is designed for 300 MegaWatt fires. Control room personnel operate the ventilation system.
- Emergency response organizations can use monitoring equipment (camera's, radar) and communication systems.

The second part of the interview method consisted of the set accident scenarios. Fire, leakage of hazardous materials and explosion scenarios were considered relevant because they have potential severe consequences.

Taking the identified direct threats into account (paragraph 2.5), six scenarios for the expert interviews were defined, in order of seriousness. It was assumed that the direct mechanisms strongly cohere with the seriousness of accident scenarios in tunnels. Indirect threats were not considered specific for tunnel accidents. No more scenario information was presented to the fire officers than would have been presented by the emergency room in case of a real alert.

The scenarios of which fire officers were to assess the emergency response possibilities are:

1. Small fire. In case of a small fire on a freight train in a tunnel, the temperature rises moderately, the spread of smoke is limited and the risk of collapse is negligible.
2. Major fire. In case of a major fire on a freight train in a tunnel, heat and smoke are intense. The risk of collapsing construction parts is plausible.
3. Minor leak of toxic chemicals (less than 10 liters). Temperature and smoke development are negligible as is the risk of collapse. Depending on the properties of the chemical, a minor leak may constitute a risk for persons in the tunnel.
4. Major leak of toxic chemicals (more than 10 liters). In this case, large amounts of (liquid) chemicals leak from a carriage in the rail tunnel for freight. Again, temperature and smoke development are negligible as is the risk of collapse. Due to evaporation, high concentrations of vapor are to be expected.

5. Explosion. A detonation has taken place inside the tunnel. The risk of (partial) collapse is plausible.
6. The threat of a Boiling Liquid Expanding Vapor Explosion (BLEVE). A carriage containing condensed gas is warmed up by heat radiation coming from a burning carriage nearby. Heat and smoke are intense. The risk of collapse will be realistic after an actual BLEVE.

Fire officers were asked to state what actions (purpose and means) they would take in the given scenarios had they been responsible for the operational tactics of the emergency response. It was emphasized that the perceived emergency response possibilities apply to situations at the tunnel entrance, at the time of arrival of the first emergency response units, and are geared to the specific tunnel properties as described above. The experts were also asked whether their perceived emergency response possibilities would be different if toxic chemicals were involved in the minor and major fire scenarios.

A standardized interview guide was constructed to prepare interviewers for requests for additional information on the exact position of the train, the number of carriages burning, the nature of the chemicals involved, the duration of the fire and the train's composition.

The experts had to be knowledgeable about tunnel emergency response possibilities. Therefore, experts were selected from various cities' fire services in The Netherlands where one or more tunnels already existed or were planned for the near future. In this way, fifteen experts were selected, including two experts from Dutch Rail.

3.2 Results from the interviews

The interviews resulted in consistent views on emergency response possibilities per scenario. It is important to consider some general notions that resulted from the interviews.

First, fire officers have a great need for precise situation information before considering entering the threatened tunnel tube. For information about the train composition, goods involved, exact location, tunnel climate, technical support systems and so on, fire officers heavily depend on Dutch Rail.

Second, fire officers assume that the train driver and a restricted number of co-drivers are able to reach a safe location outside the tunnel without external help. In fact, rail tunnels for freight are designed to meet this principle.

Third, the fire officers' main concern is the safety of firefighters. If their lives may be endangered in any way, firefighters will not be ordered to enter the tunnel. Because of this principle and the expectation that a restricted number of people in the tunnel will be able to get out by themselves, defensive tactics are generally preferred.

Fourth, fire officers consider explorative activities equal to exposing personnel to danger. This strengthens their preference for caution.

As regards the scenarios, fire officers perceive possibilities for offensive emergency response tactics only for operations involving small fires or minor leaks of hazardous materials. These scenarios are not considered life threatening. However, when dealing with a small fire, measures (like ventilation) are to be taken before entering the tunnel to stabilize the spread of smoke and rise of temperature. As for dealing with a minor leak, some fire officers mention the responsibility of the transporter or Dutch Rail for taking appropriate action.

In the other scenarios, experts state that immediately entering the threatened tunnel tube is not considered. Extensive exploration from a great distance is preferred in operations involving major leaks, and with built-in time delay after an explosion.

Fire officers are not consistent in stating the tactics required for handling a major leak of hazardous materials. Perceived emergency response possibilities for this scenario seem to depend on confidence and pre-determined risk perception. In case of a major fire on a freight train, entering the tunnel tube is not considered a realistic option: waiting is the fire officers' motto. In a situation when a BLEVE is expected, all efforts of emergency response will focus on the evacuation of people in the direct vicinity of the tunnel.

4. Modeling of emergency response to tunnel fires

The cases and the expert interviews led to the identification of threats and stated emergency response actions in several scenarios. In order to clarify the critical mechanisms for emergency response at certain moments in time, a third research method was used. Data on the development of tunnel fires were incorporated into an empirical timeline of the primary process of emergency response.

In paragraph 4.1, the physical mechanisms that appear in tunnel fires are described, using data from fire experiments. Paragraph 4.2 sets out the emergency response timeline. In paragraph 4.3, the mechanisms and the response timeline are set side by side in order to assess the situation in the threatened tunnel tube at the time of arrival of emergency responders.

4.1 Physical mechanisms in tunnel fires

The development of the physical mechanisms of smoke, heat and collapse are themselves dependent on other variables. The variables that determine the development of a tunnel fire are:

- The nature of the burning materials (wood, plastics, steel) and the extent to which all material is burnt determine the spread of smoke.
- The amount of the fire load (in MegaWatts) determines the temperature.
- The properties of the hazardous materials (acute danger, manner of intoxication) determine to what extent the tunnel climate is accessible for emergency responders.
- The extent of the fire load, tunnel wall thickness and the nature of the concrete and coatings of the tunnel wall determine the risk of collapse.

Of course, construction characteristics (length, diameter) and the set of technical support systems installed in the tunnel (ventilation, water supply, detection systems) also influence the development of physical mechanisms.

In a project initiated by the European Union, called EUREKA EU 499 FIRETUN (EU, 1999), eight European countries participated in exploring possibilities for the protection of people in tunnels, for maintaining the infrastructure in case of a tunnel fire and for the fire service with regard to rescue and fire extinguishing operations. For this purpose, experiments were carried out in the Norwegian Reppafjord Tunnel. The Reppafjord Tunnel is located 200 kilometers north of the polar circle at an altitude of 200 meters. It is a mineshaft of 2.3 kilometers length horizontally. The tunnel is 5.5 to 7.0 meters wide and 4.8 to 5.5 meters high.

Temperature, light intensity, carbon monoxide concentration, and rubble height were measured during several fires involving various vehicles in this tunnel. The measurements were held at a wind speed of 0.5 meters per second and at a height of 1.5 to 2 meters. Three vehicles were set on fire at a distance of 295 meters from the tunnel entrance. The burning vehicles were:

- A bus: 48000 Mega Joules
- A subway carriage (aluminum): 41000 Mega Joules
- A passenger carriage (steel): 77000 Mega Joules

The results of the measurements, as presented in Blume (1994) and Blume (1996), are shown below.

Figure 2 shows the temperature development in time, as measured at a height of 2 meters, 20 meters downwind from the burning vehicles. It is clear that the maximum temperatures of the bus and subway carriage fires are reached after approximately 15 minutes: 800 and 1150 degrees Celsius. The train fire reaches a maximum temperature of 700 degrees Celsius after 100 minutes.

Figure 2: Temperature in time

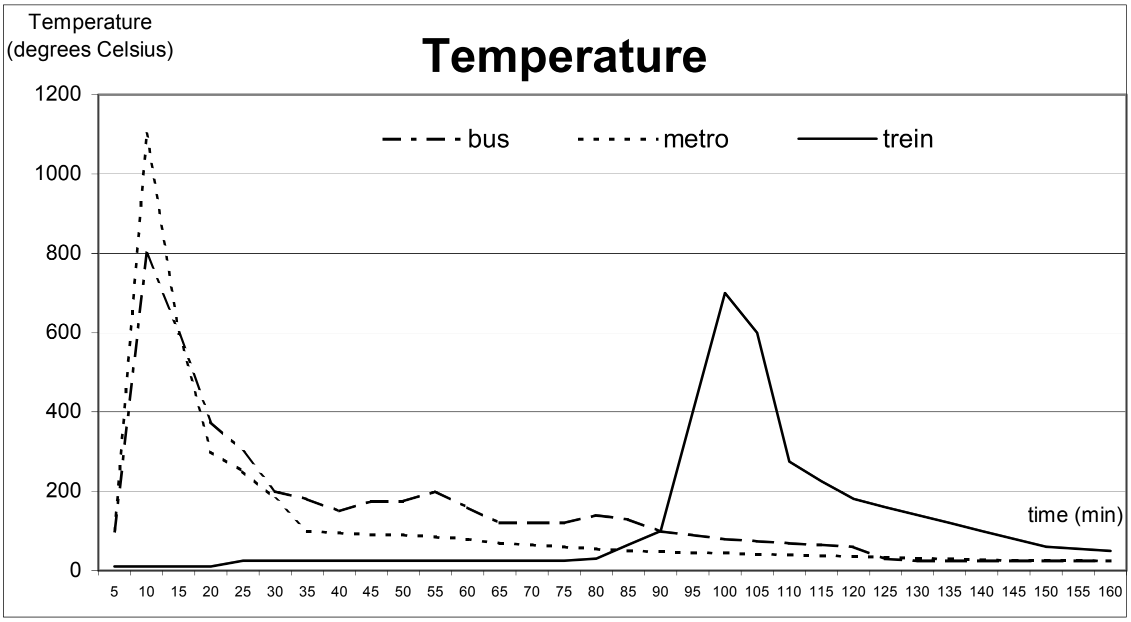
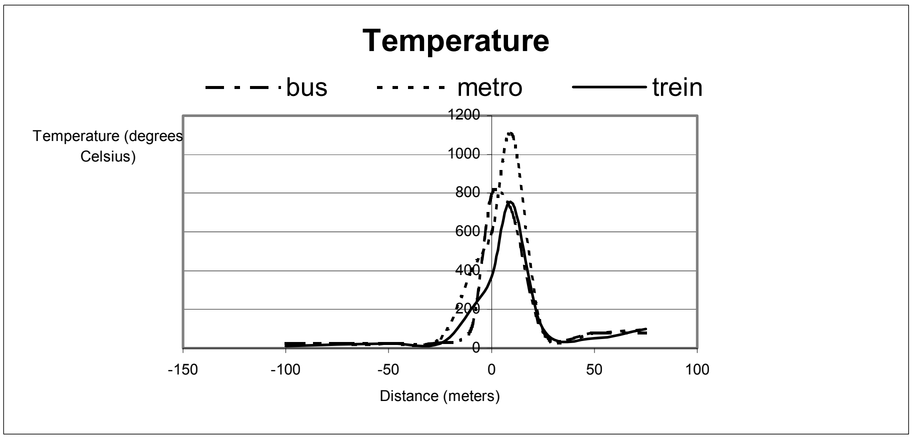


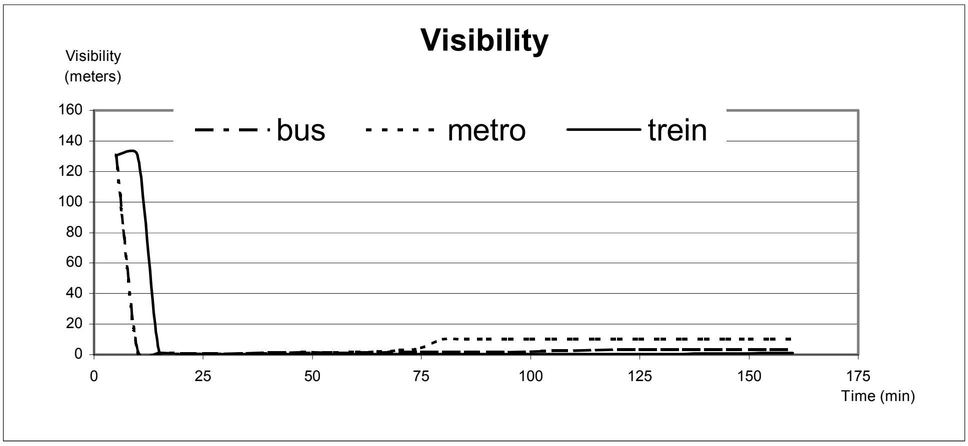
Figure 3 shows the maximum temperatures at a height of 2 meters measured at varying distances from the vehicles. Seen from the vehicles, the wind direction is toward the 2-kilometer part of the tunnel. The figure shows that the maximum temperature in the bus fire is reached at a 0-meter distance (800 degrees Celsius), whereas maximum temperatures in the other vehicle fires are reached at 15 meters (1100 and 750 degrees Celsius), probably due to the wind in the tunnel. Temperatures drop rapidly with increasing distances: at a 20-meter distance temperatures are down to approximately 100 degrees Celsius.

Figure 3: Temperature at varying distances



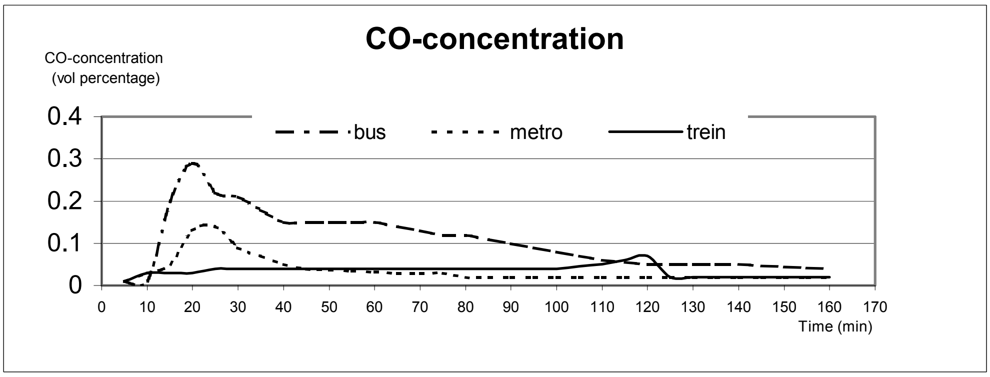
In the experiments, visibility was not measured but calculated on the basis of light intensity (I) measurements, according to Jin (1976). Light intensity was measured at a height of 2 meters at a 100-meter distance from the burning vehicles. Figure 4 shows the visibility development in time. For the first 75 minutes, the bus and subway carriage curves coincide. After 10 minutes, visibility in these fires is reduced to less than 10 meters. At the train fire, visibility becomes less than 10 meters within 15 minutes. It is also evident that visibility – at the current wind speed - hardly improves, even after several hours.

Figure 4: Visibility in time



In the EUREKA 499 FIRETUN project, no specific tests were carried out to measure toxic concentrations. Toxic concentrations heavily depend on the nature of the burning material. In fact, no products were burnt other than the empty vehicles (without their interiors). Of all the chemicals in the emitted smoke, only carbon monoxide (CO) concentrations were measured. Figure 5 shows that in the bus and subway carriage fires the maximum CO-concentrations reach peak levels (0.29 and 0.14 volume percentage[2], respectively) within 20 minutes. The train fire results in a 0.07 CO concentration after 2 hours. Concentrations drop slowly in the bus and subway carriage fires and more rapidly in the train fire.

Figure 5: CO-concentration in time



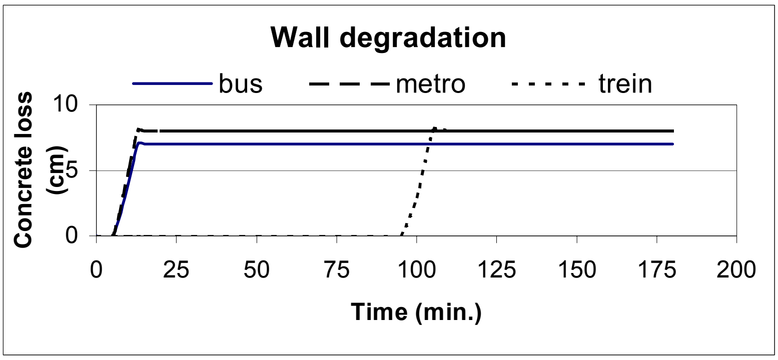
The Reppafjord Tunnel experiments did not include measurements of rubble heights near the fires. Therefore, a hypothetical curve is presented on the basis of a calculation. According to the Dutch

[2] One volume percentage corresponds with 10.000 parts CO per million parts air.

Ministry of Public Works, a realistic threat of collapse is introduced when the tunnel wall thickness is reduced to half its original value. The tunnel wall degrades by 1 centimeter per minute on average – depending on the density of the concrete - when the temperature exceeds 600 degrees Celcius. The remaining tunnel wall thickness (T) can be calculated using the following formula, in which t is the time elapsed (minutes) and D is the tunnel diameter (centimeters): $T_t = 1/25D - (1*t)$. For example, the tunnel wall thickness in a 10-meter wide tunnel after a 15-minute fire and at a temperature exceeding 600 degrees Celsius will be 25 centimeters. Because half of the tunnel wall thickness is 20 centimeters, there is no real risk of collapse.

Figure 6 shows tunnel wall degradation as calculated for the Reppafjord Tunnel fires, where the periods of high temperature (exceeding 600 degrees) determine the reduced wall thickness. Seven to eight centimeters of concrete would be lost in all three fires.

Figure 6: Tunnel wall degradation



The figures explained above show the development of the physical situation in tunnel fires. In order to assess the situation that emergency responders face when they reach the tunnel entrance, a timeline for emergency response was constructed.

4.2 Emergency response timeline

The physical situation on arrival at the tunnel entrance determines the decision for explorative or offensive activities inside the tunnel by the fire service. Before arrival, emergency response units go through several stages (McAleer and Naqvi, 1994; Repede and Bernardo, 1994; Rosmuller, 2001):

1. Report time: the time necessary for an emergency report to reach the public emergency room. Action by people in the tunnel and Rail Traffic Control Centre.
2. Alert time: the time necessary for an emergency alert to reach fire service units. Action by the public emergency room.
3. Turn-out time: the time necessary for the fire service to turn out.
4. Driving time: the time necessary for the first fire service vehicle to reach the tunnel entrance.
5. Exploration time: the time between arrival and the decision for an intervention inside the threatened tunnel tube.
6. Walking time: the time it takes to walk from the tunnel entrance to the right cross section where response tactics are to be carried out.
7. Checking time: the time it takes to check whether the overhead wire is dead.

These are successive stages. Parallel actions have to be carried out by other organizations apart from emergency response organizations, like stopping the traffic (by traffic control), self-evacuation (by people inside the train and the tunnel), shutting down power on the overhead wire and opening cross section exit doors (rail control). It is important to recognize that these parallel actions may cause delays in the stages mentioned above.

However, potential delays were ignored in the construction of the timeline. It was assumed that emergency response units will be given full support in obtaining information about train composition and cargo, opening cross section doors and shutting down overhead wire power. Moreover, it was assumed that the physical mechanisms and emergency response timeline share the same starting point (t=0), i.e. the moment when the train comes to a stop in the tunnel. In addition, the actual emergency response activities in the threatened tunnel tube were not considered.

The minimum amount of time needed for fire service units to arrive at the tunnel entrance is the cumulative time necessary for the stages mentioned above. The time per stage is set out below. In the accumulation, the minimum time per stage is used. This means, that the most optimistic scenario for emergency response is considered.

1. Report time. Based on expert judgment in the Dutch High Speed Rail (Amsterdam-Paris) Safety Committee, this time is set at 5 to 15 minutes.
2. Alert time. The emergency rooms of three fire service regions in The Netherlands were consulted. Both acute and non-acute reports can be processed into an adequate alert within 1 minute.
3. Turn-out time. According to national fire statistics, fire service units can turn out within 3 to 4 minutes. This is an average for urban and rural areas.
4. Driving time. Variables, such as road type, weather type, alert type, vehicle type and time of the day determine driving speeds under different conditions. Driving time can be calculated using these driving speeds and a pre-determined distance from a barracks to the tunnel entrance. By day and under normal weather conditions it will take approximately 10 minutes to reach a tunnel that is 10 kilometers away (a plausible situation in the Netherlands), driving through built-up areas and country roads.
5. Exploration time. Once emergency response units have arrived at the tunnel entrance, operation command at the site will have to make a decision about subsequent activities on the basis of emergency room information and own observations. Common practice shows that it takes approximately 5 minutes to reach such a decision.
6. Walking time. Rosmuller (2001) measured various walking times of firemen, taking into account variables such as walking ground, distance, weather conditions, lift load and personal physical characteristics. He deduced some rules of thumb for walking speeds: walking on a rail track (1.5 meters per second); walking up a rail slope (1 meter per second); walking up a ladder (0.5 meters per second) et cetera. These speeds will not (and cannot) exhaust emergency responders. The walking time in an accident situation involving a train standing 600 meters from the tunnel entrance right in front of a cross section door (a plausible situation for a Betuweline tunnel), at a downhill speed of 2 meters per second, would be 5 minutes.
7. Checking time. Empirical data for this aspect are not available. Consulted fire officers estimate checking time (to ensure the overhead wire is dead) at 4 to 5 minutes.

The cumulative timeline for emergency response is summed up in table 7:

Table 7: Cumulative timeline for emergency response

Stage	Time necessary (minutes)	Total time (minutes)
Report time	5-15	5
Alert time	1	6
Turn-out time	3-4	9
Driving time	Depending on distance (10 at 10 kilometers)	19
Exploration time	5	24

Walking time	Depending on distance (5 at 600 meters)	29
Checking time	4-5	33

It can be concluded, that there are roughly 33 minutes between the stopping of the train and the arrival of the first emergency responders at the right cross section inside the tunnel, ready for action in the threatened tunnel tube.

4.3 Confronting the physical mechanisms and the emergency response timeline

Based on the described mechanisms and the timeline above, it is possible to estimate emergency response possibilities. Table 8 shows temperature, visibility, CO-concentration after 33 minutes. The values are deduced from the figures presented in paragraph 4.1. This table reflects the situation, as modeled, in a tunnel tube where a vehicle has been burning for 33 minutes. Now, fire service units would be ready to enter the threatened tunnel tube near the burning vehicle, 600 meters from the tunnel entrance. It is important to recognize that no artificial ventilation techniques are used in this situation.

Table 8: Physical situation after 33 minutes

Vehicle	Temperature (33 mins.)	Visibility (33 mins.)	CO (33 mins.)	Wall degradation
Bus	App. 200 degrees Celsius (decreasing)	Less than 5 meters (constant)	0.20 volume percentage (decreasing)	No danger of collapse
Subway carriage	App. 180 degrees Celsius (decreasing)	Less than 5 meters (constant)	0.08 volume percentage (decreasing)	No danger of collapse
Train carriage	App. 50 degrees Celsius (increasing)	Less than 5 meters (constant)	0.04 volume percentage (constant)	No danger of collapse

Emergency response possibilities depend on both the physical mechanisms and capacities of trained emergency responders, as experienced in common practice or as taught by instructors.

Dutch fire service teaching material sets the maximum temperature for intervention in enclosed spaces at 70 degrees Celsius. Comparing this standard with the temperatures mentioned in table 9 shows that the standard temperature for emergency response activities is exceeded, except in the case of the train fire.

There are no accepted standards for minimal visibility in fire service activities. However, Blume (1994) states that with a visibility of less than 10 meters, victims in a tunnel fire will lose their bearings, which makes it virtually impossible for them to find their way out. Note, that visibility is extremely limited over a great distance (figure 5 depicts visibility at a distance of 100 meters). The same risk of losing direction applies to emergency responders when visibility is less than 5 meters. This means that intervening in the smoke-filled tunnel tube constitutes a serious threat to their safety.

With regard to CO-concentrations, Blume (1994) states that persons not wearing breathing apparatus will be seriously affected by a gas concentration exceeding 0.1 volume percentage. Using breathing apparatus can remove the threat posed by carbon monoxide. This means that active intervention is possible.

Reduction of tunnel wall thickness after 33 minutes does not cause a real danger of collapse. It should be recognized, however, that rubble falling from the tunnel wall that is piled up on the floor is a serious (psychological) impediment for emergency responders. It should also be considered that the use of breathing apparatus is a physical effort in itself. In addition, the physical capacities (and working time) of emergency responders are restricted because of heat absorption and harsh working conditions.

It can be concluded that reduced visibility is the first critical mechanism that limits emergency response possibilities. Heat is the second mechanism that impedes rescue or fire-fighting opportunities. Carbon monoxide does not pose a real threat to emergency response units, whereas the effect of falling rubble is a psychological barrier.

5. Emergency response possibilities

The results of the three research activities - case studies, interviews and modeling - are consistent in pointing out the extreme limitations for emergency response organizations to apply offensive operational tactics in a threatened tunnel tube.

Case studies revealed that offensive action may result in endangering the lives of emergency responders, while the effects in terms of rescue and extinguishing the fire are highly uncertain. Smoke, heat and construction damage are overwhelming.

Interviews revealed that fire officers exercise restraint in ordering personnel to work in the threatened tunnel tube. Especially with a limited number of people present in the tunnel, as is the case in rail tunnels for freight, risk calculations generally work out in favor of emergency response personnel.

Modeling of threatening physical mechanisms and the emergency response timeline revealed that a safe intervention is unlikely due to extremely limited visibility and high temperatures.

On the basis of the results, a guideline was proposed for *Emergency response possibilities in the accident scenarios in rail tunnels for freight* as used in the interviews, which can be summarized as follows:

- Small fire, not involving hazardous materials: no attempt at rapid rescue, extinguishing the fire after extensive exploration.
- Minor fire, involving hazardous materials: no immediate action, response organizations wait until the fire has gone out naturally.
- Major fire, not involving hazardous materials: no immediate action.
- Major fire, involving hazardous materials: no immediate action.
- Minor leaks of hazardous materials: no attempt at rapid rescue, possible co-operation of fire service with Dutch Rail emergency response to take out the source of the leak. Active ventilation tactics should be considered as an alternative.
- Major leak of hazardous materials: no immediate actions inside the tunnel. Active ventilation tactics and measures to lessen the environmental effects are priorities.
- Explosion: after an explosion immediate action is not recommended.
- Threat of a BLEVE: no immediate action, evacuation of the tunnel environment.

Some comments can be made on the research design and methods. First, the emergency response possibilities as perceived and stated by fire officers may be different from the decisions they will take in actual accident situations. Second, empirical data from the Reppafjord tunnel may not apply to all tunnel fires. The research did not include fires involving cargo or a considerable number of vehicles. Both tunnel characteristics and fire loads are crucial for the development of the physical conditions in the tunnel. Remember that results were not specified for situations in which active ventilation tactics were employed.

Despite these comments, there is a strong case for the conclusion, which is endorsed by all three parts of the research. Notwithstanding this conclusion, compelling topics for further research are suggested:

- More specific examples of accidents involving rail tunnels for freight should be studied. Comparative case studies in general should involve cases with standardized tunnel characteristics.

- Realistic simulation of fire officers' decision making under stress in a tunnel accident scenario could reveal the actual behavior of emergency response organizations.
- The influence on physical mechanisms (smoke, heat) of tunnel characteristics and technical systems, such as automatic extinguishing installations and ventilation systems, should be studied in controlled experiments, like the EUREKA project. In addition, fires involving different vehicles, including cargo and a considerable number of vehicles should be studied. Accident scenarios used in the experiments should be as realistic as possible.
- Similar studies should be carried out to explore possible differences in emergency response opportunities in rail tunnels for freight and road tunnels, and rail tunnels for freight and rail tunnels for passenger trains, respectively.

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Nils Rosmuller studied Public Administration and Public Policy, and Technology and Management at Twente University (1990-1995). From September 1995 to July 2000, he worked on the PhD project Safety Analysis of Transport Corridors within the Transportation Policy and Logistic Organization group of the School of Systems Engineering, Policy Analysis and Management of the Delft University of Technology. In June 2001, he finished his PhD Thesis titled Safety Analysis of Transport Corridors. Since 2000, Nils Rosmuller has been working as a researcher at the Netherlands Institute for Fire Service and Disaster Management (Nibra). His main activities are in the field of safety analysis in relation to the development of large-scale infrastructures, scenarios, occupational safety, and safety science.

Roel van den Brand studied Public Administration and Organization Theory at Nijmegen University (1994-1999). Since 2000, he has been working at the Netherlands Institute for Fire Service and Disaster Management (Nibra). He worked for two government committees that investigated two recent disasters in the Netherlands (explosion of a fireworks factory and a disastrous pub fire), both as a researcher and as a data manager. His main interests are in public safety issues in relation to mass events and in safety issues related to spatial planning.

AN ADVANCED DSS FOR MANAGING TUNNEL EMERGENCIES.

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Keywords: emergency management, tunnels, training, evaluation.

Abstract

Based on the number of accidents in European tunnels during recent years, the need for an advanced decision support system for the managing of tunnels has been affirmed. As a result, a European project, SIRTAKI[2] (Safety Improvement in Road & rail Tunnels using Advanced ICT and Knowledge Intensive DSS), has been launched. The goal of SIRTAKI is to develop a decision support system for the managing of tunnels during normal operations and during emergencies. The project is currently in its initial phase. This paper gives an overview of the SIRTAKI project, specifies the use of scenarios for creating training sessions, and outlines the plan for evaluating the final product.

A method for classifying the user requirements and for planning the system evaluation, the means-end hierarchy, will be presented.

Introduction

The geographical characteristics of Europe have historically led to the construction of very long road and railway tunnels for the transport of passengers and freight. Many of these tunnels were built decades ago and have now become insufficient to properly serve the increasing mobility needs of European countries.

The increase of the demand, the obsolescence of the installations, and the lack of an integrated management of emergency situations, are leading to acute security problems in European tunnels, as was dramatically proven in the recent examples of the Mont Blanc and Tauern tunnels.

A recent international study [1] on 25 of these tunnels, in Austria, Belgium, Germany, Spain, Switzerland, France, United Kingdom and Italy, concluded that one third of the analysed tunnels do not meet the minimum security requirements to face an accident.

Together with safety and efficient emergency management, the effective integration of the tunnel surveillance and control with the rest of the urban or interurban network management is a must.

A discoordinated management of the network with respect to the tunnel provokes congestions and even potentially dangerous situations; likewise, if the tunnel manager ignores the network situation – including the management strategies being applied - he can take counterproductive decisions that have a negative impact both on the tunnel safety and on the overall network performance [2].

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[2] SIRTAKI is an EU project IST-2000-28303, and is partly funded by EU

To summarise, tunnel safety is a key issue and tunnel managers often face emergencies that demand rapid and appropriate reactions – involving complex decisions - in order to avoid catastrophes. These actions have to be effective whilst maintaining coordination between the management of the emergency and the management of the surrounding network.

In this context, SIRTAKI plans to respond to these needs by the development and assessment of an advanced tunnel management system that specifically tackles (i) safety issues and emergencies and (ii) integration within the overall network management.

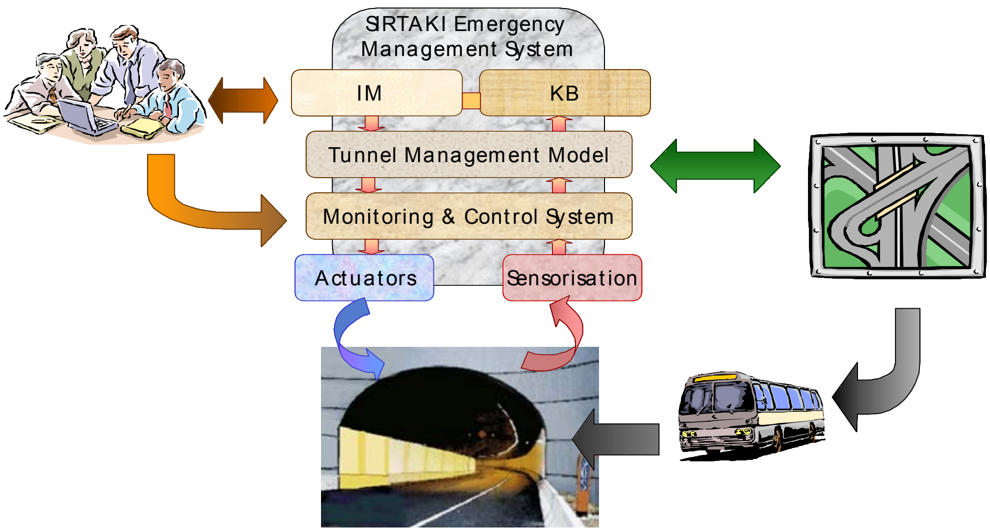
This strategic goal will be translated into a set of measurable, specific objectives:

1. To develop an integrated prototype of tunnel management and decision support system (DSS), including – but not limited to - emergency management. This prototype will be composed of four modules:
    a. Knowledge Basis: a learning tool that will support training, decision taking and automation of actions by applying previous experiences in emergency management and simulation of emergency situations.
    b. DSS: a smart decision support system that will help crisis managers to take decisions in emergency situations.
    c. Tunnel Management Model: a model of the tunnel that enables the integration of traditional surveillance and control systems with, on the one hand, DSS and KB and, on the other, the overall transport network.
    d. Tunnel surveillance and control system. SIRTAKI approach will not substitute traditional surveillance and control systems, but will enhance them with new capabilities, such as the DSS and KB, which will make control systems more efficient.
2. To integrate and validate the SIRTAKI results in a set of test sites with different characteristics and requirements (urban/interurban, road/railway, etc.) in France, Germany, Italy and Spain.
3. To establish a methodology and accompanying guidelines to facilitate the cost-effective adoption of the project results by any tunnel operator in Europe.

System architecture summary

The system to be developed in SIRTAKI is outlined in the following figure:

Figure 1: System to be developed in SIRTAKI



The benefits expected as a result of the Project are measured in technical, social and economic terms. Several benefits can be described including, first, the improvement of safety in tunnels, through a reduction in the risk and severity of accidents. Second, stress in operators and citizens during an emergency will be reduced. Third, the tunnels and the transport network will be managed in a coordinated way, which will improve performance of the transport infrastructures. Finally, the Project will allow for the performance of integrated management not only during emergencies, but also for other special situations.

The following preliminary indicators have been defined to illustrate how the project achievements will be quantified and measured: user satisfaction and acceptance (to be evaluated through questionnaires); reduction of response time to detected incidents (including the comparison with the situation without SIRTAKI); rate of false alarms; number of non-detected emergency situations; and user's assessment of the proposed corrective actions. The full set of indicators will be produced during the preparation of the Evaluation Plan - and after having elicited the user needs and requirements.

Road tunnels versus rail tunnels

Rescue operations are difficult in tunnels, as the possibilities to reach the emergency location may be limited due to large smoke generation and heat from fires and the blockade of "entrances". Here rail tunnels give more problems than road tunnels. The two systems are not comparable with each other due to their different concepts. The major reasons for accidents for the road traffic are due to human factors, which are increased by the nature of road traffic. Safety systems that are possible for the rail traffic are not applicable for the road traffic, as road traffic is driving "only on sight", safety measures are missing, and the road traffic includes a high number of ignition sources. The large number of individual drivers increases the possibility of subjective and unpredictable actions. Here rescue operations needs to stress self- and assisted rescue (by e.g. fire brigades). The fuel in the cars increases the fire load remarkably, and there is increased likelihood that the tunnel will be blocked by the accident. Fire extinguishers are seldom placed in cars and the drivers are untrained in using such devices. Furthermore, in Europe today it seems that a common citizen is very much used to and expects to get help and therefore, most persons will wait to be instructed without taking their own initiative. This is shown by investigations of the latest tunnel accidents, which showed that people would stay in their cars waiting for the rescue personnel to give advice.

The rail system with the tracks, driving by distances, safety systems including the modern guidance and safety technique, and the presence of trained personnel makes it possible to stress measures that decrease the probability of incidents/accidents and to mitigate the consequences of such situations.

Accident types

An accident is often the result of a number of succeeding or interacting factors, and when it happens it may be without serious harm in terms of injuries to people, structural integrity of the tunnel itself, and to the environment. In other situations a number of people may be harmed very seriously due to the mechanical impact of, e.g., a car crash or train de-railing, or a fire initiated by a technical defect. In some of these situations the accident does not "stop" at this stage, but propagates, as the initial accident may start a fire and/or an explosion or a fire from e.g. a technical defect gets out of control. This may give raise to toxic emissions from the cargo or the fire (toxic combustion gases). Other loads may be released in the tunnel air or are floating on the road to the deepest point of the tunnel. This can result in toxic emissions at longer distances from the accident. In case of flammable substances released, delayed fires and/or vapour cloud explosions may occur. The pressure of the blasts and the high temperature of larger fires may also damage the structural integrity of the tunnel. In terms of rescue and evacuation of the people in danger, the position in the tunnel where the accident occurs is another important factor, as emergency exits may be blocked or liquids may - depending on the actual slope of the tunnel - float "back" towards the waiting cars. Factors that also could have an influence will be the proper regulation of the ventilation systems and the functioning of the emergency lights. "Crowded" situations were many people have the same destination e.g. for football matches, large demonstrations, or cultural events can further influence the situation negatively. Thus a huge number of factors have to be taken into consideration when useful training scenarios are to be developed and knowledge is required on daily situations and unexpected events. Such knowledge may be specific to each tunnel and therefore it is important to have direct input from the accident history of the specific site in question. Other sources in which to find relevant information to build training scenarios are based on real accidents that have happened. Therefore, it is very useful to analyse accidents that occurred in other tunnels and to elucidate the relevant information and history of each accident. Here it is necessary not just to apply the information, but it needs to be adapted to suit the differences of the installations (physical parameters of the construction, typical weather conditions, exact location of the accident in the tunnel (distance from exits, ventilation systems and slope of the road) and distances to emergency exits, alarming systems etc.).

Use of scenarios

Scenarios are very effective as a means of getting realistic conditions and environments for coping with various types of situations. These could be daily routine situations or unexpected safety critical events. For these events, swift, efficient, and well structured efforts are of vital importance for minimising the consequences of the event, from a short term point of view or a long term perspective.

The development of training scenarios will often be based on requests for the need to obtain specific abilities and sufficient skills when dealing with specific situations for the persons being involved in the training session. This may speed up the skill as compared with the traditional hands on experience obtained by the daily routine.

The training of managing organisations are often based on repeated events or recent real accidents or training sessions, which may have revealed a less than optimal performance of the organisational team in specific situations. However, even though such situations may not necessarily trigger the training session itself, they may give rise to the objectives of the next training session as related to the specific goals of coming sessions.

Training scenarios are very efficient for performing emergency response training as the scenarios may support specific adaptable training objectives. Furthermore, the scenarios may be implemented in a dynamic way; i.e. the events included in a given scenario may be currently adjusted in order to keep the training along the lines originally intended.

As mentioned, training scenarios are often based on recent real accidents with the emphasis on training of specific tasks on which improved performance is desired. Thus, even though training is often demanded by the emergency preparedness plans, the goal of training is not to fulfil this demand, but to achieve an improved future personal performance in real emergency situations.

A scenario constitutes a story of a possible occurrence of events threatening to the society and/or the environments. A scenario ought to give the trainees the same kind of experiences and need for taking strategic decisions, as well as a need to exhibit creativity, insight and intuition, as in a real emergency situation. Therefore, it is of vital importance that the scenarios are plausible, but at the same time they may very well be surprising in order to create challenges to the trainee when coping with unexpected time critical situations and decisions. As the scenarios are meant for education and training, they should involve issues of which the outcome depends critically on timely and successful decisions.

The scenario is meant for ordering the visual perception of critical situations on which the emergency management response will be based. Therefore, despite the fictional presentation, this should in no way be a fixed sequence of events coming up at predefined times along the story line, but it should reflect and adjust to all the actions taken by the trainees in order to cope with the accident. So, the process should be highly interactive during the execution of the scenario, and this must be reflected in planning the scenario by the training supervisor.

The process for the supervisor of developing a training scenario begins by having in mind – based on previous experience from real life performance or training sessions - the tasks the trainees need to train. The next step is to identify the environments, situations, and other driving forces that create the mental input necessary for the trainees to provoke further gathering of information and knowledge for making the decisions to remedy the conditions and diminish the consequences of the hazardous situation.

Besides generating the physical location of the emergency, the time of the day and the direction and strength of the wind must be settled. The wind in tunnels, which may create a chimney effect, may influence the situation in case toxic material or smoke will be dispersed from the source of the accidents. Finally the specific accident must be incorporated in the scenery.

The scenario should be built as a scenario script allowing various paths through the sequence of possible events. The actual path will be based on the actions of the trainees and hereby result in various outcomes of the emergency situation. Thus, the scenario script may be seen as an event tree composed by nodes and arcs connecting different nodes. At each node the choice of path in progressing the scenario will be decided either by the previous or actual actions taken by the trainees in order to cope with the hazardous situation, or, alternatively, the supervisor may be able to decide how to progress the scenario in order to guide the scenario as he finds most appropriate in relation to the training objectives. Likewise, he may use this possibility if he finds the need to strengthen or facilitate the scenario depending on the ability of the trainees to cope effectively with the accidental situation. Furthermore, the event tree may act as a reminder to the supervisor, acting as a tool for implementing information to the supervisor in the form of notes related to the status and the progress of the scenario.

Scenario selection

The selection of scenarios for the various demonstrations will be based on the user requirements and specific wishes from the end-users related to their specific tunnel. They may be selected based on previous accidents or training events having a less than optimal outcome. Training scenarios will preferably be selected among scenarios tried out before with a well-known result and the possibility for the responsible of the training session to compare with the outcome without SIRTAKI. Therefore, these scenarios will be defined in co-operation with the end-users related to the specific demonstration sites.

Examples of types of training sessions could be:

Plain tunnels:

- Accident with fire outside the tunnel;
- Accident with fire inside the tunnel;
- Collision between a car and a truck in a road tunnel with or without fire and/or escape of toxic material;
- Collision between two trains in a rail tunnel with or without fire and/or escape of toxic material;

For Metro tunnels the scenarios may be more specific, like:

- Automatic fire alarm in trains at the station;
- Automatic fire alarm at stations or in emergency exits;
- Alarms initiated by cellular GSM phones from passengers;
- Fire in train in the tunnel between two stations;
- Fire in train at an underground station;
- Fire in tunnel installations
- Fire at stations and in emergency exits;
- Personal run-over or train accident including 1 – 10 injured persons;
- Train accident with more than 10 injured persons;

Evaluation Plans

The validation methodology of SIRTAKI will be based on user/system interaction in demonstrations using selected scenarios. This methodology will include (a) Guidelines for the definition of the scenarios at the demonstration and (b) Guidelines for specifying the data selected, how these data will be analysed, and how the results will be presented.

This point describes the 'Evaluation Plan', which the demonstrator sites will use to assess the objectives identified within SIRTAKI. Four main categories of assessment are defined:

- Testing the physical functioning of the system (or technical evaluation).
- User acceptance (friendless).
- Impact analysis (socio-economic aspects) and
- Financial evaluation and cost-benefit analysis.

This 'Evaluation Plan' specifies the framework to be used across the different demonstration sites and ensures that common procedures and indicators will be used. This will enable a cross-site comparison of results to be undertaken and to provide added value by generalising results throughout Europe.

Specifying objectives, the 'Evaluation Plan' describes the indicators necessary for obtaining valuable indicator values that are to be used by the demonstration sites. In addition to these common testing methods, each site may undertake additional tests based on specific local needs or services.

The means-end hierarchy

In order to facilitate the evaluation of the SIRTAKI outcome, the user requirements will be categorised in terms of means-end relations. The framework for this categorisation is shown in the figure below, presenting by the middle column the hierarchy in general [3,4] and by the left-hand column the means-end hierarchy in a condensed form utilising fewer levels in the hierarchy. This representation has proved successful and sufficient for evaluation purposes [5], and will be utilised in the SIRTAKI project, indicating the strategic goals on the highest level, procedures supporting these goals at the next lower level, and – at the lowest level – the operations from which these procedures are created. In this representation each level will be specified by the next upper level concerning the reason or background for an action, and by the next lower level concerning how this action may be supported (see the right-hand column).

Figure 2: Means-end relations in condensed form to be utilised for user specifying requirements in SIRTAKI, and in general with indication of the relation among the various levels

User	Means- End	Interrelations of levels		
Strategic requirements	Functional Purpose	Why		
	Abstract Function	Why	What	
Procedural requirements	Generalized Function	Why	What	How
	Physical functions		What	How
Operational requirements	Physical Form			How

The Means – Ends hierarchy was originally developed to describe the different abstraction levels in a working situation. The highest level corresponds to the system objectives, and the lowest level corresponds to the physical form used to implement the next higher level. The connections between the levels are expressed in the Interaction column where, at a given level, we can ask the question 'What' are we doing. At the next higher lever we may be informed about 'Why' it should be done, and at the next lower level get the answer to 'How' it may be done.

In the SIRTAKI project we have condensed the Means – Ends hierarchy to 3 levels. If we think of the SIRTAKI system as a collection of software modules then these modules will be at the lowest level "Operational". A combination of modules will belong to the "Procedural" level carrying out some higher-level tasks. Finally, the interaction of the whole system will fulfil the "Strategic" level in the hierarchy.

Having the user requirements classified according to the levels outlined above, the following evaluation steps may then be followed.

System evaluation normally constitutes three levels of test procedures:

- Verification, which is a check of implementation of operations specified in the user requirements, and therefore directly related to the lower level of the hierarchical representation of user requirement.
- Evaluation, which is a check of the presence of the functionality specified in the user requirements, i.e. is the system capable of executing all the sequences of operations needed for fulfilling the goals specified in the requirements. This part of the test procedure is directly related to the middle part of the hierarchical presentation of the requirements, the procedural requirements.
- Last, but not least, the validation takes care of – based on user satisfaction – the test of whether the system is of any value to the end users, i.e. do they perform better, more efficient and with lower risk for making mistakes in a critical situation than without having the system available. The question here is the difference between developing the system

right, i.e. following carefully all the elicited requirement specifications, or developing the right system, i.e. a system that really – in real life – is of benefit for the end users.

The logical way of evaluating a system is to take the top-down approach in which the evaluation and validation is tested by user interaction with the system. In case this test does not end up satisfactorily the next step would be to take the bottom-up approach, starting with the verification phase, checking the implementation of operational features and continuing with check of the functional features.

So, the SIRTAKI system evaluation will be based on the top-down approach resting on system to user interaction.

In more detail the 'evaluation and validation' of the SIRTAKI system will be performed by letting groups of test persons solve various tasks related to selected scenarios. The evaluation is partly based on measures, concerning the benefit from using the system related to:

- assessment of the current state and the current prognosis for the influence of the hazardous situation to people, tunnel integrity, and the environment;
- assessment and possible revision of the current priority of overall goals (which goals require relatively more attention and resources now?);
- assessment of the need for additional actions and agents: decision whether to alert additional agents or organisational units;
- establishment of communication links with the units and agents;
- planning of actions for coping with the accident or minimising the consequences;
- distribution of tasks and co-ordination of information to the relevant units and agent;
- executing the remedying plan.

Furthermore, the evaluation is qualitatively based on the users' subjective assessment of using the system and of the outcome of their efforts. This is done through direct interviews and through fulfilment of detailed questionnaires enlightening the general impression and understanding of the SIRTAKI system.

Conclusion

The outcome of the SIRTAKI project will be generalised for use in various tunnels, and for the future, hopefully specify the standard for emergency management in European tunnels.

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Verner Andersen got his Ph.D. in Physics in 1969. He is a Senior Research Scientist since 1992 at Risø National Laboratory. He has since 1986 been responsible as project manager and co-ordinator of various international projects related to decision support and training related to emergency management. His research topics include man-machine interactions and human factors.

Frank Markert got his Ph.D. in 1993 in physical chemistry. He is a Senior scientist at Risø National Laboratory. His work is mainly concerned with risk assessment and consequence analysis of complex industrial installations, hereunder the assessment of fire emissions. Presently, he is in charge as the co-ordinator to organise the Danish branch and the fire cluster in a European network on process safety -Safetynet (chemistry) and member of the network's steering committee.

Steen Weber got his PhD in reactor physics in 1974. Since 1990 he is a member of the System Analysis Department. He is a Senior Scientist at Risø. He has been local project leader of projects in which various knowledge-based systems were developed. His main research interests are in the development, implementation and evaluation of human-computer interfaces.

ADVANCES IN TRAVEL DEMAND FORECASTING AND WHAT THEY MEAN FOR EMERGENCY PREPARDENESS

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Keywords: Travel Demand Forecasting, Population Synthesizer, Modal Split, Time-of-Day

Abstract:

Within the transportation field, many emergency management questions can be answered by travel demand forecasting (TDF).

TDF is the science of quantifying the amount of travel in large transportation systems. TDF predicts travel demand and transportation system performance based on facility inventories and surveys (or projections) of demographic and economic activity. These projections have typically been limited to aggregate estimates of origin-destinations, transit passenger demand, daily auto travel, and rough travel time. Recent advancements have now made it possible to make more detailed forecasts of person movement and better estimates of travel times.

The TDF community has focused on many issues that are significant to emergency management professionals. These issues include: population location, population by time-of-day, population mobility, network representation, regional micro-scale simulation, and system visualization. These improvements are the focus of this paper. They provide planners with a more detailed understanding of current mobility and the impact of changes to the transportation network. Many of these advancements are currently being implemented in Portland, Oregon. This paper will demonstrate what the emergency management community can expect from emerging TDF technology, and how the technology might benefit them.

Introduction

Effective emergency preparedness requires a host of information inputs. The information needed includes population mobility, hazard identification, and reestablishing community continuity. Some of the above information needs are met within the transportation field with the emergence of new technologies. In order to establish training exercises, respond to events, and manage incidents emergency professionals need information about transportation accessibility and an understanding of how and why population and freight moves during the day. Within the transportation field, transportation modeling is where many emergency management questions can be answered. These questions include evacuation modeling and population location. This paper will demonstrate what the emergency management community can expect from emerging travel demand forecasting (TDF) and related technologies and how these technologies might benefit the community.

A transportation network is a fragile system. Emergency managers planning for a crisis event need to recognize the problems that currently exist to better plan their response. The 2001 Urban Mobility Report estimates that an average person loses thirty-six hours a year due to traffic congestion and that the current transportation network operates eight hours a day under congested levels. [1] So when the East coast network was inundated with evacuees during the terrorist event of September 11, 2001 in New York City and Washington D.C. and the week of September 13,1999 during Hurricane Floyd in South Carolina and Georgia the transportation network was brought to a stop. The perceived threat from these disasters increased travel times between high-risk areas and alleged safe areas, reminding decision makers of the vulnerability of the transportation network. Hurricane Floyd alone caused travel times to reach a 15-hour peak along a 100-mile span [2]. In New York City on September 11th during the terrorist event at the World Trade Center, 1.3 million residents and workers were asked to evacuate Lower Manhattan. These individuals needed to use new modes of transportation, as heavy rail and vehicular traffic were limited. This paper demonstrates how TDF methodologies currently used for highway congestion and air quality analysis, can answer many evacuation and other transportation related questions.

Methodology

The research within this paper utilized primary and secondary sources. Secondary sources include materials from the Department of Transportation (DOT) and Environmental Protection Agency (EPA) Travel Model Improvement Program (TMIP) clearinghouse and quick response reports and case studies from various other entities. Primary sources include DOT representatives and other transportation agencies.

Background

TDF is a tool that supports the urban transportation planning process. It is a series of analytical techniques, used to asses future demand for transportation facilities and services. It involves estimating the impacts of various changes on the transportation system and how they affect travel demand. These changes could include rerouting traffic along a freeway due to a flood or a shift in travel modes with the implementation of a new rail service. TDF plays a significant role in informing decision makers of the potential needs, alternatives to meet those needs, and potential impacts of their choices [1].

TDF models are divided into a four-step process: trip generation, trip distribution, mode choice, and trip assignment. Trip generation forecasts the number and purpose of trips. Trip distribution determines the destination of trips. Mode split predicts how trips will be divided among available modes. Trip assignment predicts the route choice. Typically, a TDF model forecasts 20 to 25 years into the future to evaluate proposed changes to the network.

The Transportation Analysis Simulation System (TRANSIMS) and the processes associated with it are taking TDF practice into the next generation of travel models. Key emphasis in TRANSIMS includes activity-based trips and microsimulation. Activity-based trips connect trips in a chain like fashion with the same start and end point. For example, the daily activity of an individual person could be represented using the following sequence: home, work, shop, eat, home. This sequence departs from the current practice that counts each trip separately. This improvement provides more detailed information and leads to a more informed analysis. TRANSIMS is considerably more data intensive and requires a higher level of traffic analysis then current TDF models. Testing of the TRANSIMS model is currently underway in Portland, OR.

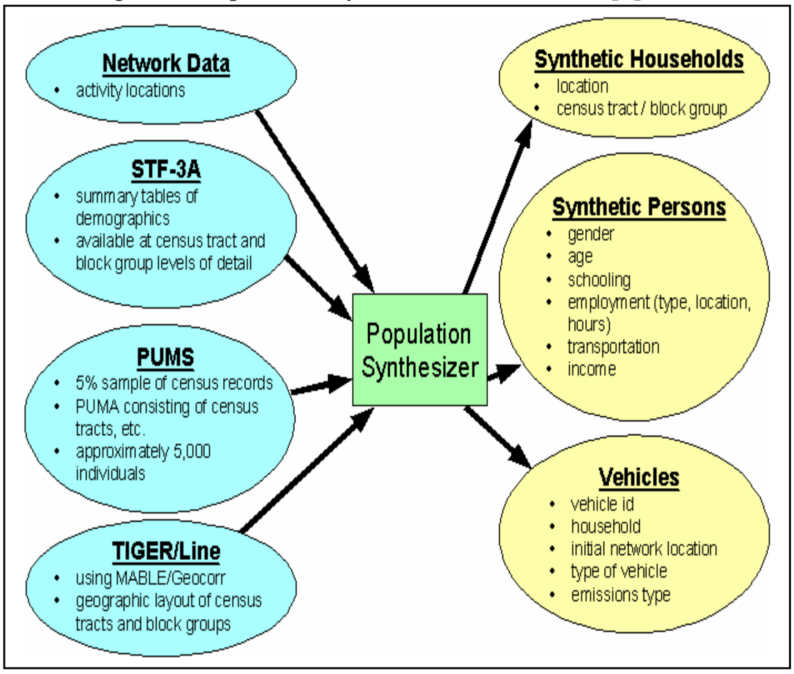
Findings

The following findings demonstrate how the TDF process can directly affect emergency preparedness. These findings are based on current practices within the field and improvements that are currently occurring in TDF.

Population Location – Population location is important to emergency management because it identifies and determines the possible impacts of a disaster event. Where the population is situated will affect the response. During the 1994 Northridge Earthquake in Los Angeles, CA emergency managers knew responders should dispatch to residential areas rather than business because of the 4:30am time of incident. This decision was clear, but if the incident had occurred at 6:30pm the choice would not have been as clear. Population location also refers to the difference between populations in motion compared to static. If an incident occurs during high travel times the disaster effect takes on a different meaning. To better manage transportation facilities prior to and during a disaster, the location of the population needs to be identified and incorporated into emergency plans. In the TDF process this population location need is currently addressed with the development of the population synthesizer and the traffic analysis zone structure.

A population model is built into a TDF model using U.S. Decennial Census demographic data, travel surveys, and the Census Transportation Planning Package (CTPP), which is part of the Census 'long form.' CTPP collects information on worker and commuting characteristics by using location of residence, place of work, and worker flows among small areas [3]. Travel surveys are conducted by planning agencies that include: personal household characteristics, activity at special generator locations and commercial truck information. After the data has been collected and validated it is place into Traffic Analysis Zone (TAZ) for analysis.

Figure 1: Population Synthesizer Framework [4]



All TDF models create multiple TAZ areas within a single study area with each individual TAZ containing information on population, households, and employment. This information is a statistical sample used to represent an entire population. A single TAZ population is generally 400 to 1000 household trips depending on the size of the study area making the population statistically aggregate.

The need for further analysis from TDF models led to a need for more disaggregate information. The population synthesizer, is part of the TRANSIMS development, and can possibly have the greatest influence on emergency planning. The reason is that in the TRANSIMS model population is disaggregated into a synthetic individual within a simulated house, one synthetic individual for every real person. Individuals are given an itinerary that tracks their movement throughout the day. Instead of 1000 TAZ areas, planners now need to track 200,000 itineraries. This data is then validated to the most current census findings. The disaggregate level of data allows for more interaction amongst synthetic individuals within the model set, which provides better information on travel behavior. At this level of detail emergency managers can gather a richer data set to test future policies.

Time-of-day – Time-of-day modeling is important because it forecasts the time a trip is made. During September 11th, the time of the incident and the response that followed was based around where the population was located at that time. If the incident had occurred three hours earlier at

6:00am rather then 9:00am the response and the devastating impact would have been dramatically different. During a sudden onset disaster, traffic flow will vary depending on the time of the incident.

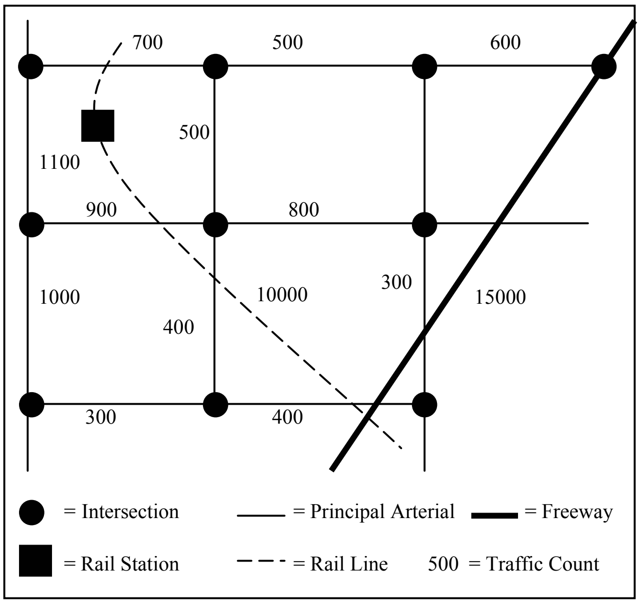
As an example current TDF models demonstrate travel in one movement for a single day, 50 trips went from TAZ 12 to TAZ 45. Sensitivity to time is not included. However, due to air quality policies, TDF models are now moving forward to include a time of day split. Large and serious areas with poor air quality are considered nonatainment areas and are required to do some level of time of day analysis. This analysis is usually divided into an AM peak, a PM peak and off-peak periods. Emergency plans that are sensitive to time of day movement would benefit greatly from this current process. TDF allows the user to test an emergency scenario at three different time periods within the same location in order to determine the effects on the transportation system.

Network – The TDF network is important to the emergency management field because it provides a coarse representation of a transportation system. When the Bay Bridge, which connects San Francisco to Oakland, CA, collapsed during the Loma Prieta earthquake in 1989, decision makers needed to find a way to reroute 300,000 daily travelers. An accurate network will provide emergency management a tool to test possible alternatives and measure their effectiveness.

When planning for a disaster, it is imperative to understand the transportation network. Rarely does a crisis occur that does not involve some aspect of transportation. The location of roadways and transit lines and how they interact will affect how people evacuate a hazardous location and how responders get in. TDF models are built with extensive consideration to accurately represent a study areas transportation network.

Networks are more then random lines crisscrossing each other on a sheet of paper. Each TDF model generates roadways and the available transit lines with information that includes speed1, capacity and accessibility. When a CSX train carrying hazardous materials derailed and caught fire in a tunnel in Baltimore, MD, on July 18, 2001, the accident closed the entire vicinity for at least two days. Traffic that normally flowed in and out of the area was detoured onto other arterials in the area. Using the TDF network and their characteristics can help generate information about the capacity of the other roadways in the area and help to transfer the demand that previously had been met by the affected facility to other areas.

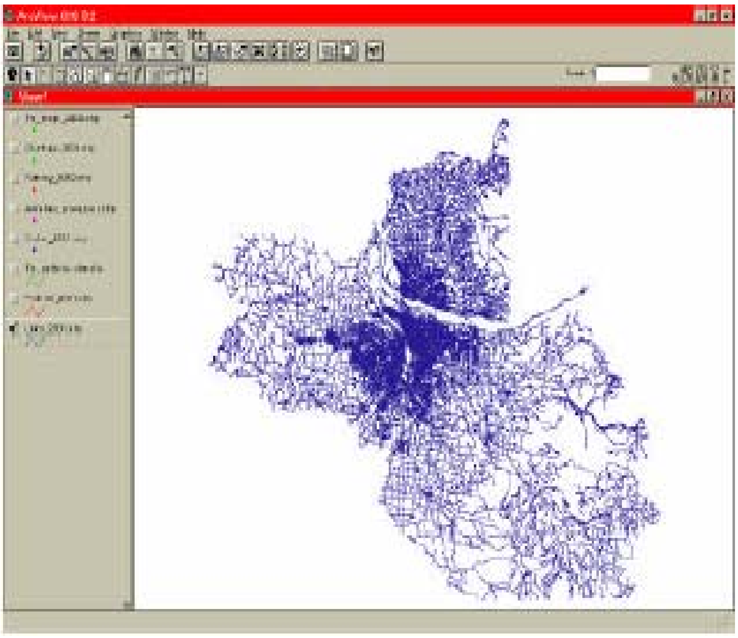
Figure 2: Example of a transportation network with only principal arterials, freeway, and rail line



Current TDF models use links to represent roads and transit network sections as represented in figure 2. Link attributes include length, capacity, speed and area type. The policies that direct the TDF model development will determine the network's level of detail required in a study area. A large aggregate model can function with only principal arterials and freeways identified while a disaggregate model will need collectors (streets that collect traffic from local streets in neighborhoods, and channels flow into the arterial system) and minor arterials included. The analysis required for the model will dictate the level of effort necessary for the network development.

If planners wanted to simulate a large-scale evacuation from a coastal town they would only need freeways and principal arterials because the majority of the trips generated within the study area would travel to external (outside the study area) locations. Freeways and major arterials are more attractive for long distance travel due to their speeds and limited accessibility. However, they are also known to reach capacity quickly resulting in major delays as seen during Hurricane Floyd. A TDF model with guidelines to test the ability of an area to function under extreme stress can easily be established by rerouting trips to the roadways in question. This knowledge can then be implemented during an actual coastal evacuation to better inform travelers of the delays and reroute travelers to different routes.

Figure 3: Entire Portland Network area [6]



A TDF network with freeways and major arterials would be enough for an analysis when modeling a major evacuation with lead time. However, an evacuation, due to a sudden event on a more disaggregate level, would require more roadways in the TDF network. For instance if a fire occurred within a downtown square block during a typical workday, what would the effect be on the network? For this level of information a network containing city blocks, collectors, and possibly sidewalks will need to be added. For every street closure a vehicle can be rerouted from it usual trip and the effects can be collected for analysis. This type of analysis requires a lot more effort, but the information generated would be invaluable.

Currently Portland, OR has a network with this level of detail within its model. Every road is broken into lanes and sidewalks. Portland's network contains 124,904 links or roadway segments [7]. This includes driveway/parking locations to expressways. This network took over two years to build, however since Portland was the first site to build a network with this much detail, lessons were learned that could be applied to reduce the time investment required by other areas.

The more detailed the network, the more scenarios and policy testing can be done for emergency preparedness. For instance, a policy on the effectiveness of lane reversal during a coastline evacuation can be tested. Using the network developed for Portland, emergency planners can simulate three lanes reversed so seven lanes of an eight-lane highway are moving in the same direction. Once traffic is redirected onto those lanes the results can be compared for analysis. Although most current TDF networks do not have this level of detail they can still be useful on an aggregate level.

Mobility – The issue of mobility is important to emergency management because it reflects the population's ability to move within an area. The capacity in which a population can move will dictate how the request is handled. Whether it is a lead time evacuation like a hurricane or a sudden evacuation from a chemical release, a population needs to move and an emergency manager needs to know how this will occur. The timeliness and the speed will be dependent on the route they chose and their mode of transportation.

Figure 4: Example of Home Base to Work Trip Table [8]

Computed Productions and Attractions		
TAZ	Productions	Attractions
1	25	1,000
2	125	350
3	350	500
4	800	100
5	600	250
Total	1,900	2,200

In the TDF model, the use of production and attraction rates dictates the movement in and out of a TAZ. These rates identify where trips are going. Production rates estimate the amount of trips leaving a TAZ and attraction rates estimate trips entering a TAZ. These rates are placed into a trip table that generates trips between and within TAZ areas. These rates would provide emergency managers with a method to move populations from one area in the community to another. For instance, a scenario is created in which a Hurricane threatens the model area. Emergency managers can manipulate the attractiveness of a TAZ area so that an external TAZ area is overwhelming more attractive then any TAZ within the study area. When the model is calibrated emergency managers will be able to identify what level of congestion will exist on that proposed evacuation route. Alternatives can then be proposed along with traffic control policies that reduce the expected evacuation congestion

This example also leads to TDF models that reduce evacuation travel times during a hurricane evacuation. When a trip is assigned to a TAZ part of its attractiveness is related to the travel time to get to that zone. If emergency managers know the time needed to evacuate an area, the window to announce an evacuation would increase. This means that travel times would be decreasing, allowing for more time before an evacuation is officially requested. This is where better modeling would lead to better planning, which would eventually lead to reduced travel times. Increasing the time needed to request an evacuation would limit loss to business and diminish the stress in a community. During Hurricane Floyd this was clear when residents in Northern Florida were asked to evacuate. When the hurricane completely bypassed the area many residents were upset and frustrated. A TDF model could have been used to analyze the area giving emergency managers a large window to order the evacuation**.**

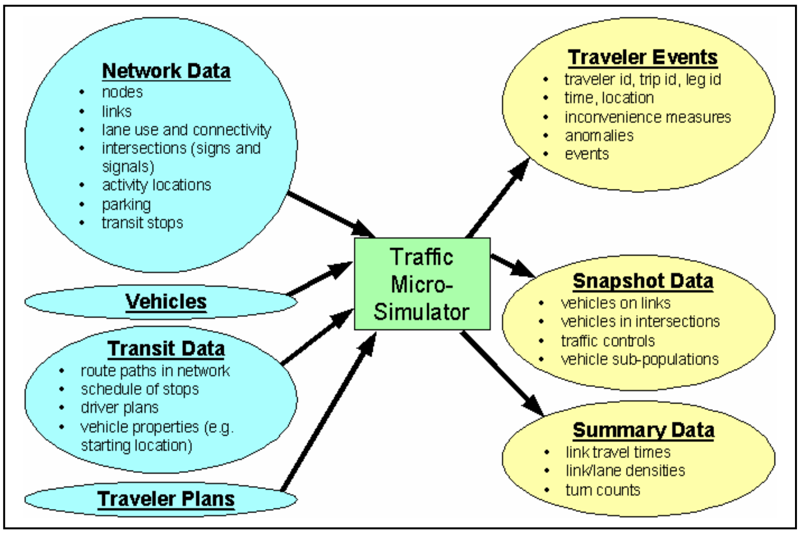
Modal Split – Modal split is important for emergency managers because it refers to the different modes that a community can use to travel. This may include walk/bike, single occupancy vehicle, 2-person vehicle, 3+vehicle, light and heavy rail, bus and ferry. In a sudden onset emergency, the timeliness of a community's reaction will depend on their mode of travel. Each community mode choice model varies depending on the availability of each mode within that area. For a traveler the mode decision is usually based around cost/time to make the trip and person/trip/land use characteristics.

A mode split model creates additional trip tables for each mode when it enters and leaves a particular zone. This information is tallied, and assumptions within the zone can then be made. This information provides emergency managers the vulnerability of a population's ability to move within a zone. During the September 11th attacks in New York City people walked across various bridges due to the rail lines being destroyed and vehicular traffic operating at a minimum level. A large amount of the population in Lower Manhattan relies on the rail line, and when that system failed people were forced to find other means. A TDF model would have recognized this as a problem by closing several commuter lines in the model.

The TRANSIMS model would take the above example a step further. After that group of would be travelers were identified, each itinerary could be augmented for walking trips. Emergency managers could then estimate approximate times it would take to move a population from a hazardous location to a safe location when a transportation network completely fails.

Microsimulation – Microsimulation is a new part of the TDF model and is available in the TRANSIMS model. Microsimulation is important to emergency management because it allows tracking of the activities of a synthetic individual over the course of an entire twenty-four hour day.

Figure 5: Traffic Microsimulator Framework [9]



Currently, when a trip is made from zone to zone, that trip is placed on a road link that includes number of vehicles on that link. With microsimulation, trips can now be calculated across the entire network with sensitivities to road characteristics, such at streetlights and street parking. After the itinerary of a synthetic individual has been developed, their trip begins. The microsimulator will then track each individual along the network second by second and enforce physical constraints like not allowing an individual be in two places at the same time.

In 1996 the microsimulator was used in a case study in Dallas, TX. [10] The case study analyzed two proposed roadway improvements that would alleviate congestion in a business area between 5:30am and 9:30am. One improvement proposed a lane in each direction added to the interstate, and the other was to lower arterial intersections. The metrics for the study included travel time, speed, average vehicle miles, and network reliability. The case study was able to prove the effectiveness of the microsimulator, as the freeway option was more effective until 7:30am when individuals began to empty the freeways and from 8:00am on the street arterials improvements were more effective.

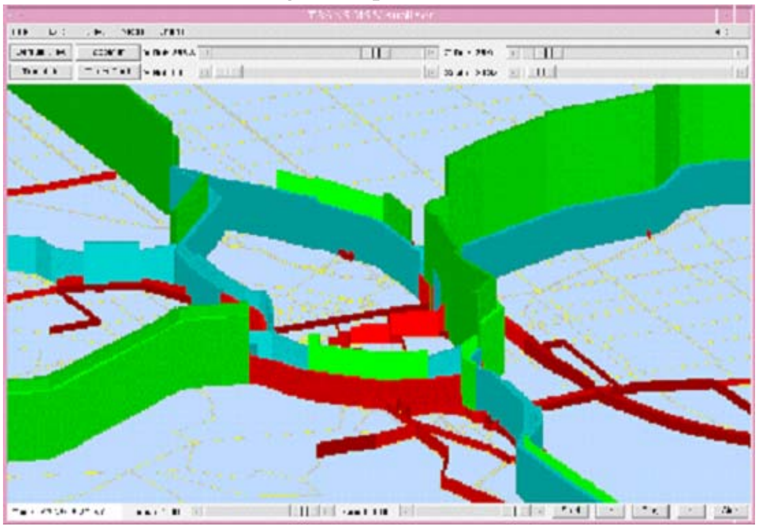
Besides analyzing routes another emergency management use could be testing the effect of a biological/chemical release. Suppose a terrorist released an airborne toxin that could be transmitted from person to person. The toxin plum can be layered on top of the microsimulator highlighting every synthetic person that is affected by the plume. As the individual continues about the network each person that comes into contact with them would be highlighted. This would help provide some information for a risk analysis on possible biological/chemical dangers.

Visualization – The final finding in how TDF can help emergency preparedness is with the advancements in visualization techniques. This is important to emergency management because it provides a method of interpreting the results. Visualization can also help TDF users identify results that normally would have been overlooked.

Current models display their results on a basic computerized map with the travel demand placed on each link. However, more TDF models are moving to a geographical information system (GIS) platform. The main advantage of the GIS system is its ability to relate tabular data to digital maps and relate various sources of spatial data to one another. The GIS system can forecast travel, validate and calibrate the model, test environmental impacts, and measure social impacts.

The TRANSIMS model allows the analyst to dynamically view the output from the microsimulator module. All displays are both temporally and spatially dynamic. This means that spatial areas can be located and zoomed in on in order to provide the best view. Also, the display can move through time to assess the changing characteristics of the roadway network, which potentially can show the congestion points along the roadway network.

Figure 6: Multiple routes overlaid in time to show predicted congestion points [10]



Conclusion

As demonstrated within this paper, there is a lot of information that can be taken from the TDF process and used in emergency management. This information includes work currently done on the location of population, the time of travel, its mode of travel, transportation network development, mobility, microsimulation, and visualization. The TDF results would help provide better transportation information to emergency preparedness plans.

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Acknowledgement

I would like to thank the Travel Model Improvement Program team, especially Brian Gardner and Dr. Fredrick Ducca, for their oversight and support. I would also like to acknowledge Dr. John Harrald at the George Washington University for this opportunity.

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ONE STEP CLOSER TO THE EFFICIENT MANAGEMENT OF SPEED-RELATED RAIL INCIDENTS

Cheila Duarte, Colardelle[1], Jacques Valancogne[2], Stéphanie Fond[3]

Keywords: typology of rail incidents, positive experience reflection, organizational learning

Abstract

This paper aims to shed light on frequent and reoccurring rail-related speed incidents observed in the largest railway company in Paris, France, the RATP[4]. Based on internal examples in the RATP transportation rail system, we will identify, by means of a return-on experience method, the main causes behind these incidents. The causes may be of diverse nature and if identified can facilitate the analysis of each speed-related incident. This study therefore aims to demonstrate how to better address and efficiently manage such incidents with a view to better revealing the dysfunctional elements within the system, dealing with them efficiently and thus reducing their frequency and scale.

1. Introduction

Notre Dame de Lorette is the rail speed related incident that has had the most impact on the minds of rail RATP workers. On the 13 August 2000, on line 12 of the metropolitan RATP rail system, a metro[5] derailed and slid several metres on its side before entering onto a headline collision with the opposite track platform. Once come to a halt, the human damages were made public, 24 lightly injured due to overspeeding. The driver was 30km/h over the set speed limit of 30km/h (maximum speed on this part of line).

This incident has by no means influenced the number of speed related incidents, which are unfortunately recurrent. They may not be of similar gravity to the one experienced at Notre Dame de Lorette, but they are indeed very frequent in number and potentially serious. They are, for these reasons, becoming a matter of concern. In fact, between 1996 – 2001 there were, according to internal RATP sources, on average, over 5000 speed excess (a great part of them being of minor importance) related incidents per year.

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[4] RATP : Réseau Autonome des Transports Parisiens, founded in 1948. RATP employs approximately 38 465 individuals. The RATP represents 80% of all human transports in the Parisien urban area and transported 2,5 billion people in 1999.
[5] Metro : subway or underground train used for transportation. Each train has four to six coachs. The RATP metropolitan network comprises 211 km of rail and 380 stations.

In 2001 the MRS[6] department of the RATP decided to look deeper into this matter, by means of an experience reflection study. Several questions were posed, namely:

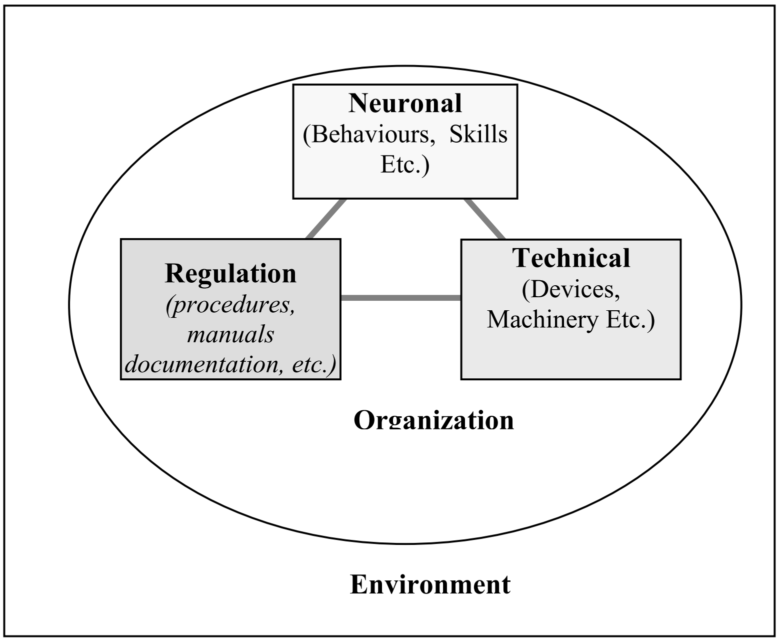
- Is there some kind of system dysfunction that contributes towards the redundancy of speed incidents?
- To what degree can the risk-taking behaviour of drivers, involved in these speeding incidents, be assessed and managed appropriately?

This article endeavours to present the results obtained by a 6-month study of speed-related incidents in the RATP rail system. With a view to clarity the study is structured in three parts. Firstly, we will proceed with a cross section of rail driving context. This cross section will endeavour to set the groundwork, shed insight into the area of study and help evaluate its complexity. Secondly, the interest of the positive experience reflection method employed in the study will be discussed. Lastly, a succinct review of the study findings will be exposed.

2. A Complex Integrated System

Three main components of the navigational rail speed system (human, regulation and technical) need to be clearly established before tackling the subject of speed-related incidents. These 3 sub-systems make it possible to grasp the complexity of the system.

Figure 1: The complexity triangle of a system



Technical

Speed is measured automatically whilst the train is in motion by a chronotachygraph.

Each speed violation is apparent. Should a driver violate speed limits "too frequently" or "too far above the allowed level", his or her driving conduct will constitute an object of inquiry or sanction. However, what qualifies as "too frequently" or "too far" depends on the attention that the metro lines local authority desires to give each case.

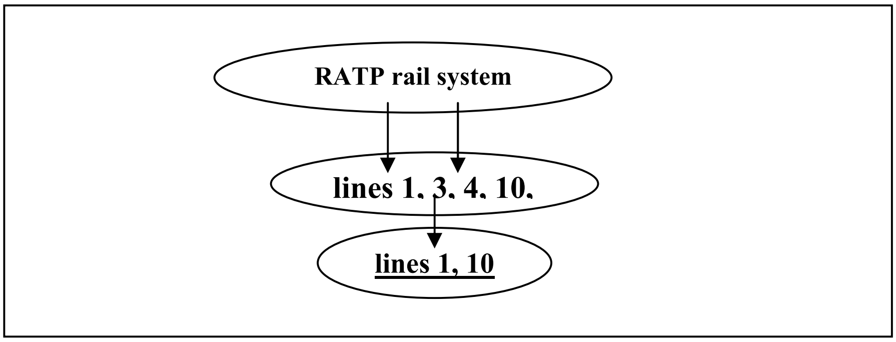
To better exemplify and analyse the existing behaviour on metro lines a deliberate selection of

[6] MRS : Maîtrise des Risques Systèmes, created on 1st July 1998

metro lines was made for the study. The sifting process consisted of 3 stages.

- The RATP metro network, constituted of 16 lines has lines on which navigation is either automatic, where the driver's role is limited, or manual. On these manually driven lines, the driver is almost solely responsible for the navigation. Therefore, the first selection of metro lines was made by narrowing down the metro lines that would participate in the study to manually driven metros.
- A second criterion of choice, which narrowed down our choice even further, was that of the existence of recent data on excess speed related incidents. The incidents that were studied were:
  - Deficient use of brakes when confronted with a repeater of a shunting signal at yellow indicating that the repeated signal is closed.
  - Various speed violations in 2 interstations.
- Thirdly, the metro lines personnel need to be conscious of the importance of the investigation. Therefore, those that demonstrated the maximum interest in participating in the study were selected. In the end, 2 metro lines remained and participated in our study, lines 1 and 10 of the RATP metro system.

Figure 2: Sifting process selection of metro lines



Regulation

In order to better apprehend the behavioural patterns of personnel in the RATP network rail system, we decided to focus our attention not exclusively on the literal unfolding of the speed incident itself, but on the driver's perception of the incident. Was the driver aware of the procedure to be respected whilst driving an underground train? What elements guided him during his driving shift? There are various reasons for this choice.

Firstly, standard written navigational procedures exist and must be followed. In fact, written procedures insist on:

- The inculcation of respect and adherence awareness to the reglementation as a whole.
- Safe and smooth driving.
- Adherence to and respect for prescribed speed limits and traffic regulation signals/indicators.
- Adherence to and respect for operational practical driving procedures (eg: given set time taken to cover an interstation)
- The driving procedure to respect during an degraded situation

These written standard procedures exist in order to ensure a safe journey whilst navigating in the rail system as well as a non-violation of speed limits posted throughout the tracks. The drivers are well versed in these procedures not only due to the initial training period they are all subjected to, but also due to experience in navigating. Their professional experience should make them not neglect the importance of respecting regulations.

Other than the existing code of written rules, there is a secondary form of regulation that is dispensed before a driver is considered as such. While a driver is a trainee he/she undergoes practical driving lessons. The training period of 3 months is dispensed by instructors. These instructors are themselves drivers with a licence who have solid driving experience on the RATP lines. Each monitor bases his/her teaching on what the written regulation requires and on personal experience. Each of them has his/her own personal set of golden rules what they call "les bons gestes du conducteur/the good conduct of the driver " (see Figure 4 in Annex).

Apart from the initial training dispensed, there is a continual check-up on the driving capacities of drivers. This is done through occasional surveys and by keeping a record of speed related incidents a driver may be implicated in. Continual monitoring is considered a good indicator or thermometer of the driver's level of professionalism and competence.

Human component

Speed incidents involve young drivers as well as older and more experienced ones. In the case of older and more experienced drivers, these should most probably capitalise on their professional experience and their skill should improve with time. So, there must be other reasons other than lack of training to account for the influx of speed excess incidents.

3. The Positive Experience Reflection Tool

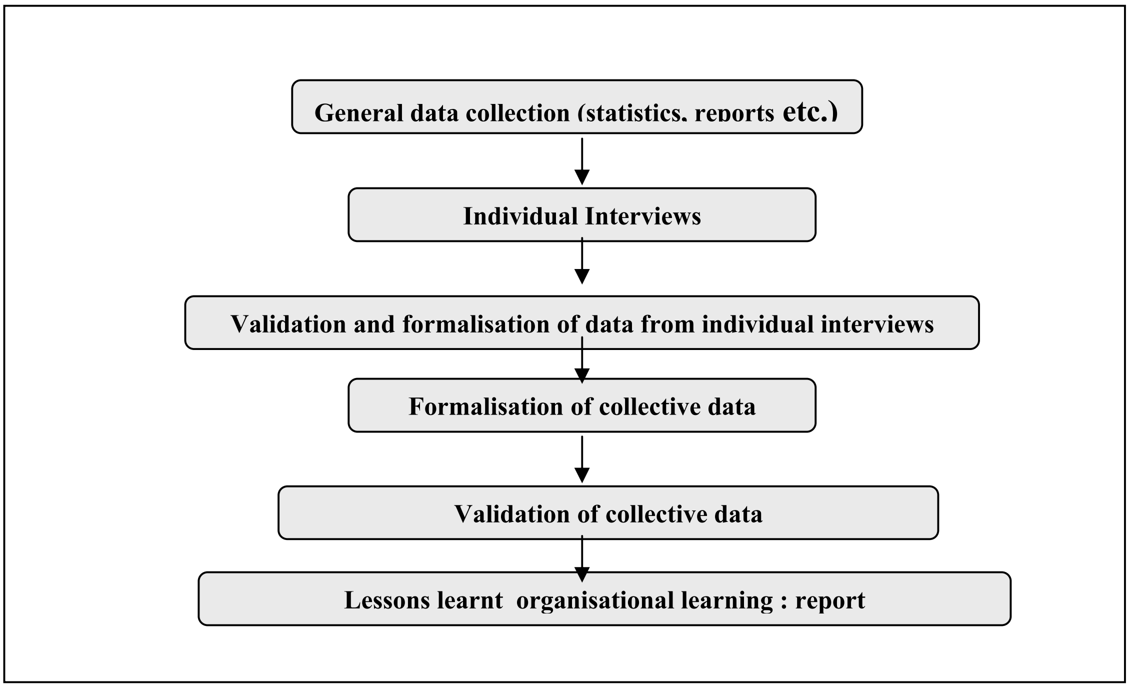
One of the main difficulties that companies have today is to tap into the invaluable sources of individual tacit information. Companies often become frustrated with not being able to reveal and to learn from the rich source of individual day to day learning experiences. Organizational learning depends on and stems forth from individual inputs [Nonaka & Takeuchi 1995].

The main reason is the absence of tools enabling companies to exploit individual experience, to disseminate its lessons and to translate them into effective action [Kleiner & Roth 1997]. The RATP has several tools (eg: employee surveys, database etc.) that endeavour to capture the best practices, individual experiences and implicit ideas.

As generally observed, these often fall short, failing to give the full picture. Hidden factors and logic are not taken into account. Also, once the hidden logic has been acquired, managers have difficulty in exploiting them. Transferring newly acquired knowledge, in order to modify certain behaviours, is no easy task [Garvin 1993].
The RATP therefore turned its attention to an external qualitative positive experience reflection method comprising six different steps. This method had been implemented by the RATP in 1999 and, having been well perceived, was implemented once again in 2001. The positive experience reflection approach complements other existing risk management methods. It allows for an identification and capitalisation of individual practices and personal experiences in their entirety. It also legitimises organizational changes in that all persons feel involved and feel that they contribute to the better functioning of the system.

The 6-step positive return on experience reflection method referred to above (see Figure 3 hereunder) was developed by the Cindyniques research Centre of Ecole des Mines de Paris.

Figure 3: Positive experience reflection method



By means of this 6-step process, the positive experience reflection method analysed 3 types of driving practices: prescribed navigation; normal or operational navigation; and abnormal navigation (eg: in an incident, during works etc.): crisis or incident management

Rich qualitative data was collected on these three modes of driving. Drivers were questioned on which actions correctly characterised, according to their own experiences, each type of driving practice. The data, collected from individual anonymous and open interviews, was represented graphically, in the string of key events graph[7][Colardelle 2000]. Each key action, particle of experience, has 4 steps [Wybo 2000]:

- Context
- Analysis of the context and options
- Decision(s) taken
- Effects of the decisions

Two types of key moments are identified - real actions and hypothetical actions that can be acted out. Hypothetical actions can be of two natures, positive ones (that improve the functioning of the system/ systems function) and negative actions (that contribute to the deterioration of the system) [Colardelle 2000].

To better exemplify, a key of string events graph (Annex Figure 5) representing a collective example, construed after a number of interviews, has been included for consultation. This simplified version of the collective string of key event graph applies to the standard written code of rules which need to be respected while navigating.

Each string of key events is basically evidence of the democratisation process through science. The string of key events graph allows for an understanding of the key moments or actions undertaken during navigation as perceived or as experienced first hand by the drivers. Each driver has stored

[7] From the French expression "Fil Conducteur".

his/her information into a scientific information collection model, the string of key events graph. Each individual account is fragmented as no drivers can have the complete picture and possibilities of action. Not having the complete story is not a problem seeing as how the interviews are a pretext to congregate drivers and to initiate an introspective process and to initiate dialogue.

A collective string of key events graph is obtained by piecing all individual accounts into one full collective account, a bit like a puzzle. In the end, three collective key of string events graphs remained, sometimes with contradictions. The information contained in each of them was discussed until all drivers came to a collective consensus. The information was in this way authenticated and validated by all the drivers that participated in the study. The objective of the validation step is to encourage a discussion of the three types of key of string events driving possibilities. This convivial exercise has several positive effects on drivers:

- Allows for communication between drivers of the same and different lines, with different years of experience, backgrounds and practices.
- Elicitation of and capitalisation on tacit knowledge
- Sharing and transfer of knowledge
- Dynamic individual and collective reflection

The outcome of this study also has several positive effects on management, making it possible:

- To identify with greater precision the causes or origin of frequent speed incidents
- To understand the drivers' perception on risk taking when these show no regard for regulation
- To identify the drivers' risk perception concerning a stretch of rail, a metro line and the metropolitan rail system.
- To be better equipped in formulating appropriate, accepted and legitimate measures that can be ensued in the three main system components:
    - Technical. By means of an up-date on ergonomy, modification of localisation and speed limits of traffic speed indicators etc.
    - Procedural. By means of an up-date on regulation by taking into account practiced golden rules if positive
    - Human. By means of training and sanctions, if necessary.

The validation stage of the method, meetings, offers a platform for wide-spread concerns or beliefs which are usually non-existent in formal proceedings. It is a moment characterised by free dialogue within the framework of a scientific model, the string of key events graph. The situation is normally de-dramatised and the conversation oriented around positive actions that were taken or positive actions to be encouraged.

4. Findings

The implementation of the positive experience reflection method met with a number of obstacles, namely:

- Difficulty in obtaining information due to the absence of data on past speed excess incidents.
- Difficulty in getting the agents of the lines to participate in the interviews.

The lack of exhaustive and organized data on speed related incidents encouraged us to suggest the creation of an up-dated and tailored speed excess incidents data base. The new data base would enable the RATP to characterise the nature, origin and circumstances surrounding each incident and therefore constitute a typology of speed related incidents. Once an incident is identified and classified in a particular group, a more in-depth return on experience process inquiry can be initiated if deemed necessary by the RATP management.

A certain number of indicators need however to be taken into consideration when compiling the data base. Factors permitting a better analysis of the circumstances involving speed excess incidents have to be identified. The investigated Metro lines were scouted in order to identify the areas at risk (areas that have been the object of various and frequent speed excess incidents). Finally, the new data base has to be simple and concise. In other words, appealing enough to interest the drivers.

The positive experience reflection method, based on the driver input and experiences, allowed for the beginnings of construction of a new data base on excess speed related incidents (see table 1 hereunder). According to the drivers, three areas are at the core of speed related incidents: the environment, a conjunction of circumstances and human factors.

Table 1: Typology of speed-related rail incidents

Environmental or Structural Indicators	Static	**Example:** Straight line Curbed zone Gradient / slope Ergonomics of signal placement Others:
Conjunctural Indicators	Dynamic	**Example** : Licensed driver / titularized driver Non disponibility of Automatic Pilot/ degraded driving Others:
Human Indicators	Behaviour	**Example:** Actions due to human error Recurrent speed infractions Others:

The second difficulty encountered in this study pertained to the data collection, obtained during individual interviews. Most drivers have a very tight schedule and work at varying hours, so they are difficult to reach and to interview. By accompanying the drivers in their driving routines, we were able, by observation, to note down various reactions and identify each action that the drivers took. Then, after the driver had finished his/her shift or during his/her coffee breaks we were able to ask why they reacted the way they did or decided in favour of a particular course of action.
The positive experience reflection method therefore revealed:

- Existing palpable gaps between the behaviour expected by the company, as exposed in regulation manuals and during training periods, and the real behaviour of the driver, the theory in use [Argyris & Schön 1978]. Some of these practical adaptations practiced by the drivers are spontaneous. A number of these adaptations are positive and should eventually be taken into account and shared with other drivers of the RATP rail system. Others, however, may be dangerous and the company would need to counteract divergent behaviour.
- Three principal explanations for excess speed related incidents :
    - Environment: Structural elements that complicate operational driving, namely complicating braking and leading to speed excess (the network configuration, differences in speeds in various signals, speed limits that are not apparently always coherent etc.)

- Conjunctures: driving in an abnormal, degraded or failing context (eg: works).
- Human errors: not paying sufficient attention, not enough practice when it comes to manual driving, relying too much on automatic pilot, personal problems, under the influence of drugs, risk taking, the need for training.

5. Conclusion

By means of the positive experience reflection method, speed excess driving incidents were sorted out and characterised according to their kind. Also, the analysis of qualitative data made it possible to better tune into and attend to the various risk perceptions and obstacles faced each day on rail lines by drivers.

Management is better equipped to understand, to manage and to capitalise on speed related incident situations. By identifying the real cause of the incident, managers can treat drivers fairly and thus improve relations between the two bodies, which are often tense. Indeed, a main source of tension was due to the handling of speed related incidents. The study therefore allowed for a better understanding of underlying causes and enabled managers to deal with the incidents in an appropriate manner. In this way, the sanctions that were administered in general to all speed related incidents without distinction, now have a wider acceptance because drivers are sanctioned on "real mistakes"on human errors.

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7. Annex

Figure 4 : The good conduct of the driver, « les bons gestes du conducteur »

Train in movement
- The driving must be smooth

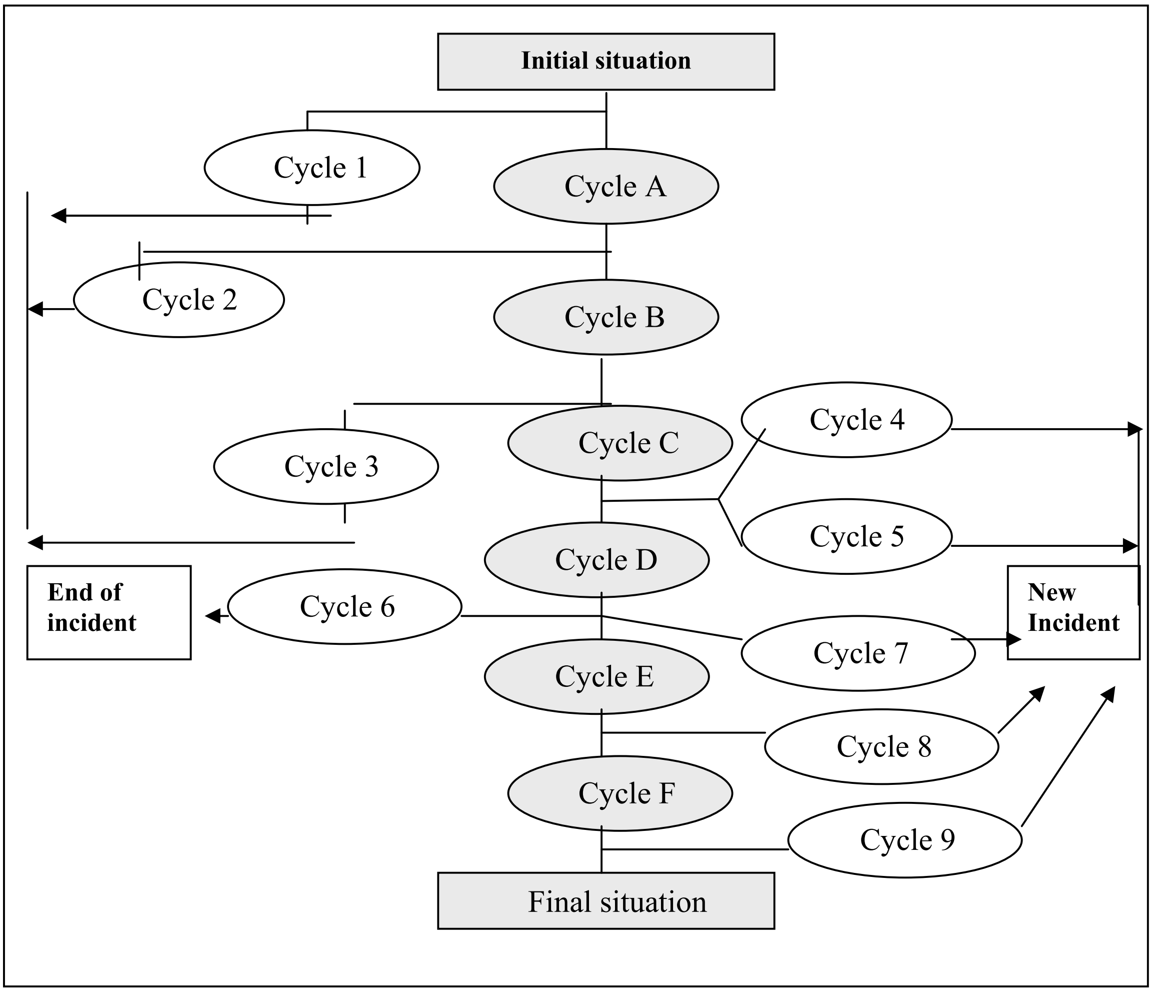
On entering a station
- Must be in a position to brake before entering a station in order not to break the standard speed limit of 40km/h
- Engage in a smooth, constant and progressive breaking in order to:
  - not break the standard speed limit of 30km/hr at the mid level of the train quai
  - Never open train doors if the train has not come to a halt.
  - Always keep a braking margin whilst pulling up into a station and until the train halts.

When the train has come to a halt
- The train must be in a brake position

Adhering to speed limitations
- Test the breaking capacity after all change of technical material
- Never hesitate to engage automatic pilot when one's attention is taken/attention level is low.
- Be familiar with the location and speed limitations of all traffic indicators posted along the train lines
- Cease accelerating before having reached the allowed speed limit.
- Anticipate braking

Adhering to traffic regulation
- Slow down as soon as a one sees a restrictive traffic signal (ex: signal with an orange or red light)
- Never anticipate the go-ahead signal of a traffic indicator
- Traffic signals must never be arranged according to hierarchy for what they are but rather for what they are conveying/according to what they indicate.
- Do not come to halt to close to a closed signal

Figure 5: The string of key events graph for the navigational standard written regulation



Real Cycles

Initial situation: Context (Metro leaves a station in direction of another, hour of less traffic, train manually navigated etc.)
Cycle A: Move train forward
Cycle B: Visual contact with traffic indicators orange light
Cycle C: Crossing of orange light traffic indicator and observance of the written regulation to apply in these cases
Cycle D: Visual recognition of traffic speed indicator of 45km/hr
Cycle E: Train comes to a halt at the traffic manœuvre signal
Cycle F: Train on the move again
Final situation: Train come sto a stop in the next station

Hypothetical Positive Cycles
Cycle 1: Encourage drivers to navigate manually
Cycle 2: Anticipate the orange light traffic indicator

Cycle 3: Better clarify all possible options when confronted with a traffic indicator with orange light.
Cycle 6: Delocalise the traffic speed indicator

Hypothetical Negative Cycles
Cycle 4: Ignore traffic indicator displaying an orange light
Cycle 5: Partial application of written regulation
Cycle 7: The driver keeps on moving and attains a velocity of 45km/hr
Cycle 8: Train violates traffic regulation (it moves instead of halting)
Cycle 9: Train on the move before its time

SECTION 7:

EARTHQUAKE & LANDSLIDE DISASTER MANAGEMENT AND MITIGATION

The International Emergency Management Society
9th Annual Conference Proceedings
University of Waterloo, Canada, May 14-17, 2002

A CLOSER LOOK AT GIS-EARTHQUAKE LOSS ESTIMATION METHODOLOGY TO IMPROVE CRISIS MANAGEMENT CAPABILITY

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Key words: Earthquake Consequences, Earthquake Loss Estimation (ELE), Sensitivity Analysis, Earthquake Risk, and HAZUS.

Abstract

This paper uses HAZUS[1] for sensitivity analysis for earthquake scenarios for San Francisco County. In addition, in the paper, we suggest guidelines that could be used in response to earthquake catastrophe in the San Francisco Bay Area (SFBA), and for other regions. This analysis will help emergency mangers and decision-makers to understand the potential risk in their jurisdictions from an earthquake, which will help them in preparedness and planning for future catastrophes. Urbanization compounds the problems associated with earthquake disasters in large cities. Furthermore, forecasting of unknown accuracy of earthquake loss estimation is of limited use, and can be very misleading to stakeholders. The parameters that are used in the sensitivity analysis are: 1) site effect, 2) attenuation relationships, 3) ground failure effects, and 4) building inventory. In this analysis, we used hypothetical earthquake scenarios to test the number of people who would be killed, the number of people who would need hospitalization, the number of people who would seek shelter, and the total economic losses that would result from residential building damage. It is apparent that Potential Earth Science Hazards parameters (items 1-3 above) are more sensitive to earthquake magnitude than the Direct Physical Damage parameter (item 4 above). Ground failure effect, from no liquefaction susceptibility to detailed liquefaction susceptibility, is the most sensitive parameter in earthquake loss estimation, followed by choosing the attenuation function, subsequently, site effect parameters, from soil type D to detailed soil type map of the region, and lastly effects of building construction parameters, high code standards to moderate code standards. The building construction sensitivity on the economic losses is relatively stable. For the other loss estimations—number of people who would be killed, number of people who would be hospitalized, and number of people who would be sheltered—the sensitivity of the other analysis parameters, either enlarged or diminished with the increasing in earthquake magnitude.

Introduction

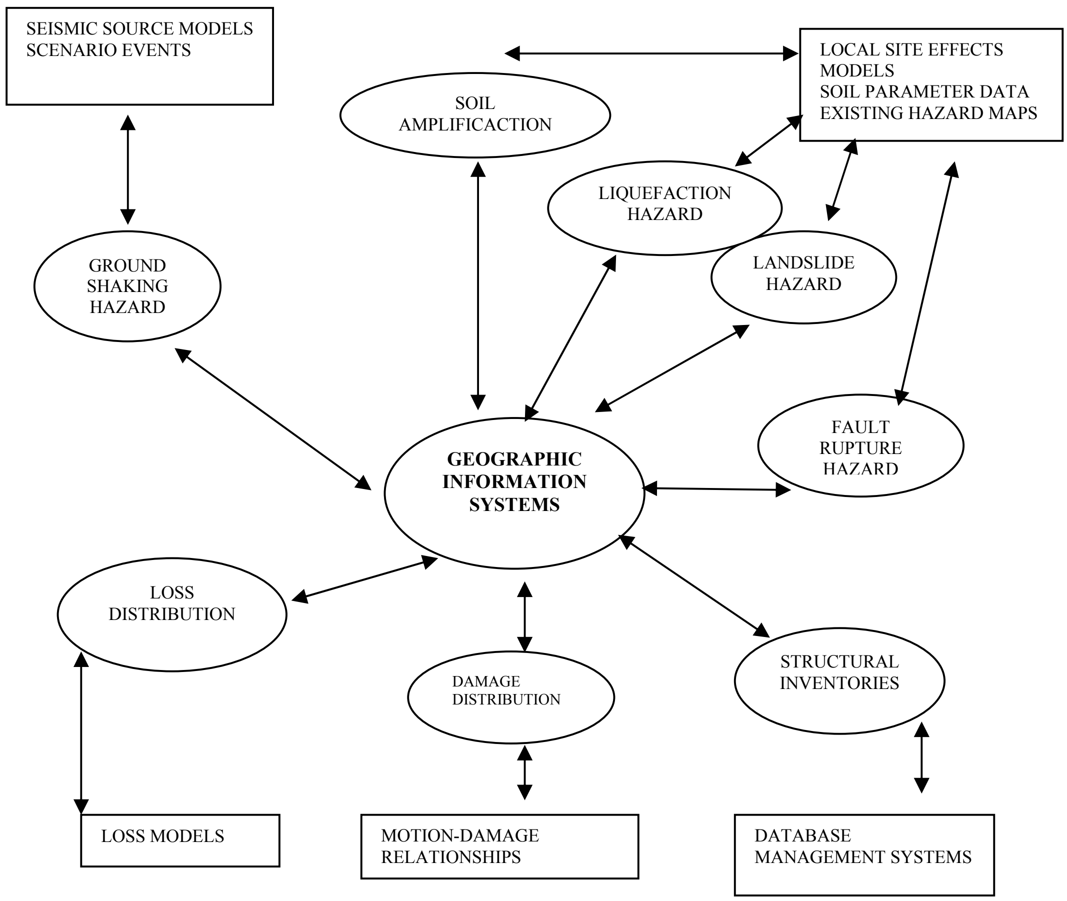
Earthquakes are both physically and emotionally devastating to the population and detrimental to a country's assets. For example, the world experienced two large earthquakes that hit hard two of the most advanced countries in earthquake science, the United States and Japan. The Northridge

[1] An earthquake loss estimation methodology developed in 1997 for FEMA by the U.S. National Institute of Building Science (NIBS)

Earthquake in the United States and The Kobe Earthquake in Japan resulted in huge impacts in terms of casualties and monetary losses. Engineers, scientists, and other interested groups visited the earthquake-damaged areas hoping to learn lessons from such disaster. Beyond site visit, it is possible to study earthquakes and their associated impacts with models such as HAZUS (Hazards U.S.). We used hypothesized earthquake scenarios and analyses to measure the sensitivity of earthquake loss estimation in order to improve crisis management capability in response to earthquake catastrophe in our study.

Earthquake risk is coupled with local site effects of soil amplification, liquefaction, landslide, and surface fault rupture, and the built environment. These factors are combined with the seismic activities in a region to study the expected damage to the built environment from an earthquake scenario. There have been many hypothesized earthquake scenario studies to understand the potential earthquake risk for human life and monetary investment in a study region. These studies were very data-intensive and time-consuming processes. Nevertheless, with the advances in information technology, especially the Geographic Information System (GIS), it was possible to run different earthquake scenarios for the same study region without extra investment. More importantly, GIS enabled us to do earthquake loss estimation sensitivity analysis. King and Anne (1994) distinguished their research from others by using GIS in regional seismic hazard and risk analysis as shown in figure (1).

Fig. (1) The Role of Geographic Information Systems in Regional Seismic Hazard and Risk Analysis

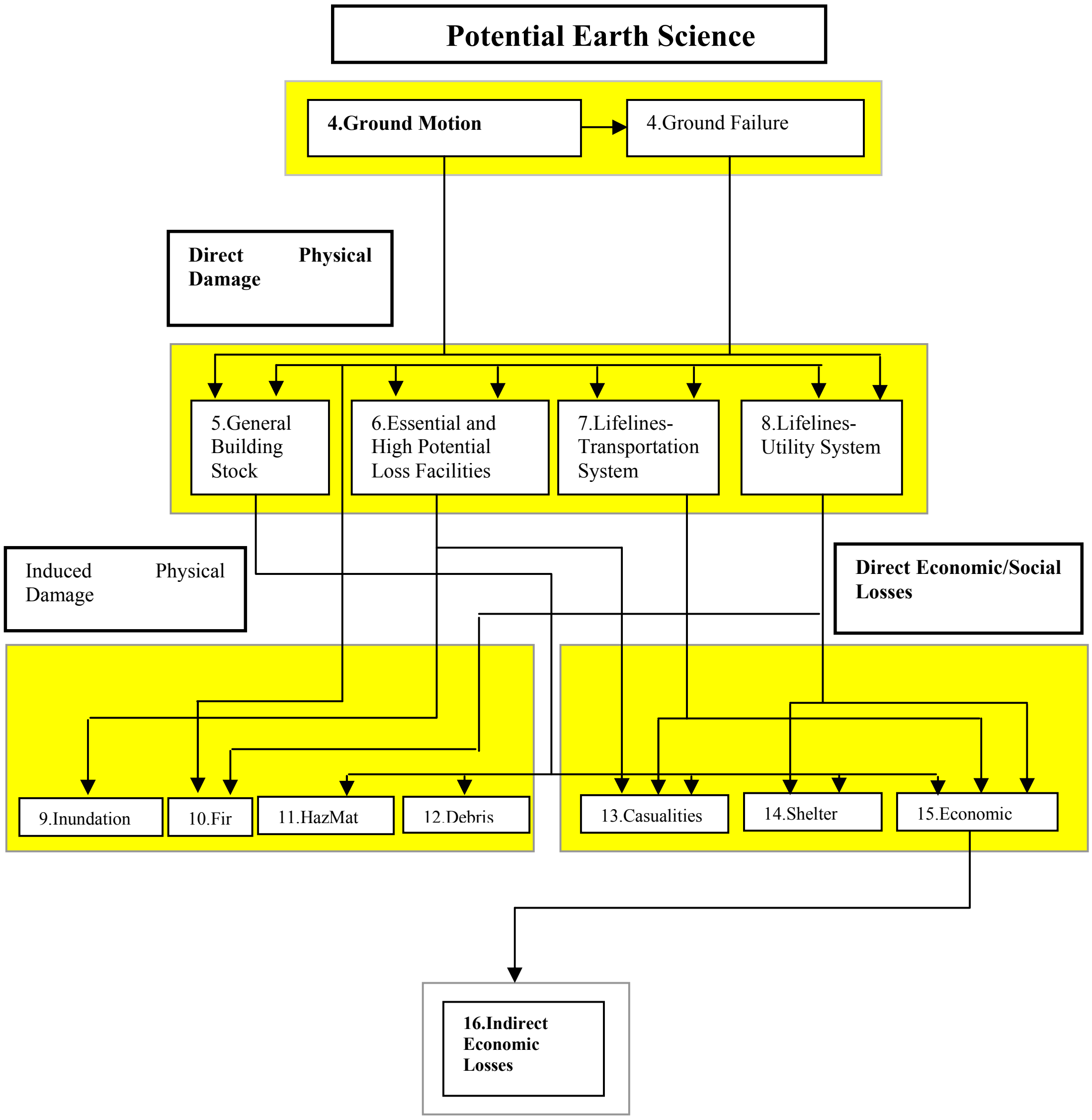


The Federal Emergency Management Agency (FEMA) also tries to capitalize on GIS capability by introducing HAZUS (HAZARD U.S.), an earthquake loss estimation methodology that is intended for local, regional, or state manipulation, for public use in efforts to reduce damage and social and economic impacts from earthquakes. This GIS-based earthquake loss estimation methodology is an improvement over existing regional loss estimation methodologies, and it is in public domain

GIS Earthquake Loss Estimation Methodology

HAZUS is an earthquake loss estimation methodology that is intended for local, regional, or state manipulation. The methodology has been developed for the Federal Emergency Management Agency (FEMA) by the National Institute of Building Science (NIBS) to provide a tool for developing earthquake loss estimates. The Earthquake Loss Estimation methodology, as shown in figure (2), capitalizes on the GIS capabilities to manipulate large multidisciplinary database with different quality and to provide maps that are used in earthquake loss estimation

Fig. (2) HAZUS Loss Estimation Methodology



The framework of the methodology consists of Potential Earth Science Hazard (PESH), Inventory Data (ID), Direct Physical Damage (DPD), Induced Physical Damage (IPD), Direct Economic/Social Loss (DSEL), and Indirect Economic Loss (IEL) models as shown in figure (2). These models are interdependent with the output of some models acting as input for other models.

The Potential Earth Science Hazard (PESH) model consists of earthquake-related hazards that are considered in evaluating casualties, damage, and resultant losses from an earthquake. These hazards are: fault rupture, liquefaction, and landslide.

The Inventory Data (ID) model contains the collection and classification of different buildings and utility systems, data and attributes required for performing damage and loss estimation. These data include: buildings and facilities, transportation systems, utility systems, hazardous material facilities, census data, county business patterns, and indirect economic data for the study region.

The Direct Physical Damage (DPD) model, as shown in figure (2) above, determines the probability of slight, moderate, extensive, and complete damage to general building stock. The extent and severity of damage to structural and non-structural components of buildings is described by one of five damage states (none, slight, moderate, extensive, and complete) based on functions for estimating building damage due to ground shaking. These building damage functions include fragility curves, which describe the probability of reaching or exceeding different states of damage given the peak building response, and building capacity curves, which are used to determine peak building response.

Induced Physical Damage (IPD) model, as shown in figure (2), estimates induced physical damages which include: inundation, fire, debris generation

Direct Economic /Social Losses (DESL) model, as shown in figure (2), estimates direct economic and social losses from an earthquake. These types of losses are:

Economic Losses. HAZUS estimates the direct economic losses results from earthquake. These losses consist of building related losses and transportation and utility lifeline losses.

Casualties. HAZUS estimates the number of people who will be injured and killed by the earthquake. The casualties are broken down into four severity levels that describe the extent of the injuries. The levels are described as follow:

Severity Level 1. Injuries will require medical attention, but hospitalization is not needed.
Severity Level 2. Injuries will require hospitalization but are not considered life threatening.
Severity Level 3. Injuries will require hospitalization and can become life threatening if not promptly treated.
Severity Level 4. Victims are killed by the earthquake

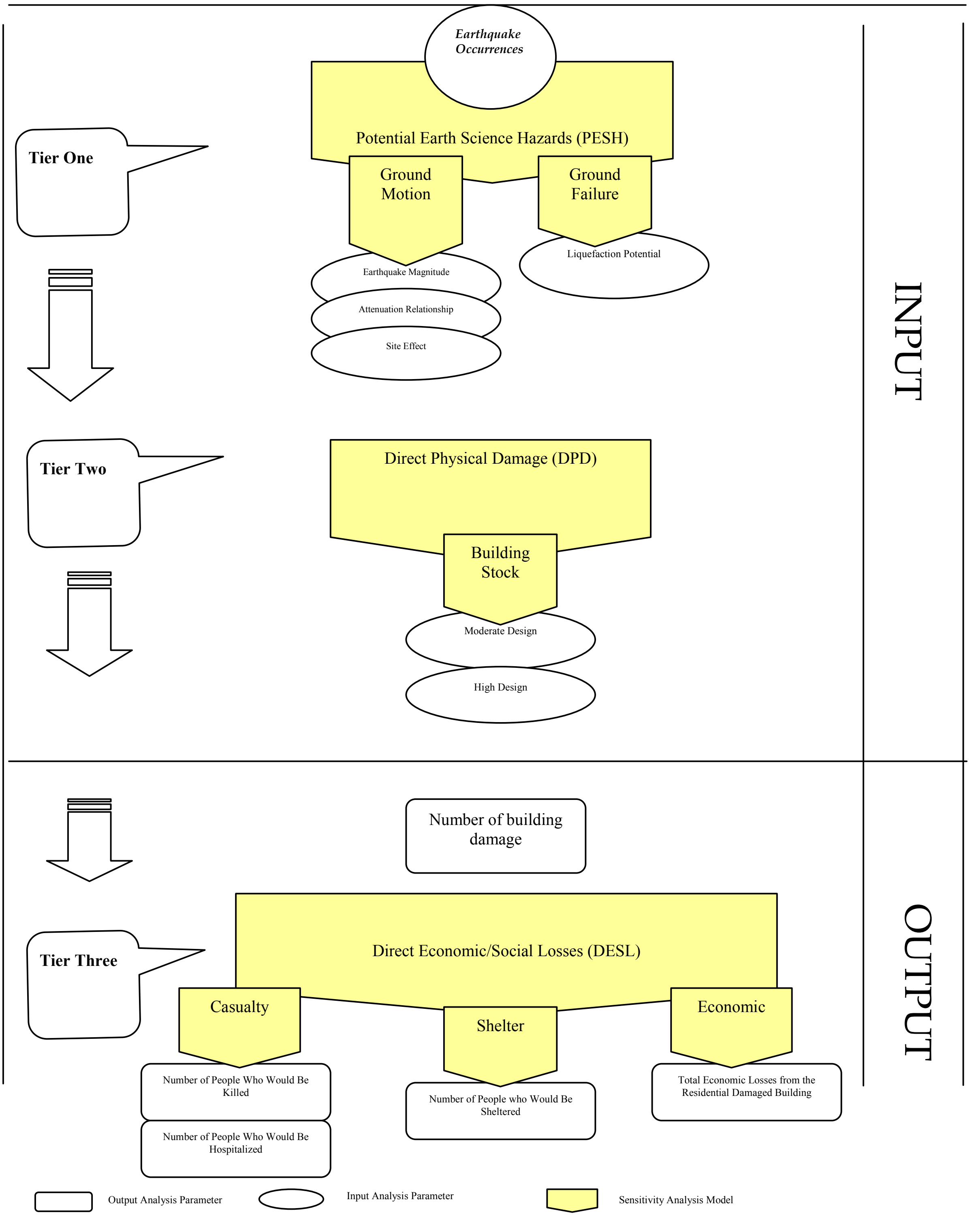
Shelter requirement. HAZUS estimates the number of households that are expected to be displaced from their homes due to the earthquake and the number of displaced people who will require accommodations in temporary public shelters.

The Indirect Economic Loss (IEL) model, in comparison, estimates the long-term economic impacts to the region for 15 years after the earthquake. The model quantifies this information in terms of income and employment changes within the study region.

Scope of Analysis

In this analysis, we worked on three tiers of models, as shown in figure (3) below. The first two tiers of models were used to select the parameters that were used in the sensitivity analysis, and the third tier was used to measure the HAZUS methodology output sensitivity for the selected parameters.

Fig.(3) Scope of Sensitivity Analysis Models and Parameters



earthquake magnitude, attenuation relationships, site effect, and liquefaction potential effects. In the second tier models, we considered the general building stock from the Direct Physical Damage (DPD) model. In the third tier models, we considered casualties, shelter, and economic models from the Direct Economic/Social Losses (DESL) model. We examined 240 earthquake scenarios for the analysis. In each scenario, we kept one factor stable and changed the others.

Analysis Parameters

Earthquake risk is coupled with local site effect of soil amplification, liquefaction, landslide, and surface fault rupture, as well as the built environment. These factors are combined with the seismic activities in a region to study the expected damage to the built environment from an earthquake scenario. In the following sections, we will discuss the models that were used in the HAZUS ELE sensitivity analysis.

<u>Potential Earth Science Hazard (PESH) Model</u>

The Potential Earth Science Hazard (PESH) model is the main model in the HAZUS loss estimation methodology. Moreover, as shown in figure (2), the model output is used in evaluating casualties, damage, and resultant losses from an earthquake scenario. Most damage and losses caused by an earthquake are the direct result of the ground shaking. This shaking strength mainly depends on the earthquake magnitude and how the shaking waves move from the earthquake hypocenter to the impacted area, and, lastly, the site effects. Therefore, in our study we considered the earthquake magnitude and the attenuation function—which shows how the earthquake shaking attenuates with distance—as well as the soil types that could amplify or reduce the shaking intensity below the building environment based on different soil types at the site of interest.

Earthquake Magnitude

Earthquake magnitude is the key factor that was used to direct our analyses, as shown in figure (3) above. In order to understand the variety of the HAZUS methodological output in different earthquake scenarios, we chose the earthquake range from 5.5 to 7.5 for the sensitivity analysis. It is important to remember that an earthquake with magnitude less than 5.5 will not cause significant damage. Therefore, we were not able to measure the sensitivity of earthquake damage below this range. An earthquake with magnitude larger than 7.5, furthermore, is unlikely to happen. In addition, the attenuation relationships that were used in the analysis are applicable to earthquake magnitude within this range.

Attenuation Relationship

The HAZUS methodology provides five different attenuation functions that are used for the Western United States (WUS) region. In our analysis, we used Boor, Joyner & Fumal (hereafter BJF94); Sadigh, and Chang, Abrahmson, Chiou, and Power (hereafter Sadigh93), as well as the Project 97 attenuation function, which is a linear combination of the WUS attenuation functions that are based on the theory developed by the United State Geological Survey (USGS). The Project 97 attenuation function is used as a default attenuation function in the HAZUS methodology. These different attenuation functions predict different peak ground acceleration (PGA) values, which will further be used to measure the earthquake losses for the study region.

Site Effect

HAZUS methodology uses soil amplification functions to account for the local site condition of the earthquake scenario area. Soft soil tends to amplify certain frequencies within the ground shaking, resulting in greater damage. HAZUS uses six different soil classification types based on The National Earthquake Hazards Reduction Program (NEHRP) 1997 provision, which classifies the soil types based on their shear-wave velocity (Vs).

The default soil class for HAZUS is soil class D. It is described as stiff soils with a shear wave velocity between 180 m/s and 360 m/s. In our sensitivity analysis, we used the default soil class as well as an updated soil class map, a detailed map contains soil types B, C, D, and E, for the study region.

Liquefaction Potential

In addition to the damage that results from ground motion, HAZUS considers three features of earthquakes that can cause permanent ground failure. These features are fault rupture, liquefaction, and landslide. HAZUS assumes no liquefaction potential for our study region. In our research, we used an updated liquefaction map in the HAZUS sensitivity analysis. Seed et al. (1983) described the Liquefaction phenomenon in which "if a saturated sand is subjected to ground variations, it tends to compact and decrease in volume that results in an increase in pore water pressure, and if the pore water pressure builds up to the point at which it is equal to overburden pressure, the effective stress becomes zero, the sand loses its strength completely, and it develops a liquefaction state. The phenomenon of liquefaction could cause damage to the built environment if the earthquake magnitude triggers the liquefaction effect.

<u>Direct Physical Damage (DPD) Model</u>

The Direct Physical Damage model determines the probability of slight, moderate, extensive, and complete damage to the general building stock based on functions for estimating building damage due to ground shaking.

General Building Stock

HAZUS provides the number of buildings that will be damaged within different damage classes. HAZUS provides a description for these states of damage for each model building type (e.g., descriptions for extensive damage wood structures are: toppling of most brick chimneys; cracks in foundations; partial collapse of room-over-garage or other soft-story configurations; small foundations cracks). Buildings classified as complete or extensive are unsafe to enter and should be inspected for possible evacuation.

HAZUS provides different default occupancy to building type mapping based upon a default mix of ages (i.e., pre 1950, 1950-1970, and post 1970) and heights (i.e., low rise [1-3 stories], medium rise [4-7], and high-rise [more than 8 stories]). This mapping scheme varies by state, and it is possible that different census tracts within the study region will have different age and height mixes. In addition, HAZUS provides a mapping scheme to reflect different design levels. In this mapping scheme, buildings are classified, as structures that are built to code, are superior to the code or inferior. In addition, HAZUS provides a mapping scheme to reflect the design level. For example, the design level is high in California, moderate and low in Florida. HAZUS provides three different mapping scheme combinations of the above mapping classifications for our study region. Those are high, moderate, and low. We used the default high and default medium in our analysis.

Casualties

HAZUS provides casualty estimates for each census tract at three times of the day (2 AM, 2 PM and 5 PM). We used HAZUS default parameters, which are based on previous earthquake experience and expert judgment, to measure these estimates. The output from this model consists of a casualty breakdown by injury severity, defined by four severity scales, as we discussed above. In our analysis, we measured the casualties in residential buildings that would result from an earthquake at 2 AM. Casualties in the residential buildings at this time of day would be greatest. In our analysis, we measured the number of people who would be killed and the number of people who would need hospitalization.

Shelter

HAZUS contains default factors that are based on previous research from earthquake experiences to estimate the shelter needs. We used the default factors in our analysis to calculate the number of people who would seek shelter after an earthquake.

HAZUS provides estimates of displaced households due to loss of housing habitability and short-term shelter needs. Loss of habitability is calculated directly from damage to the residential occupancy inventory and from loss of water and power. The following inputs are required to compute the number of uninhabitable dwelling units and the number of displaced households: fraction of dwelling units likely to be vacated if damaged, probability that the residential units are without power and/or water immediately after the earthquake, and percentage of households affected by utility outages likely to seek alternative shelter.

Economic

HAZUS provides default parameters to estimate the economic losses that result from an earthquake. We used these parameters to estimate the economic losses resulting from residential building damage. These losses are directly derived from building damage that consists of cost of repair and replacement charges for damaged and destroyed buildings, costs of damage to building contents, and losses of inventory contents related to business activities. These are the main contributors to the economic loss resulting from the residential building damage. Moreover, HAZUS provides estimates for additional indirect losses that also contribute to the total (e.g., relocation and building repair time expenses), but they were not included in our study.

Model City Study

HAZUS is the earthquake loss estimation methodology that was developed and calibrated mainly based on the building inventory and previous earthquake experience in California. HAZUS involves different models, parameters, and expert judgment to measure the potential loss from an earthquake.

We chose a study area in California in order to minimize the span of uncertainty from choosing a different study area for the sensitivity analysis.

In this research, HAZUS was used to estimate the Earthquake Loss Estimation (ELE) for earthquake scenarios in San Francisco County. A HAZUS run is a time-consuming operation. In order to facilitate a large combination of earthquake scenarios, a small region, which is very vulnerable in terms of its infrastructure and inventory content value, was used.

In this study, the description of the demographic and the building inventory content for the study region, as provided by the HAZUS Earthquake Event Report for the region, is

The geographical size of the region is 48 square miles and contains 152 census tracts. There are over 306 thousand households in the region and has a total population of 724,000 people (1990 Census Bureau data). . . . There are an estimated 128 thousand buildings in the region with a total building replacement value (excluding contents) of 58,663 million dollars (1994 dollars). Approximately 93% of the buildings (and 67% of the building value) are associated with residential housing . . . . In terms of building construction types in the region, wood frame construction makes up 91% of the building inventory.

Analysis Scenarios

We chose two seismic faults, from the San Francisco Bay Region fault sources. These faults are the San Andreas (SA) fault, Peninsula Segment, which experienced a 7.0 earthquake in 1838, and the Northern Hayward (NH) fault, which experienced a 6.8 earthquake in 1836.The length and slip rate and the probability of earthquake occurrences on these faults as discussed by the working group on California Earthquake Probabilities, are shown in table (2) below.

Table (2). San Francisco Fault Sources for Earthquake Scenarios

Fault	San Andreas (SA) Fault, Peninsula Segment	Northern Hayward (NH) Fault (
Length (Km)	85	35
Seismic Width (Km)	13	12
Slip Rate (mm/yr)	17	9
Significant Earthquakes	1838, M~7.0 37.6 Lat., -122.4 Long.	1836, M~6.8 37.8 Lat. , –122.2 Long.
Probability of M>/= 6.7 earthquake before 2030	15 %	16 %

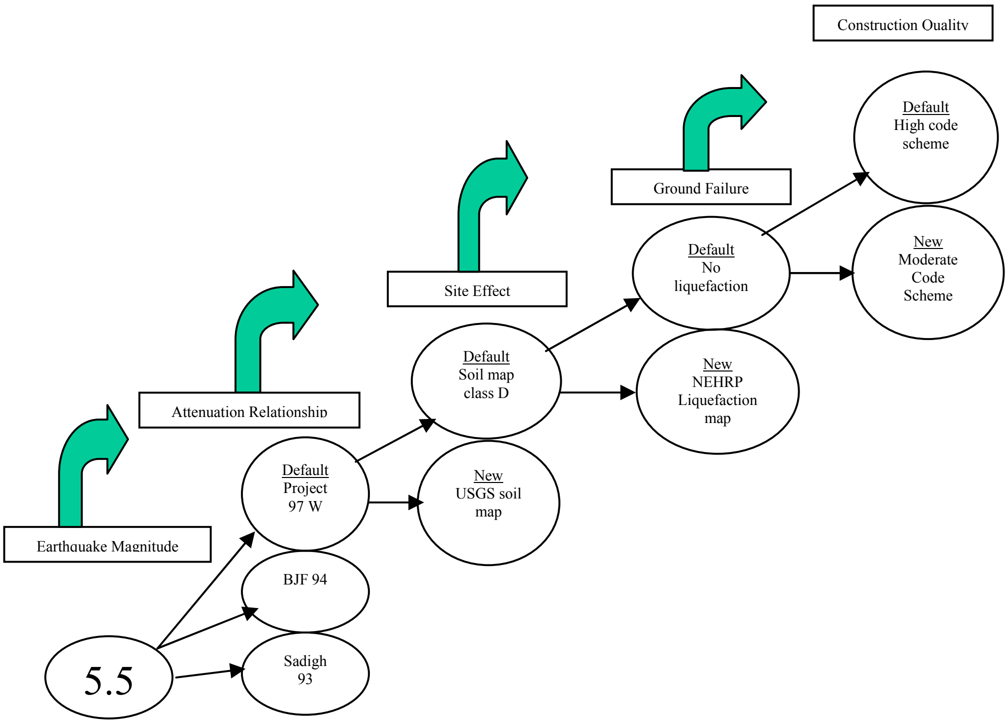
Therefore, we will have two sets of analyses for NH and the SA faults. Any major earthquake on these faults will be a catastrophic event for the San Francisco area. Hayward fault is considered in many previous earthquake scenarios for SFBR. Moreover, the San Andreas Fault was the source for the 1906 Great San Francisco Earthquake, which resulted in catastrophic damage for San Francisco County.

We examined 120 earthquake scenarios for each fault to measure the sensitivity of each selected parameter in our analysis. The earthquake scenarios for both faults, as shown in figure (8), were as follows:

- San Andreas (SA) fault, Peninsula Segment. The earthquake epicenter was chosen to represent a repeat of the 1838 earthquake that ruptured the SA fault with magnitude of ~ 7.0. The epicenter was 37.6 Latitude and –122.4 Longitude.
- North Hayward (NH) fault. The earthquake epicenter was chosen to represent a repeat of the 1836 earthquake that ruptured the NH fault with a magnitude of ~ 6.8. The epicenter was 37.8 Latitude and –122.2 Longitude.

Therefore, we selected the earthquake epicenter based on the above discussion. Then, for each earthquake magnitude within the range 5.5 to 7.5 we tested the same analysis parameter. An example of the HAZUS scenario for an earthquake with a magnitude of 5.5 is shown in figure (4) illustrated below. Then, for the earthquake scenario, there were three attenuation function relationships guiding each scenario. In each one, we chose the attenuation function and then changed the other parameters, which are for site effect, ground failure, and construction quality. For the attenuation relationship, three attenuation functions were chosen for the analyses; they were Project 97 West (as default attenuation relationship), BJF 94, and Sadigh 93. The site effect in this analysis identifies the capability of the soil to amplify or to reduce the earthquake intensity. The default in our analysis that HAZUS assumes for the San Francisco County is soil class D (stiff soil type). The default ground failure effect with the methodology assumes no liquefaction for the study area. The new liquefaction map, which was developed by the NEHRP, contains different liquefaction susceptibility for the study region. These maps were provided by the HAZUS Working Group for the Bay Area. In the Construction Quality layer, the High Code mapping scheme is considered the default for the study area, and the updated one is for the Moderate Code mapping scheme.

Fig. (4) Example of Choosing the Earthquake Scenarios for Earthquake Magnitude



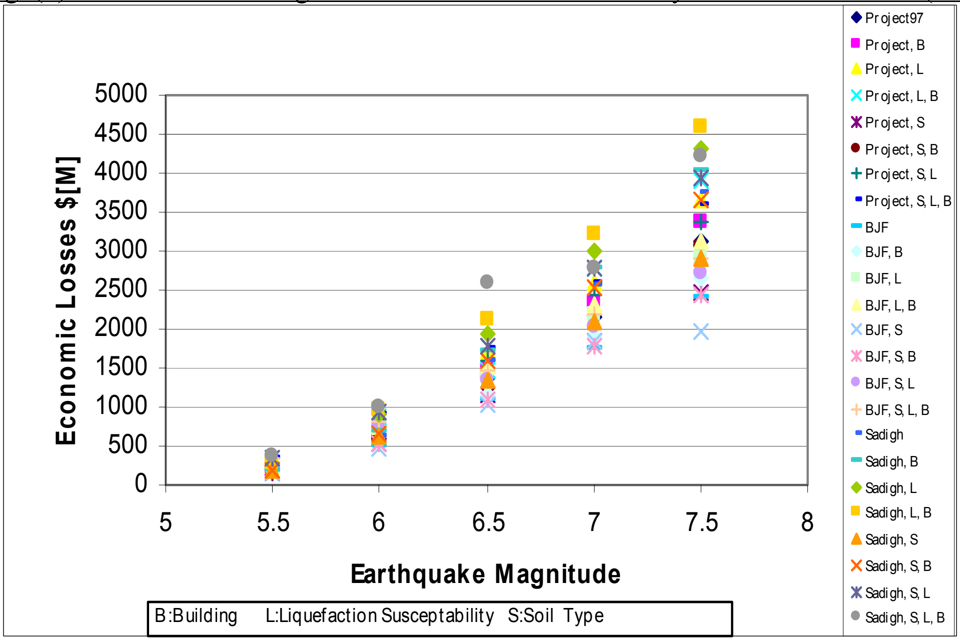
What might be expected from an earthquake with magnitude 5.5 that ruptured through the NH fault? The epicenter, we know, would be 37.8 Latitude and –122.2 Longitude. If we chose the Project 97 West attenuation function, and assumed soil class D (stiff soil) for the Region, as well as there was no liquefaction for the study area, what might be the potential losses from this earthquake for San Francisco County, assuming the buildings for this region are built to high code standards.

We tried to answer this question with different variables, such as earthquake magnitude, attenuation relationship, soil type, liquefaction potential, and building quality through conducting sensitivity analysis (earthquake loss estimation) for San Francisco County.

Results and Analysis

In our analysis, we examined 24 earthquake scenarios for each earthquake magnitude for both the NH and SA faults. The results were then analyzed to understand how these results could be used in emergency response and decision making for the SFBA area and furthermore, be used for different regions. Figure (5) below, shows the millions of dollars in residential economic losses that could result from an earthquake scenario on the NH fault. In the figure below, S refers to the soil type, from soil type D to a detailed soil type map; B refers to the building construction, from high code to low code standards; L refers to liquefaction susceptibility, from no liquefaction susceptibility to detailed liquefaction susceptibility for the study region.

Fig. (5) Residential Buildings Economic Losses in North Hayward Fault Scenario (NH)



The sensitivity analysis of earthquake scenarios illustrated that the Potential Earth Scenic Hazards parameters (earthquake magnitude, attenuation function, ground failure effect) are more sensitive to earthquake magnitude than the Direct Physical Damage parameters (building inventory). Ground failure effects (from no liquefaction susceptibility to detailed liquefaction susceptibility) is the most sensitive parameter in earthquake loss estimation, followed by choosing the attenuation functions, site effect parameters (from soil type D to detailed soil type map of the region) and lastly the effects of building construction parameters (high code standards to moderate code standards). The building construction sensitivity on the economic losses is relatively stable. For other losses estimations— number of people who would be killed, number of people who would be hospitalized, and number of people who would be sheltered—the sensitivity of the other analysis parameters either enlarged or diminished with the increasing in earthquake magnitude. Figure (6) shows an example of the sensitivity of the analysis parameters on the residential economic losses for the Project97 attenuation function that would result from the North Hayward (NH) fault scenario.

As shown in Fig (7) below, HAZUS losses estimation is within a factor of 10, and a factor of 4 for residential economic losses. For an earthquake magnitude of 7.0, for the NH fault, the maximum value of the residential economic losses are $3229.1 million and the minimum losses are $1496.8 million. Therefore, the ratio between the maximum and the minimum is 2.18. If we assume the factor of economic losses is 3.0, we can use the default parameter values for the sensitivity analysis—soil type, attenuation function, liquefaction susceptibility, and building construction— to get rapid estimates for the potential economic losses from an earthquake scenario.

Fig. (6) Percent Change in Residential Economic Losses for Project 97 Attenuation Function

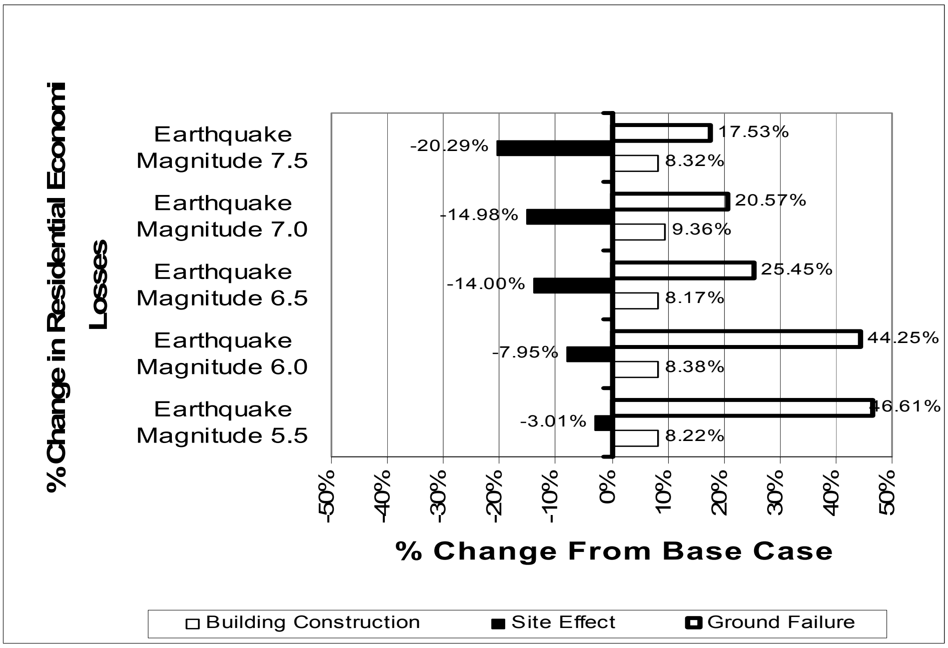
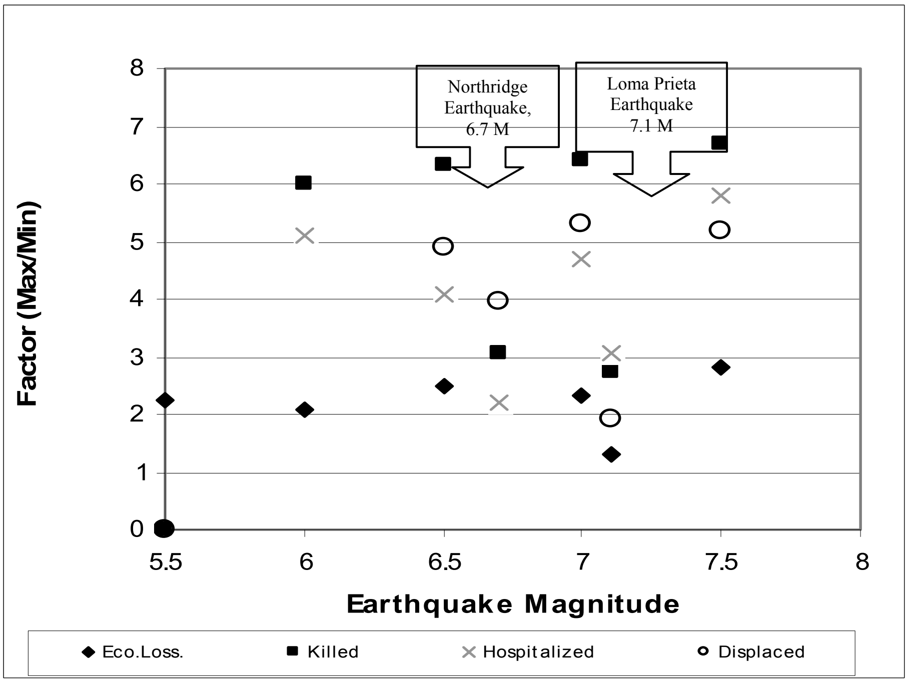


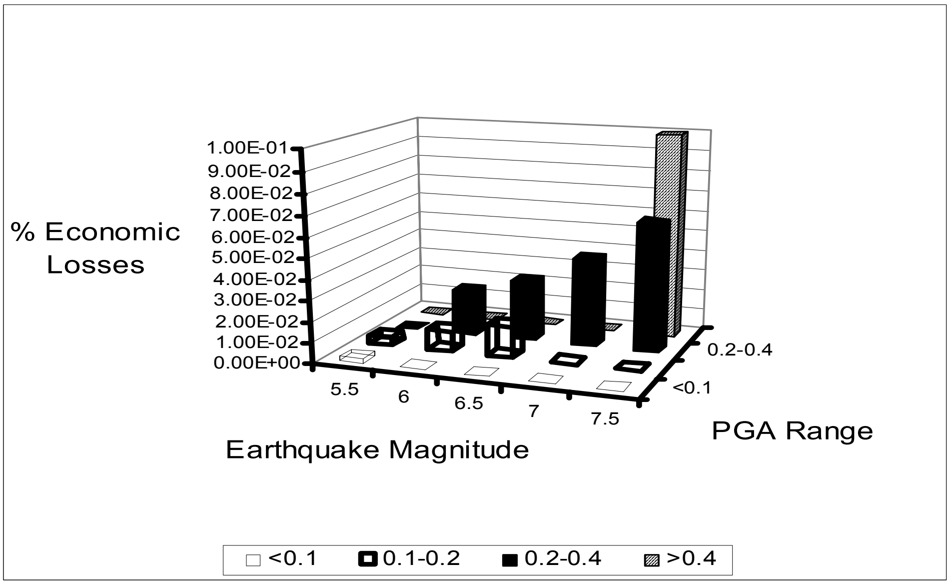
Fig. (7) Ratios of the Maximum and Minimum Losses From Earthquake Scenarios



In the graph above, the factor value of the Northridge and Loma Prieta earthquakes is the ratio between the maximum and the minimum of the reported versus the actual losses that resulted from both earthquakes. The HAZUS earthquake scenario for the Northridge Earthquake resulted in a total economic loss of $4,981.04 billion, 9 people killed, 1095 people hospitalized, and 1116 people displaced from Los Angeles and Ventura Counties. Whereas the reported loss from this earthquake is $20 billion in economic losses, 57 people killed, 9000 injured, and 20,000 people displaced. The Loma Prieta Earthquake resulted in a total economic loss of $10 billion, 62 people killed, 3,700 injured, and 12,000 displaced. A HAZUS scenario for this earthquake resulted in $8.485 billion of total economic losses, 191 people killed, 3077 people hospitalized, and 25,825 people displaced from San Francisco, San Mateo, Alameda, Sant Clara, Contra Costa, and Marin counties.

In order to use our results for the San Francisco Bay Area (SFBA) or other regions, we normalized our estimated losses against exposure in the study region. We measured the potential losses and exposure for each census tract (a parcel of land that contains 2,500 to 8,000 people) in the study region for each of the estimated losses--number of people who would be killed, number of people who would be sheltered, number of people who would be hospitalized, and total residential economic losses. There are 152 census tracts in the study region. We grouped the PGA ranges into four groups, less than 0.1 (slight shaking intensity), 0.1 to 0.2 (moderate shaking intensity), 0.2 to 0.4 (strong shaking intensity), and grater than 0.4 (violent shaking intensity). Figure (8) below, shows the normalized values that resulted from an analysis of the residential economic losses in the NH fault. For example, an earthquake magnitude of 7.0 would result in 0.434% of the building inventory value in economic losses

Fig. (8) Percent of Residential Buildings Economic Losses



This paper introduces a guideline for interpreting the HAZUS earthquake loss estimation output for a given scenario area, which could be used for future catastrophes in a scenario area. This paper helps HAZUS users understand the effects of choosing analysis parameters on the loss estimation results. A ratio of the maximum to the minimum losses of 10 could be used to get a rapid assessment of potential earthquake losses without developing data to be used in the loss estimation. These data are for the liquefaction susceptibility map, the soil type map, and the building inventory. Additionally, this paper shows the sensitivity of analysis parameters on the estimated losses. The sensitivity of the ground failure effects (from no liquefaction susceptibility to detailed liquefaction susceptibility) on the loss estimations, is the largest for a given earthquake scenario. Lastly, this paper presents factors that could be used for different areas in the study region by knowing the earthquake magnitude, the PGA value, and the total exposure for each PGA intensity level in the impacted area. These values need to be validated from future earthquake events. Such interpretation helps in directing the resources needed for the most impacted areas, and if used by agencies, can help in planning and increasing the agency's readiness to meet the expected needs following an earthquake. Additionally, this analysis provides other states and counties that do not have adequate resources for full-scale data collection, but face significant earthquake threats, with information enabling them to invest more significantly in data collection activities and to invest in preparing more accurate data for HAZUS input. Identifying the most significant factors contributing to the earthquake risk provides a maximum benefit from the application of the HAZUS model for a limited data-collection budget.

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THE ROLE OF NONSTRUCTURAL COMPONENTS OF HOSPITALS: 1999 IZMIT EXPERIENCE

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Keywords: Hospitals, Izmit Earthquake, Disaster Preparedness, Turkey.

Abstract

In September 1999, less than a month after the August 17 Izmit earthquake, 10 public hospitals from the highly damaged provinces Kocaeli, Sakarya, Yalova and Bolu of Northwestern Turkey were surveyed. Participants provided answers to a questionnaire examining the extent of damage or loss they experienced, the impact of this damage on the operation of the hospital and their assessments of the importance of different medical systems and departments to the functioning of the hospital during and following the earthquake.

This paper reports our findings that are used to identify critical nonstructural systems, essential hospital departments and the diagnostic and treatment equipments necessary to sustain functionality of a hospital or a critical care unit during or following a major seismic event. Findings reveal that, even if the structural components were intact, nonstructural failures in the facilities had remarkable effects on the functioning of hospitals following an earthquake.

Introduction

Hospitals play a key role in managing disasters. As noted by FEMA the functionality of a hospital is highly dependent on the functioning of most of its nonstructural elements (FEMA, 1989). Improved building codes and increased code enforcement have reduced the susceptibility of the hospital buildings to catastrophic failures, however, similar improvements in the performance of nonstructural systems have not been realized (Myrtle et. al., 2002) despite their high susceptibility to damage in even a fairly mild earthquake, and such damage is a major factor affecting the functionality of hospitals (Seismic Safety Commission, 1984).

As much as measuring the effects of nonstructural components, identifying the key equipment and systems that are essential to the continuing functioning of hospitals has significant implications for disaster preparedness. Nevertheless, as reported by Myrtle et.al, (2000; 2002) opinions continue to differ as to which systems or components are critical or essential in maintaining the functionality of hospitals and critical care units. This paper intends to contribute to the body of knowledge by presenting the empirical findings of a survey research conducted following a major disaster in Izmit, Turkey.

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Izmit Earthquake

Nine densely populated provinces in Northwestern Turkey (Table 1), with a total population of 12,444,619, approximately 18.3 % of Turkey's 68,000,000 people, were affected by the 7.4 magnitude earthquake on August 17, 1999. The total surface area hit by the 7.4 magnitude earthquake was 59,261 km^2, approximately 7.3 % of the Turkish lands. The August 17 earthquake, also known as the Izmit earthquake, occurred on the North Anatolian Fault (NAF) Zone with a macroseismic epicenter 40.702N, 29.987E (KOERI, 2000) near the town of Golcuk, Izmit. The province of Kocaeli, located only 12 km (KOERI, 2000) from the epicenter, had the highest damage: 8,744, approximately 57 %, of the 15,466 total deaths and 9,231, approximately 40 %, of the 23,954 of the total hospitalized injuries occurred in this province. As could be seen from Table 1, 96 % of the total deaths and 96 % of the total injuries concentrated in 4 provinces, respectively Kocaeli, Sakarya, Yalova, and Istanbul. In Sakarya, 17 % of the deaths and 22 % of the injuries; in Yalova 16% of the deaths and 19 % of the injuries; and in Istanbul 6 % of the deaths and 15 % of the injuries happened.

Izmit Earthquake's Impact on Hospitals

According to the Ministry of Health (MOH) there were 47 hospitals (Table 1) with a total of 5,060 beds in the four surveyed provinces in operation at the time of the earthquake. The hospitals ranged from 413 beds to 10 beds in size. Kocaeli, had 3 hospitals, Sakarya had 1 and Bolu had 2 hospitals with 300 or more beds. In Kocaeli, 5 hospitals had between 100-300 beds, Sakarya had 2 facilities in this size range, Bolu had 3 and Yalova had only 1 hospital with 100-bed. There were 17 major hospitals in these four provinces and the survey covered 58.8% of them.

Out of the 47 hospitals in the four provinces, 31 of them (65.9 %) were owned and operated by MOH. Their sizes ranged from 10 beds in the small cities to 400 beds in the big cities. Two of the 47 hospitals were university hospitals; 1 in Bolu with 200 beds and 1 in Kocaeli with 370 beds. Five of these 47 hospitals were owned and operated by Social Security Agency (SSA), all having 150 or more beds; 3 in Kocaeli,-- SSK Kocaeli Hospital being the biggest of these 47 hospitals with 413 beds--, 1 in Sakarya and 1 in Bolu. The survey covered 6 MOH and 3 SSA hospitals and no university hospitals were surveyed.

The only municipal owned and operated hospital was in Izmit, Kocaeli with 20 beds. Eight of the 47 hospitals, approximately 17 % of the total hospitals, were owned and operated by the private sector; 3 in Kocaeli, 4 in Sakarya and 1 in Bolu. Their bed sizes were relatively small, all less than 60 beds. The total number of beds in these private hospitals was 232, constituting only 4.5 % of the total beds. Therefore, the private sector had an insignificant share in the market. The survey covered neither private nor municipal hospitals. Also, there were no nonprofit hospitals in the region.

Table 1. Provinces Effected from the Earthquake (1999).

Province	Population	Total Dead	%	Total Injured	%	Total Number of Hospitals	Number Of Hospitals Surveyed	%	Total Number of Beds	Number of Beds Surveyed	%
Kocaeli	1,160,322	8,744	56.53	9,231	39.12	13	5	38	2,038	1,163	57
Sakarya	762,115	2,627	16.98	5,084	21.54	14	3	21	1,207	735	61
Yalova	166,382	2,501	16.17	4,472	18.95	1	1	100	100	100	100
Istanbul	8,980,425	978	6.32	3,547	15.03	138	0	0	31,350	0	0
Bolu	653,409	264	1.71	1,163	4.92	19	1	5	1,715	400	23
Bursa	1.932,000	263	1.69	333	1.41	26	0	0	3,901	0	0

Eskisehir	680,833	86	0.55	83	0.35	11	0	0	2,574	0	0
Zonguldak	655,692	3	0.01	26	0.11	8	0	0	1,705	0	0
Tekirdag	545,763	0	0	35	0.14	12	0	0	846	0	0
Surveyed Provinces	2,742,228	14,135	89.7	19,950	84.53	47	10	23	5,060	2,398	51
TOTAL	12,444,619	15,466	100	23,954	100	242	10	4	45,046	2,398	5

Source: General Directorate of Disaster Affaires of the Ministry of Public Works and Settlement and MOH statistics.

Sample and Data Collection

In September 1999, less than a month after the August 17 Izmit earthquake, 10 public hospitals from the highly damaged provinces Kocaeli, Sakarya, Yalova and Bolu of the Northwestern Turkey were surveyed. Respondents were either the facilities directors or their assistants. USC-Affiliated research associates met with the participants to explain the purpose of the research and to obtain their answers to a questionnaire examining the extent of damage or loss they experienced, the impact of this damage on the operation of the hospital and their assessments of the importance of different medical systems to the functioning of the hospital during and following the earthquake.

The research instrument utilized in this study was divided into five parts. Parts I, II, and III of the instrument examined the overall damage on the hospitals, and part IV, and V were designed to assess damage at the departmental level. Part I of the questionnaire had both open-ended and closed-ended questions about the type of problems the hospitals experienced during and after the earthquake. These questions included whether the earthquake caused problems with staffing, basic lifeline systems (water, electricity, communications, sewer disposal system, and central air supply), air conditioning, heating, piping, medical gases, as well as damage to a list of nonstructural elements. Part I also asked questions about the location, type, and extent of the damage that was experienced.

Part II of the questionnaire asked respondents the extent of earthquake related impacts on the operation of their hospitals. A 5-point Likert scale was used to measure the earthquake's impact on non-structural systems. Respondents provided answers to 42 questions about whether their hospital's ability to function was affected by availability of staff, communication systems, electrical systems as well as damage to the internal structural and nonstructural elements, and time it took to overcome these problems.

Part III of the questionnaire asked the respondents to identify the importance of different hospital units during different stages of the earthquake. These stages were: I-Immediately after the earthquake, II-During the stabilization, III-Recovery and Cleanup, and finally IV-Transition to Normal Operations. Part IV of the questionnaire was designed to assess the impact of damage on the departments and Part V of the questionnaire asked respondents to identify whether a number of mechanical and functional systems effected the operation of individual departments or units[2].

Characteristics of the Hospitals Surveyed

Six of the 10 hospitals from the provinces of Kocaeli, Sakarya, Bolu and Yalova of the region surveyed, were owned and operated by the Turkish Ministry of Health and three were hospitals operated by the Social Security Agency (SSA) of Turkey. The SSA hospitals were SSK Kocaeli Hastanesi, SSK Izmit Hastanesi and finally SSK Adapazari Hastanesi. The final hospital, Toyotasa Acil Yardim Hastanesi, was an Emergency Hospital operated by the Ministry of Health.

[2] See Myrtle et. al 2002 for the development of the survey instrument.

The 10 hospitals surveyed had a total of 2,398 beds, and covered 51.3% of the total beds in the four provinces (Table 2). These 10 hospitals employed a total of 558 doctors, of which 420 were specialists and 138 were practitioners in 1998. During the same year these 10 hospitals served to 2,541,636 patients and performed 30,462 surgical operations.

Table 2. Surveyed Hospitals Before the Earthquake (1998)

Hospital	Beds	Blood Center	Specialists	Practitioners	Out-Patients	Discharged In Patients	Deaths	Total Patient Days	Surgical Operations	Deliveries
Kocaeli Devlet Hast	400	1	63	36	343,220	17,506	427	71,152	3,637	2,745
Gölcük Devlet Hast	100		25	18	105,456	4,499	25	16,169	1,174	1,417
Karamürsel Devlet Hast	50		12	7	82,127	2,633	11	7,616	514	536
SSK Kocaeli Hast	200		38	8	277,927	14,430	132	67,893	4,808	1,832
SSK İzmit Hast	413		37	9	440,429	25,647	340	114,395	5,306	3,820
Sakarya Devlet Hast	400	1	74	13	316,411	12,594	390	57,904	2,879	
Toyotasa Acil Yrd.Hast	55		16	11	27,798	1,174	15	7,491	746	1
SSK Adapazarı Hast	280		41	10	416,556	17,149	325	75,646	5,051	3,513
Düzce Devlet Hast	400	1	61	11	231,762	15,248	183	76,241	3,857	3,614
Yalova Devlet Hast	100		53	15	181,524	7,546	56	30,384	2,490	1,931
TOTAL	2,398	3	420	138	2,423,210	118,426	1,904	524,891	30,462	19,409

Based on the MOH statistics.

Kocaeli, Sakarya and Yalova provinces were chosen because they had the highest percentage of the total deaths, total injures and total damaged buildings. Although Yalova is a very small province with only one hospital, it was included in the survey because of the massive damage in the province. Although Bolu did not suffer as much damage as Istanbul, it was included in the study sample. The largest hospital of western Bolu, Duzce Devlet Hastanesi, rather than the other hospitals in the province, was chosen due to the concentrated damage on the western half of the province. The damages in provinces Bursa, Eskisehir, Zonguldak and Tekirdag were relatively small, less than 1 % except in Bursa, and thus no hospitals from those provinces were included in the survey.

In Kocaeli province, 5 of the 13 hospitals, 38 % of the total, were surveyed. These 5 hospitals had 1,163 beds, 59 % of the total beds in the province. Three of the 5 surveyed hospitals in this province were owned and operated by MOH. Kocaeli Devlet Hastanesi was the largest of these with 400 beds and 99 physicians, and was located in Izmit, the largest city of the province. The other 2 MOH owned and operated hospitals, Golcuk Devlet Hastanesi and Karamursel Devlet Hastanesi were relatively small size hospitals however, they were the largest facilities in those cities.

The other 2 hospitals in the province were SSK Kocaeli Hastanesi and SSK Izmit Hastanesi. Both were owned and operated by SSA and were located in the city of Izmit. SSK Kocaeli Hastanesi had 200 beds and 46 physicians in 1998. SSK Izmit Hastanesi was the biggest of all 10 surveyed hospitals with 413 beds. Its medical staff of 46 physicians was among the smallest compared to the hospital's size. Even so, the hospital provided health services to 466,076 patients (1998), which represents the highest number of patients in between the 13 hospitals in the province. The only university hospital of the province, relatively large in size, was not included in the survey.

In Sakarya province, 3 of the 14 hospitals were surveyed. Two of these were general hospitals and the third, Toyatasa Acil Yardim Hastanesi, was an emergency hospital. All three were located in the city of Adapazari. These 3 hospitals had 735 beds representing 64 % of the total beds in the province. Sakarya Devlet Hastanesi, with 400 beds, and Toyotasa Acil Yardim Hastanesi, with 55 beds, were owned and operated by MOH. SSK Adapazari Hastanesi had 280 beds and supplied health services to 433,705 patients, the highest number in the province in 1998. It performed 5,051 surgical operations and 3,513 deliveries. The hospital had a total of 51 physicians, a relatively low number given the amount of the service it provided.

Overall, SSA hospitals had the highest number of patients (Table 2), and had performed the highest number of surgical operations. However, they also had proportionally the smallest number of the physicians.

Finally, in the province of Yalova, the only hospital, MOH owned and operated, was included in our survey. In 1998, Yalova Devlet Hastanesi employed 68 physicians provided health services to 7,546 inpatients and to 181,524 outpatients. They also performed 2,490 surgical operations in 1998.

In Kocaeli, Sakarya and Yalova provinces and in the city of Duzce of Bolu province, a total of 89 health facilities (Table 3) including hospitals, small size public health centers, laboratories and administrative buildings were damaged as a result of the Izmit earthquake. Twenty seven percent of those facilities were either collapsed or were heavily damaged. The remaining 72.9% were either moderately or slightly damaged. Of all the damaged health facilities 84.3% were in Kocaeli and Sakarya provinces. In these 4 provinces, earthquake damaged 24.7% (121) of the 489 pharmacies, of which 57 (47%) pharmacies were heavily damaged. Similarly heavy damage to the pharmacies was more concentrated in the Kocaeli and Sakarya provinces.

Table 3. Damage to Health Facilities

	# of Damaged Health Facilities			# of damaged Pharmacies				# of Undamaged	# of Hospital
Province	Heavily	Slightly	Total	Heavily	Moderately	Slightly	Total	Pharmacies	Beds Lost
Kocaeli	9	22	31	35	20	11	66	193	1,190
Sakarya	6	46	52	13	7	7	27	157	568
Yalova	3	1	4	0	1	2	3	56	0
Bolu/ Duzce	1	1	2	9	11	5	25	83	197
Total	19	70	89	57	39	25	121	489	1,955

Source: Prime Ministry Crisis Management Center (PCMC)

The statistics show that hospitals in these 4 provinces lost 1,955 of their total beds as a result of the earthquake damage and Kocaeli (1,190) and Sakarya (568) were the two provinces with the biggest losses. Thirty-six percent of the total (1,955) bed losses in the four provinces were in the 10 surveyed hospitals. Overall the 10 hospitals lost 70.6% of their bed capacity. In 5 of the 10 hospitals, namely Kocaeli Devlet Hastanesi (92.5%), Sakarya Devlet Hastanesi (89.75%), SSK Kocaeli Hastanesi (85%), SSK Izmit Hastanesi (82.3%) and SSK Adapazari Hastanesi (71.5%), the damage was very significant. These five hospitals are located in the two cities, Izmit and Adapazari, and they were big facilities. On the other hand, 3 of the 10 hospitals did not have any bed loss despite the fact that they were as close to the epicenter of the earthquake as the other heavily damaged hospitals. One common characteristic of them were they were relatively small size hospitals.

Table 4. Number of Beds

Hospital	Before the Earthquake	After the Earthquake	Loss %
Kocaeli Devlet Hast	400	30	92.5
Gölcük Devlet Hast	100	30	70
Karamürsel Devlet Hast	50	50	0
SSK Kocaeli Hast	200	30	85
SSK İzmit Hast	413	90	82.3
Sakarya Devlet Hast	400	41	89.75
Toyotasa Acil Yrd.Hast	55	55	0
SSK Adapazarı Hast	280	80	71.5
Düzce Devlet Hast	400	200	50
Yalova Devlet Hast	100	100	0
TOTAL	2,398	706	70.6

Source: Prime Ministry Crisis Management Center (PCMC)

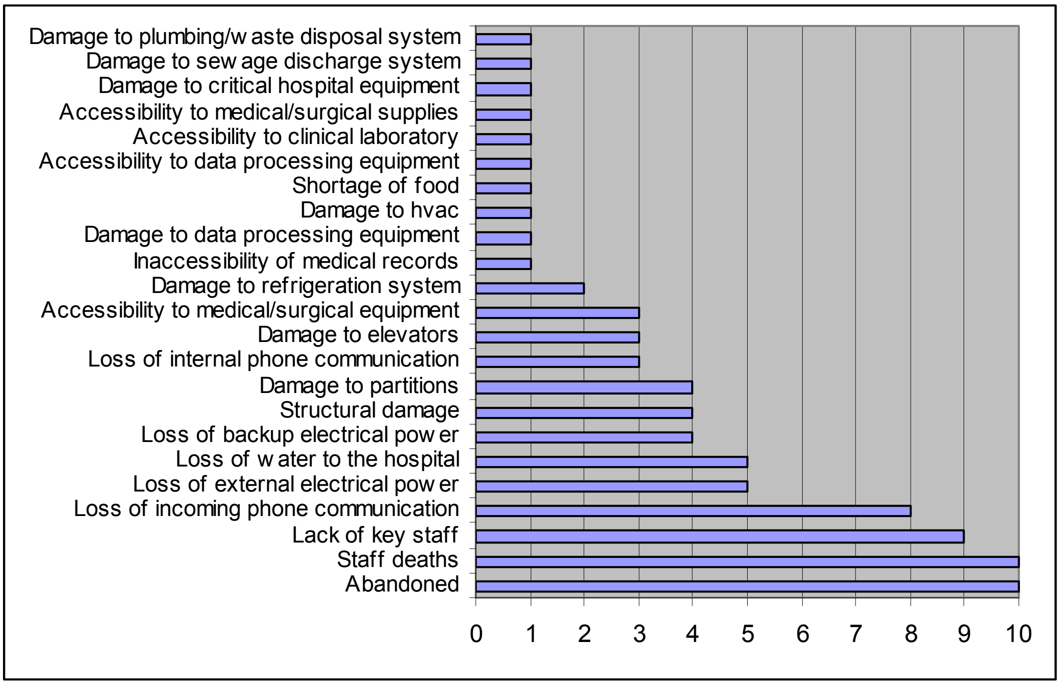
Due to the damage caused by the earthquake, all hospitals had to deliver their services either in open areas or in tents for a time period ranging between two days to two weeks. One of the main reasons for not being able to use the facilities was continuing damage by the aftershocks. After immediate treatment, all the existing and arriving patients were transferred to the other cities by ambulance, helicopter and sea bus.

Findings: Damage to the Nonstructural Components of Hospitals

All of the 10 surveyed hospitals reported they had been abandoned following the earthquake. Three of those were reoccupied within several hours and others have yet to be reoccupied. Since the interviews were conducted while most of the hospitals were operating in temporary facilities, some of the responses reflect the impact of the earthquake on the original facility and others reflect the impact of the earthquake on the current operations of the temporary facility. While every attempt was made to have the respondent focus their assessment of the impact of the earthquake on the original facility, the responses to some of the questions suggest that some respondents may not always have been able to do so.

The first part of the questionnaire asked about the type of problems they experienced. These included whether the earthquake caused problems with staffing, lead to a loss of water, electricity, communications, heating and medical gases as well as damage to a list of nonstructural elements. For many of the questions, the respondents were asked to indicate how long the problem persisted and to provide additional information about the problems encountered with an open-ended response category. The responses of the study participants to the open-ended portion of the questionnaire are presented first, followed by their responses to the closed-end question.

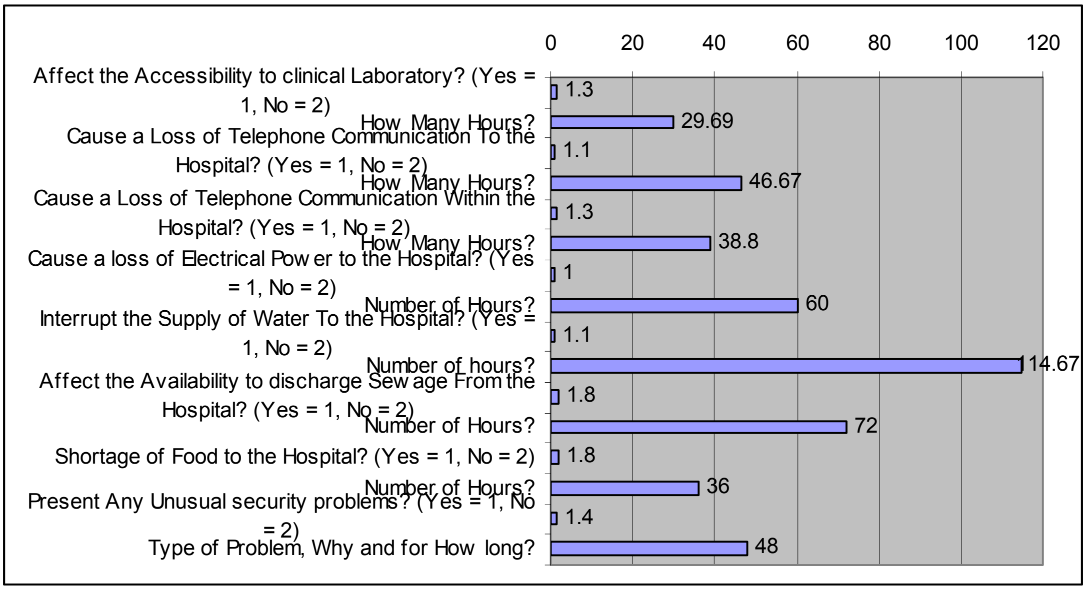
Figure 1. The Impact of the Izmit Earthquake on the Functionality of the Hospitals



In Figure 1, the results of the open-ended assessments of the impact of the earthquake on the functioning of the hospitals are reported. All of the hospitals reported staff deaths that resulted from the earthquake. The major conditions affecting the functionality of the hospitals were the inability of key staff to report to duty and the loss of telephone communication to the hospital. Loss of electrical and water services also presented problems which were exacerbated by the failure of the backup power supply.

The closed-ended portion of the questionnaire contained a list of life-line and nonstructural elements. The respondents were asked to review this list and indicate whether the earthquake affected that particular component, and if so, for how long. All of the respondents reported that the earthquake had an impact on the availability of key hospital staff, damage to ceilings and ceiling tiles, damage to partitions and a loss in electrical power. Over 25 percent of the hospitals' emergency treatment staff were not available because of the earthquake. Restoring the water supply to the hospitals took an average of 114 hours. On average, it was 3 days before hospitals were able to discharge their sewage. It took almost as much time (60 hours, on average) before power to the hospitals was restored. Telephone services took one to two days to be restored. Gaining access to key departments such as the laboratory took over 24 hours, on average to achieve (Figure 2; Also see USC 2000c for complete results).

Figure 2. The Impact of the Izmit Earthquake on the Availability of Staff, Supplies and Equipment (Average Scores) (0=N/A)[3]



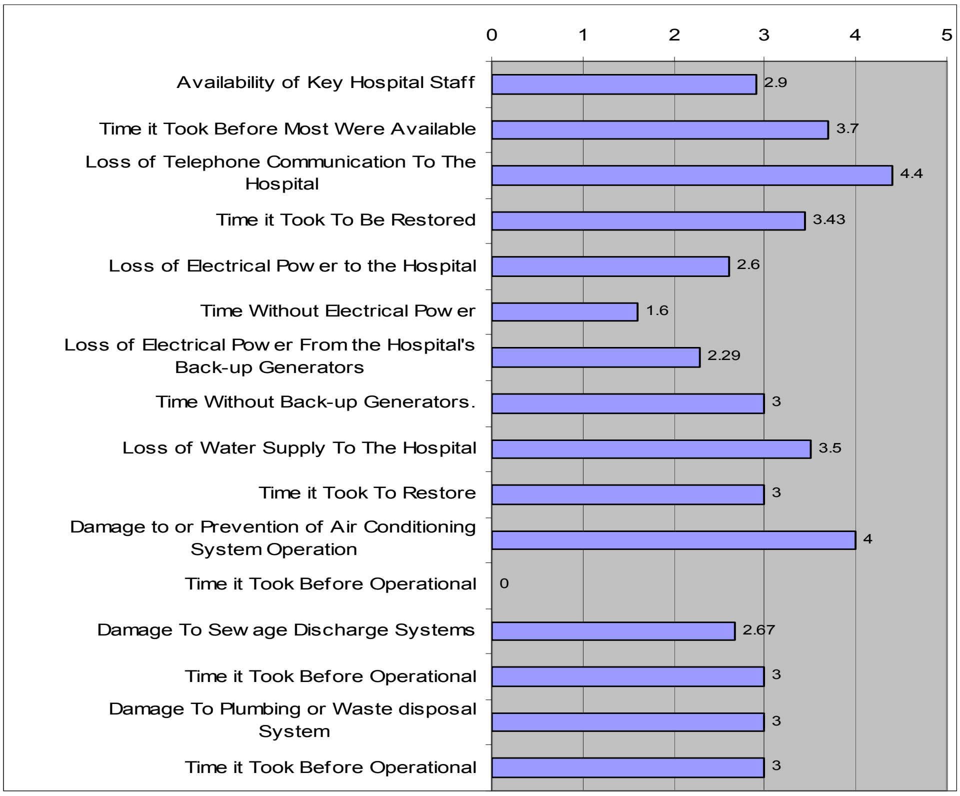
A second set of questions asked the respondents to indicate, using a 5-point Likert scale, the impact that the damage to the life-line and nonstructural systems had on the operation of their hospital. They reported that the loss of communication to the hospital had the greatest impact on their ability to function. Nearly as significant was the damage to the air conditioning system. The loss of water and damage to the waste disposal systems also presented significant problems on the hospitals' functionality. Also important in terms of the impact on the functioning of the hospital were the time it took before staffs were available and before the telephone system was back in operation (Figure 3; Also see USC 2000c for complete results).

The respondents also reported that the damage to life-line and nonstructural systems had a limited impact on certain areas or functions of the hospital. They reported that the earthquake had limited impact on the following: Damage to computer terminals; Hazmat incidents or problems; Damage to fire alarm systems; Damage to stairs or fire escapes; Damage to lights or light systems; Damage to critical hospital records; Loss of water supply within the hospital even though the external supply was interrupted; Damage to or the prevention of the heating system from operating; Damage to emergency lighting systems.

A third part of the survey asked the respondents to indicate how critical, a key hospital service delivery unit was to the functioning of a hospital at different points during and following an earthquake. These points in time were characterized as: Phase I was immediately following the earthquake; Phase II was described as a stabilization of operations; Phase III was defined as the recovery and cleanup phase; and Phase IV, reflected a transition to normal operations.

[3] Due to space limitations only those items that were out of service for more than 24 hours were reported.

Figure 3 The Impact of Earthquake Related Problems or Conditions on the Operation of the Respondent's Hospital (Time= # of Days, 0=NA, 1= No Impact 5= Very Great Impact)[4]

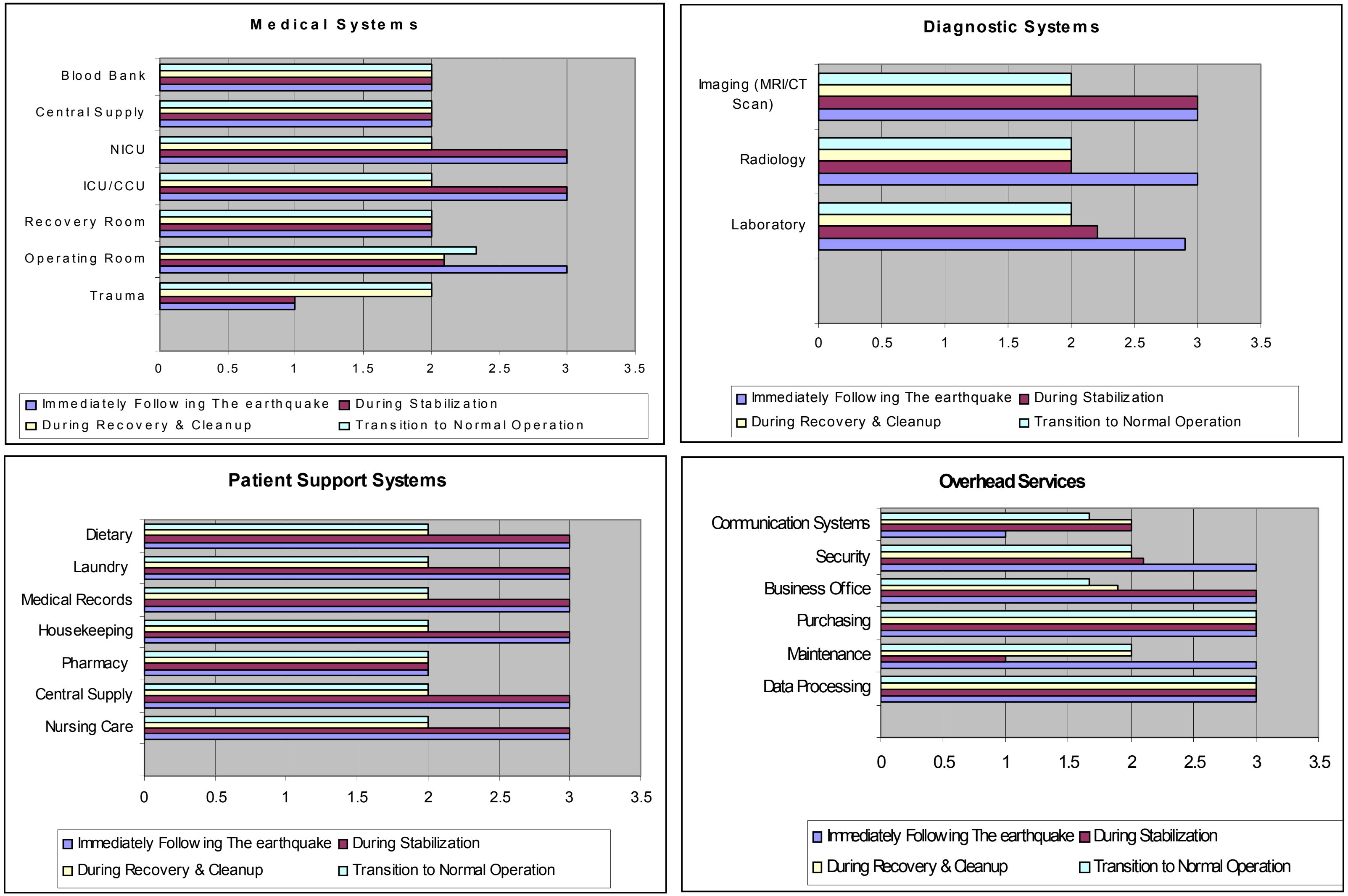


Each respondent was given a list of key departments along with spaces where they could add departments that were not included in the list provided. They were asked to review the four phases of the earthquake and to indicate how critical each department was to the functioning of the hospital at each phase. Four response categories were available. The first was "Essential", which was defined as "A department whose functioning is essential in the described situation". The second was "Important" which was defined as "A department whose functioning is important, but not essential, in the described situation". The third was "Useful" which was described as "A department whose functioning is useful but not important in the described situation. The last category was "Not Applicable" which was characterized as "a department that is not needed in the described situation".

A summary of the average response scores is presented in Figure 4. In scoring the responses, a "1" was the value assigned to essential services or departments, a "2" was assigned to important department or service, a "3" was assigned to useful department or services. No value was associated with departments listed as not needed in the described situation.

[4] Due to space limitations only those items with a 2.5 or higher value were reported.

Figure 4: The Importance of Key Departments and Services over the Life Cycle of an Earthquake



Two systems, Trauma and Communications, were described as essential to the operations of the hospital immediately following an earthquake. This pattern changes somewhat during the stabilization phase where Maintenance becomes essential along with Trauma. However, no service is seen as Essential during the Recovery and Clean-up phase and the Transition to Normal Operations phase.

In contrast, 16 of the 24 systems were regarded as "useful" immediately following the earthquake. This number declines to 12 during the stabilization phase with only two departments – data processing and purchasing – continuing to be seen as "useful" in the "recovery" and "transition" phases.

Conclusions: Hospital Performance

This study used information from survey data obtained from key hospital and medical personnel of 10 public hospitals in Turkey about the performance of their hospitals and critical care facilities. Findings were used to identify critical nonstructural systems, essential hospital departments, and the diagnostic and treatment equipments necessary to sustain functionality of a hospital or a critical care unit during or following a major seismic event.

Findings suggest that the functionality of hospitals is influenced by a number of different factors. First, the severity, proximity and duration of seismic forces have a major impact on the extent which structural components were able to resist damage. Second, functionality of all hospitals is influenced by the seismic standards governing the construction of the facilities and their enforcement as well as the age and type of construction of the facilities as empirically demonstrated by the studies on Northridge and Loma Prieta earthquakes (USC, 2000).

Our survey findings also reveal that, even if the structural components were intact, nonstructural failures in the facilities had remarkable effects on the functioning of hospitals following an earthquake. Interruptions of water, sewage, electrical and telephone services to the hospital were a major factor limiting hospitals' functioning. While most hospitals had back up capacity, structural and nonstructural damage often hindered the operation of back up systems. Consistent with other findings, most of the damage to the functioning of the hospitals was caused by the failure of supply systems rather than by damage to a particular piece of equipment (2000b). These findings were also confirmed in similar studies in California and Japanese hospitals after major earthquakes (USC, 2000). Pipe failures, particularly water lines, severely limited the functionality of hospitals in most cases. However, an interesting finding in the Turkish case was that the existence of water wells in some facilities reduced the possible interruptions that might result from the damage to the municipal piping systems.

Interruptions in the communications and transportation systems as well as the damage to the cities' infrastructure limited hospitals' access to staff, information, supplies, and services. During the early hours of the earthquake, sudden increases in the number of drivers and telephone calls crippled the communication and transportation lines. While the hospitals, through the initiative and improvisational skills of their staffs were able to function in spite of the damage, the lack of information about the extent of the damage in the area; questions about the structural integrity of the building; and, uncertainties over the state of critical systems hindered the functionality of the hospitals during and following the Izmit earthquake and its aftershocks.

In addition to the structural and nonstructural failures, uncertainty and information isolation were the next group of factors that hindered the functionality of the hospitals. Especially during the early hours of the catastrophe, TVs and mobile phones, when they were not jammed, had a pivotal role in overcoming the uncertainty and information isolation.

The implication for managers and policy makers is that earthquake mitigation and preparedness requires consideration of both internal and external elements of a health system influenced by the earthquake as well as the structural and nonstructural components of the hospitals.

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COMMUNITY BASED PARTICIPATORY MODEL FOR NATURAL DISASTER PREPAREDNESS - LANDSLIDES

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Keywords: Roads, Landslides, Community, Participatory Process Oriented Planning, Hazard Mitigation, Disaster Management, Emergency, Knowledge Base System (KBS)

Abstract:

The community participatory method of approach is not ruled or specific. Success will always depend on “people’s commitment” other than the “concept”. Once a fruitful observation is entered, either as a new rule, step or change in the forms of preparedness because of newly recognized dependencies, the old knowledge must be correctly or completely updated or removed from the primary concept. This is a conceptual approach of observational method of assessment which can be applied when disaster strikes. The collective efforts of community participatory groups, volunteers’ and local emergency service officials can be addressed to deliver the above message with an integration of preparedness into problems of everyday nature. To ensure that compassion and generosity of people are put to good use, the media should highlight various facts on what is needed and where to send it. Author suggests a more appropriate community participatory based information system which will support participatory process oriented planning, implementing, execution and monitoring for hazard mitigation. When planning interventions, prioritization is made on the basis of hazard, geographical location, vulnerable groups and nature of activities; co-operation with governments, NGO’s and the private sector and volunteers. This may be a simplest model approach for mitigation planning including activities that prevent an emergency.

1. Introduction:

Landslides are often a secondary hazard related to other natural disasters. Human resource is the backbone of all other activities pertaining to development and economic growth of a country or a region. Infrastructure development and maintenance too need to be preserved against the same. Consequently, the investigations of slope instabilities have been increasingly integrated with broader aspects of hazard assessments and mitigation. Questions are commonly encountered in selection, diagnosis, evaluation, interpretation, prediction, monitoring and control. The efforts have neither reduced the frequency of disasters and resulting damage nor the level of vulnerability in the hilly region due to a variety of reasons. One of the main reasons is that various efforts lack strategy to integrate disaster management within the broader development context. Another is that most mitigation programmes rely on scientific data and advanced technology and are "hazard-centered" rather than "people-oriented," therefore less relevant to specific locations.

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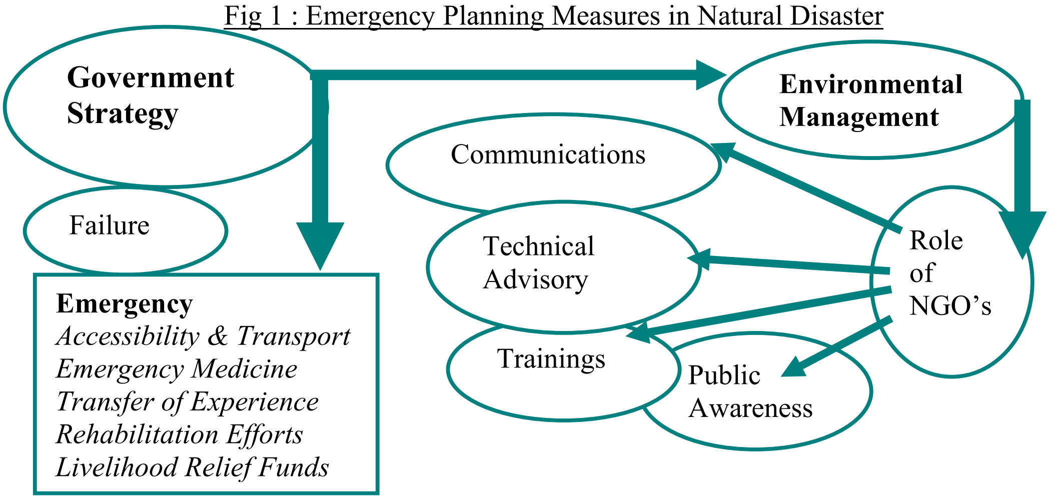
Most of the reported natural disasters in Sri Lanka are rain induced landslides and flooding. Between 1964 and 1991, floods are reported to have killed about 750 people and left about 1.3 million homeless. Landslides, which are often triggered by intense rains, are responsible for about 300 casualties and considerable losses to road and infrastructure; approximately about 10,000 sq km of the hill Country. Some statistics are given in Table 1 below.

Table 1: Landslides Occurrence against Landuse Patterns of Hill Country [Source: District Integrated Development Project, Nuwara Eliya, Sri Lanka]

Landuse Pattern	Nuwara Eliya Distric Area % Occurance of Landslides	Badulla District Area % Occurance of Landslides
Forest	28%	31.6%
Scrub land	16.4	16.2
Tea Cultivation	38.8	16.9
Chena & Tobacco	6.4	10.1
Paddy & other annual crops	5.5	9.4
Home gardens	4.8	15.8

To accommodate a rapidly growing urban population in hill country, Sri Lanka, the built environment has been transformed within the past two to three decades by reconstruction and destruction of traditional homogenous building stocks without consideration being given to landslide risk. The peripheral agricultural land, haphazard settlement, ignoring natural hazards without basic amenities, is converting the entire area into a disaster-prone zone. The lack of a systematic disaster planning implementing strategy is mainly responsible for most of the events. Now efforts have been formulating on design, research and implementation strategies which are specifically looking at landslide mitigations.

Fig 1 : Emergency Planning Measures in Natural Disaster



Authors pin point that some of the added advantages of community participatory programmes have successfully raised the capacity of society in vulnerable areas to prepare and manage plans for disaster in an emergency and risk reduction (Fig 1 & Fig 2). One primary observation is that a selected group of Local Communities should be empowered to plan and initiate their own development programmes, including mitigation of disaster with, for instance, devolution of power to rural committees through legislation. The public awareness is compulsory for better understanding and better response with the impact of disasters, both prediction and prevention.

2. Know Your Risk

The vulnerability of the people in the hill country Sri Lanka increases every year as a result of population growth and increasing rural-to-urban migration pattern. Landslides pose a permanent threat to Sri Lanka and economic underdevelopment accentuates the extent of losses. However, emphasis is on the physical process and infrastructure development, with less attention given to human components. Most of these programmes, though successful by their own criteria, are less tangible in having any impact on the society, not only due to lack of coordination and continuity of the mitigation work. The Local context of sustainable environment and community vulnerability have been largely ignored

Change in slope or geomorphology from naturally or man made events may cause disequilibrium between earth mass, transported material, flow debries, and sediments. The mechanism of disequilibrium events of terrain instability can be recognized with different type of movements as recorded in Table 2.

Table 2: Geomorphologic Disaster Proven Risk Elements in Landslides

Type of Movement	Type of Material in fall, flow or deposited		
	Bed Rock	**Debries (coarse soil particles)**	**Earth (fine Soil, soil water mixd)**
Fall	Rock fall	Debries fall	Earth fall
Topples	Rock topple	Debries topple	Earth topple
Rotational Slides	Rock slump	Debries slump	Earth slump
Translational Slides	Rock block slide Rock slide	Debries slide	Earth slide
Spreads	Rock spread	Debried spread	Earth lateral spread
Flows	Beadock flow	Debries flow Debries avalanche Block stream Soil creep	Wet sand flow Rapid earth flow Earth flow Dry earh flow(sand & fines)
Complex	Composite failures in rock including topple, fall and slump etc.	Slump and earth flow	Composite failures in soils including fall and sliding etc.

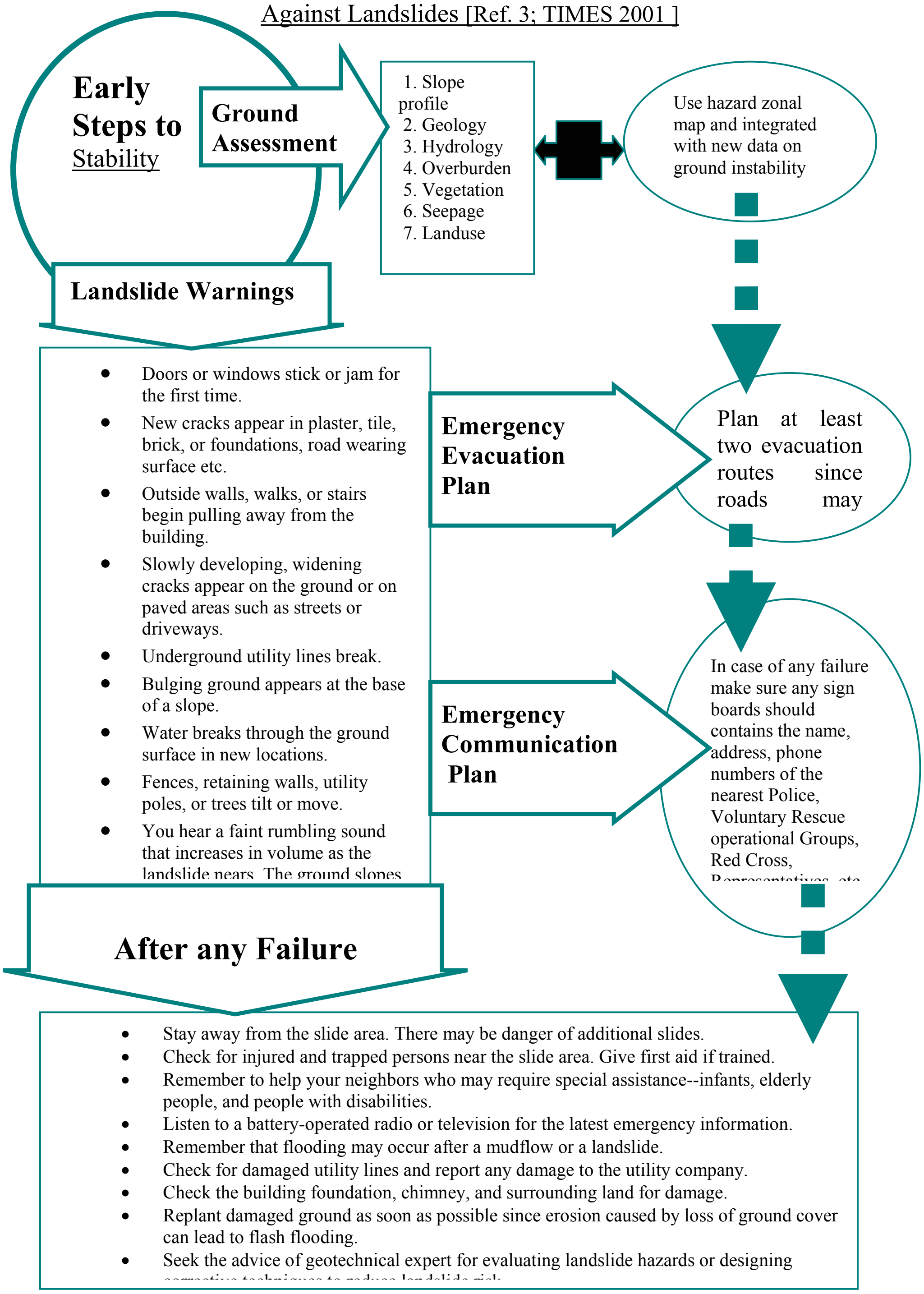
Rapid landslides are debris flows, debris avalanches and rock falls and rock avalanches. Slow, ductile toppling of rock masses commonly create large-scale mountain slope deformations. In some cases, toppling can initiate a brittle catastrophic rockslide. The failure behavior of landslides in clay soil and residual soil are very different from above. Some continue to exhibit intermittent, relatively slow deformations with limited mobility. In some instants suddenly developed into a catastrophic failure, extremely rapid flow slides with various combination of soils and rock. These may cause damming of large rivers in the course of a few minutes and projecting a wave onto the opposite bank and subsequent failures as well. Typical example of earth failure was recorded at Ocdagala mountain range, Mandaramnuwara, Sri Lanka in 1986.

3. Acceptable Risk

There is no simple approach for the determination of the potential risk of landslides. The concept of acceptable risk is an important one but there is currently no definition of acceptable risk associated with landslides or sensitive terrain. Even a landslide hazard integrated map still produces less accuracy compared to the present day victims. One reason is that regional planning measures are restricted to geomorphic data log rather than the inherent geotechnical contents of the ground.

The lack of clear definition regarding the "acceptable risk" is plainly evident in the terrain stability classification themselves. If detailed terrain mapping is available, the areas can be designated as having "a low, moderate or high likelihood of landslides". Therefore, the acceptable risk concept in landslide area is valid only if it establishes a continuous vigilance monitoring unit as a disaster risk reduction and emergency planning against landslides (Fig 2).

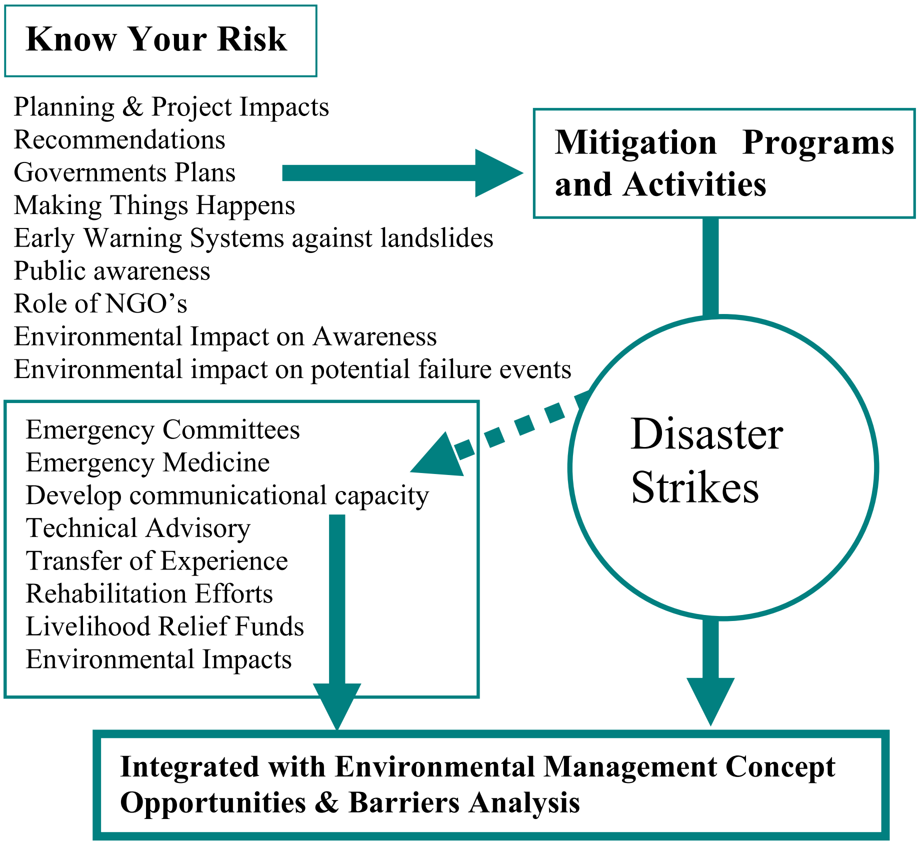
Fig 2 : Data Acquisition Model for Natural Disaster Risk Reduction & Emergency Planning Against Landslides [Ref. 3; TIMES 2001]



4. Strengthening Local Disaster Preparedness Structure

The growing complexity of relief appeals has resulted in major international policy reviews underlining the importance of linking relief, disaster preparedness and development. The UN World Conferences, the European Commission, and more specifically the European Community Humanitarian Office, announced their Action Programme for Disaster Preparedness. Considering the primary observations of above findings, the authors suggest a KBS Model (Fig 3) which can be forecasted and strengthen the local disaster preparedness structure.

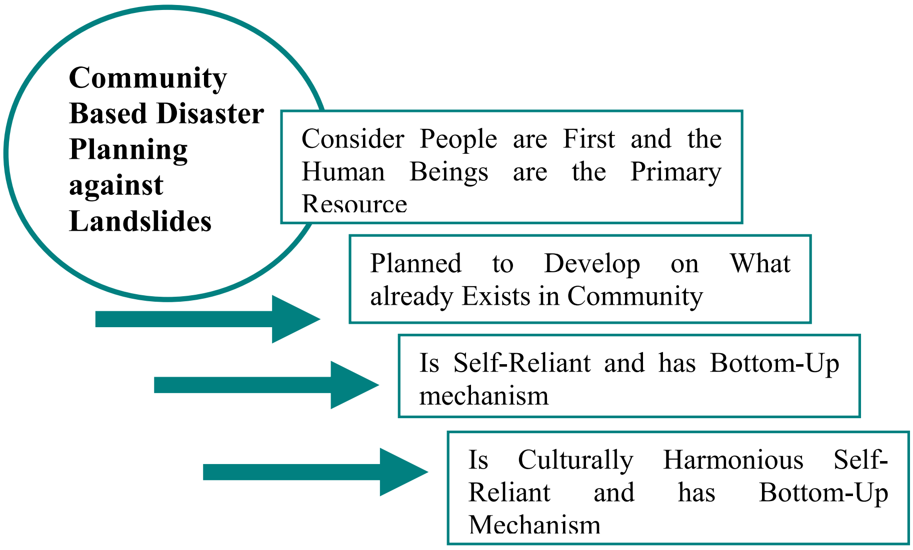
Fig. 3: KBS Model



5. Making Things Happen

Many of the good concepts developed in the area of facing disaster and hazard mitigation have not reached the implementation stage successfully due to two reasons. One is validity of these concepts has not been tested through interaction with the community participation. Secondly, the policy makers bureaucracy attempts to implement the programmes without involving the effective community participation. The participatory oriented programmes (Fig 4) are always initiated from the grass roots level of the community, implemented within the community and benefit the community. Therefore, it is always strengthened by self reliance, empowerment, minimization of suspicion and fear, satisfactory mentality, reduction of emotional distress & mental unrest, consolidation of institutional supports and ultimately establishment of a sustainable society. Therefore, this will ensure a reduction in the loss of life from natural disasters events and ensure sustainable recovery. The volunteers and group of trained staff are required to express and initiation work, so that working with other grassroots community participatory groups, organisations could address the needs of vulnerable communities; those of greatest risk from situations that threaten their survival or their capacity to live with a minimum of social and economic security and human dignity.

Fig 4: The Logical Approach of the Community Base Participatory Model



6. Community Participation and growing Empowerment

Community participatation is a concept which respects the target group ideas and the confidence in a sense of ownerships. Therefore, beneficiaries are enhancing the sustainability. In addition, objective strategy mainly rest on people's participatory order, to ensure that vulnerable groups are fully represented in decision making through better definition and communication. This form of approach will enhance empowerment. These mechanisms have successfully raised the capacity of non governmental organisations such as Red Cross Society, Youth Rehabilitation Organisation, etc., in the region to prepare and manage plans for disaster preparedness and response risk reduction. It has also increased the interaction between National Societies and Community Participatory Groups. This shares the principles of;

Sharing cost - beneficiaries contribute self capacity, material and money
Increasing efficiency - beneficiaries assist in project planning and implementing
Increase the Effectiveness - beneficiaries will look on outcome in due time
Building beneficiaries capacity - beneficiaries share in management task or operational responsibilities
Increasing community Empowerment - beneficiaries share power and increase their social awareness and influence over development outcome

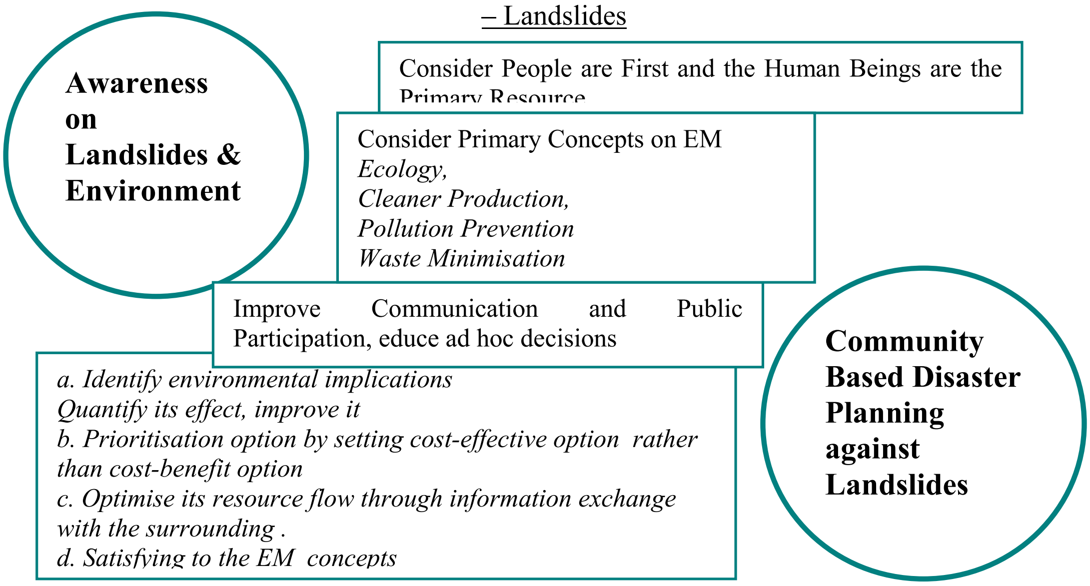
7. Role of NGO's

Implementation of NGO's should include disaster awareness and public education as well as community organization and community micro projects. When planning interventions, prioritization is made on the basis of hazard, geographical location, vulnerable groups and nature of activities; co-operation with governments, NGO's and the private sector; and integration of preparedness into problems of everyday nature. In order to increase efficiency of delivery services, it has been decided to decentralize authority, which require a long-term evolution of political structures.

8. Integrated with Environmental Management Concept

An integration with the environmental management (EM) concepts (Fig 5) can be developed by simplifying and integrating four known environmental management criteria which declares “the continuous improvement of process, product or services to reduce the use of natural resources, to prevent pollution at its source, to reduce the volume and toxicity of generated waste and consequently reduce the human and the environment”. Therefore, ecological stability; pollution prevention, cleaner production and waste minimization acts as the goals or objectives for disaster mitigation planning measures and improves environmental performances. Most instantces ad hoc decisions have just managed an emergency crisis and do not obey the environmental disciplines or requirements. The significant observations are re-settlement, re-rooting of highways and re-habilitation of community, just after the event of a disaster. The effect of environmental threat can be minimized by adopting a system view of primary issues as in the log form assessment chart (Fig 5) given below.

Fig 5: Environmental Management Concepts which are applicable to Natural Disaster Mitigation – Landslides



	Environmental Management Concepts / practices			
	Ecological Stability	**Clener Production**	**Pollution Prevention**	**Waste Minimisation**
Aims	Promote sustainability	Waste minimisation	Reduced risk to humans and the environment	Reduction of quality or toxity of hazadius wastes
Focus	Minimise the speding of environmental threat after the event	any industrial factories, hospital wastes within the landslide vulnerable areas and focus on protection in an emergency	Chemical storages, petroleum storages, fertilizer storages within the landslide vulnerable areas and focus on protection in an emergency	Individuals, industrial etc.

9. Opportunities & Barriers Analysis

Opportunities and barrier analysis will express the requirement of the continuous monitoring and auditing on conceptual planning and management. This will create an arena for attention on human beings during operation. Some parties always put economic benefit in the first in priority. In such instances, they have to reduce the cost component by applying not recommended techniques or no provisions for environmental sustainability. It is not the problem of lack of awareness, it is primarily due to ignorance. Also, environment is not an urgent issue in people's life when basic needs are still lacking in the developing or under developing countries in the world today.

10. Conclusion

The community participatory approach of disaster mitigation – landslides is to provide an opportunity for government and non government professionals in a country to understand the common problems in nature and develop a mitigation concept with broader idea. Some of the key areas of concern are livelihood relief, gender assessment and complexities in coordination. Therefore, the successor organization should broaden its contacts and activities to deal not only with governments and specialists, but all stakeholders at all levels. This means the local communities should be empowered to plan and initiate their own development programmes to some extent, including mitigation of disasters with, for instance, devolution of power to rural committees through legislation.

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12. Acknowledgment

The authors would like to thank the project team of the Pre Feasibility Study of Designing of Major Roads in Landslide Area, Central Engineering Consultancy Bureau (CECB) for their association and help extended at various stages. The views express in the paper are however those of the authors only. Our grateful thanks are due to Eng. H B Jayasekara, Chairman and Eng N Rupasinghe, Additional General Manager, Central Engineering Consultancy Bureau for the permission and encouragements. The all assistance received from the Mr. B M P A Mapa , Project Manager, Laboratory & Site Investigation Unit & the Staff is gratefully acknowledged.

SECTION 8:

APPROACHES TO BUSINESS CONTINUITY

RE-ENGINEERING BUSINESS CONTINGENCY PLAN TO BUILD A RESILIENT COMPANY

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Key words: re-engineering, resilient, contingency plan, business continuity, knowledge management

Abstract

According to the statistics of U.S. Department of Labor, over 40% of companies never reopen after suffering a disaster attack and over 25% of the remaining companies close within two years. Indeed, after terrorists' attack on September 11, 2001, this event evoked all companies to focus on business continuity. Sequentially, this attack also tested the business contingency plan of the disaster-affected companies. **PURPOSE:** the purpose of this paper is re-engineering the business contingency plan to build a resilient system to ensure business continuity. **GENERAL APPROACH:** A resilient system is a sustainable network of physical facilities and intellectual assets. Physical facilities are the tangible components of companies which are buildings, computer and communication equipment, and office merchandise. Intellectual assets are the intangible components of companies which are computer data, employees, and clients. **METHOD:** This research describes a combinative model for business contingency plans. Reviewing past and present literatures show that emergency managers should re-engineering business contingency plans to build a resilient system to respond an emergency. **FINDING:** The strategies for business continuity are protecting intellectual and tangible facilities, employees, and customers.

Introduction

"According to the statistics of U.S. Department of Labor, over 40% of companies never reopen after suffering a disaster attack and over 25% of the remaining companies close within two years."[13] Indeed, after terrorists' attack on September 11, 2001, this event evoked all companies to focus on business continuity. Sequentially, this attack tests the business contingency plans of the disaster-affected companies. [2][4][5][8][11] Of course, this attack also shows the importance of a Business Contingency Plan (BCP) to ensure the business continuity of an enterprise.

Knowledge consists of skills and understanding that people have gained through learning or experience to solve problems.[10][14] Today, how to manage knowledge becomes a hot topic in corporate business. A Company's process and its employee's experience are regarded as intangible and important assets in a company. Therefore, Knowledge Management (KM) is a process that people identify, acquire, develop, share, distribute, utilize, and preserve knowledge in order to improve the capability of organizations.[10]

The key concept of KM is how to get the right information to the right people at the right time.[6] Further, BCP provides the right directions to rebuild or recover the business continuity in disasters.

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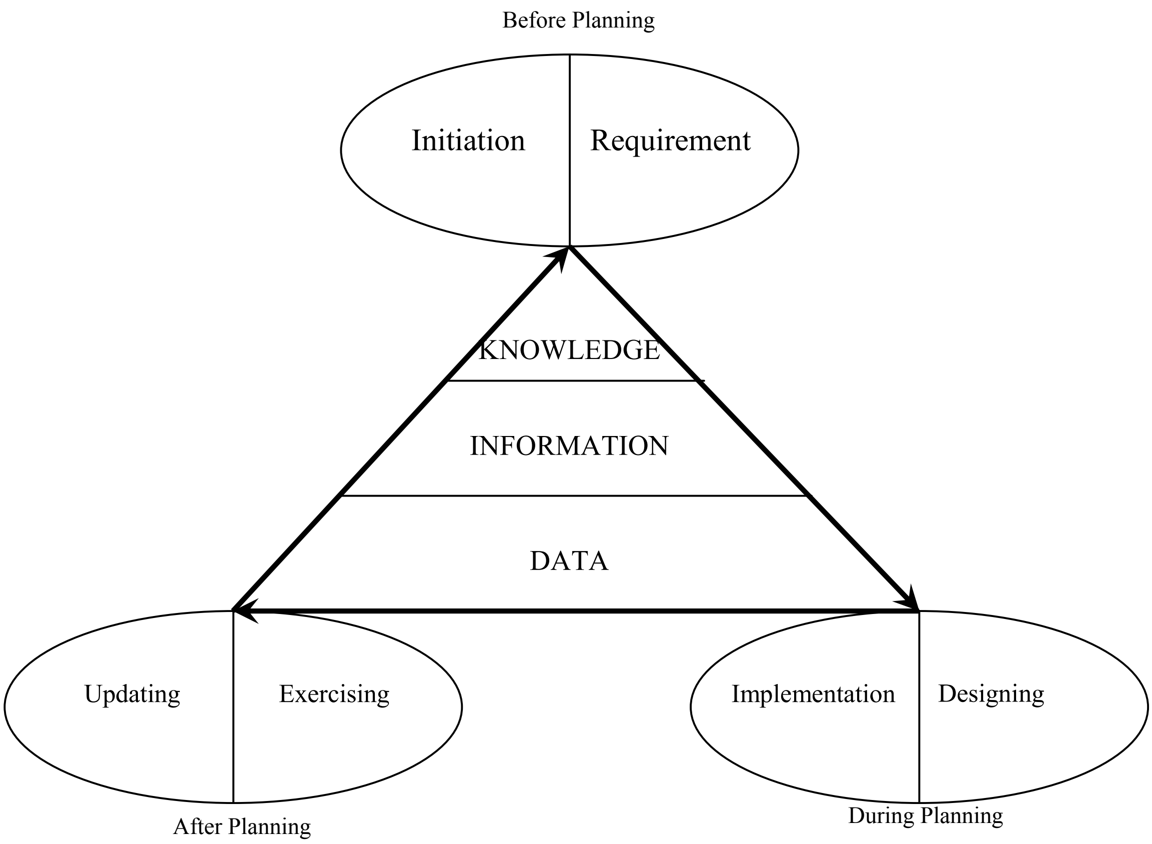
Both concepts, BCP and KM, address critical issues for organizations. In order to improve the capability of business continuity, applying KM concept to re-engineering BCP is necessary for BCP managers to consider.

Purpose

The models of BCP are initiation, requirement, designing, implementation, exercising, and updating.[9] [12] In each phase, the project will produce a mountain of data and information. To link each phase as an integration task, figure 1 shows that BCP managers should transfer data and information to become knowledge. Indeed, to get the right information to the right people at the right time, the BCP managers should process knowledge in order to identify, acquire, develop, share, distribute, utilize, and preserve knowledge. To improve the effectiveness of BCP, the purpose of this paper is applying knowledge management concepts to re-engineer business contingency plans to build a resilient system to ensure business continuity.

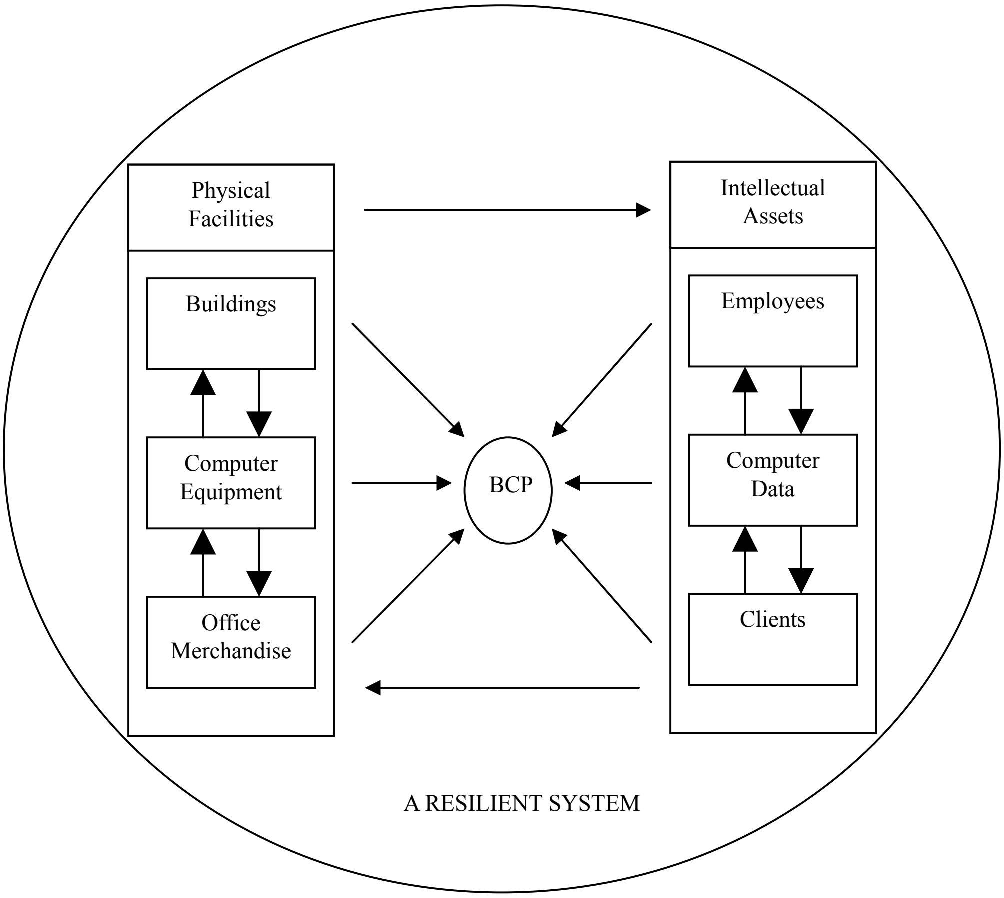
Figure 1: Knowledge and Business Contingency Plan



General approach

A resilient system is a sustainable network of physical facilities and intellectual assets. Physical facilities are the tangible components of companies which are buildings, computer and communication equipment, and office merchandise. Intellectual assets are the intangible components of companies which are computer data, employees, and clients.[7] In an emergency, the tangible and intangible assets will be damaged or affected by natural disasters or man-made hazards.[3] The purpose of BCP is building a resilient system that a company can rebuild and restore the normal business in a short time. For this reason, how to create an effective, efficient, and efficacious BCP is a challenge for BCP managers to address. Figure 2 illustrates a resilient system.

Figure 2: A Resilient System



Method

After September 11, 2001, the contingency plan of a company gathers all attention from management. Suddenly, business continuity becomes a hot topic in the business administration. A large number of articles show the importance of business continuity and the consequence of an ineffective, insufficient, and inefficient contingency plan. [1][2][4][5][8][11] Thus, to accomplish this study, the author uses the ABI/Inform and Google search engines to conduct a literature and web site review with the keywords: "business continuity" and "contingency plan". Indeed, to find applicable articles and web information, the author used expert judgment to screen titles and abstracts. The process of reviewing past and present literatures focuses on the importance of business continuity and how to conduct business contingency plans. Moreover, the author analyzed the articles, gathered findings, and developed conclusions. Therefore, this research describes a combinative model for business contingency plans.

Discussion

The models of BCP

In order to understand and develop the model of BCP, people need to know what kind of risk will break the business continuity. These risks include natural disasters and man-made hazards that cause loss, damage or denial of access to infrastructure services, information systems, and key staffs and political actions that cause sabotage, extortion or commercial espionage.[9] Further, BCP managers can use a development life cycle to create a BCP as figure 1. [12] The following table 1 demonstrates the detail model of BCP. [3][9][12]

Table 1: The Detail Model of Business Contingency Plan (BCP)

Initiation Phase	Set Planning Policy and Form Steering Committee
Requirement Phase	Risk, Business Impact, and Cost-Benefit Analysis
Designing Phase	Scope and Objective
	Risk Reduction Measure
	Disaster Recovery Strategy
Implementation Phase	Procedure Development
	Command, Control, and Communication
	Delegation and Resource
Exercising Phase	Education and Awareness
	Training and Plan Testing
Updating Phase	Review and Change Plan

The process of KM

Knowledge is a valuable asset for a business. Certainly, the right utilization of knowledge can improve the function and capability of BCP to guarantee that companies survive in disasters or terrorist's attacks. To achieve this goal, BCP managers should understand what is knowledge management. Knowledge management includes: (cf. Fig. 3)[10][14]

Knowledge base: The knowledge base is a repository that consists of individual and organizational knowledge to assist the organization to accomplish its tasks. The individual and organizational knowledge can come from internal employees or external consulting companies. Meanwhile, this knowledge base includes data and information which organizations create.

Identify knowledge: Knowledge is not visible. How can we expose the existing knowledge? Further, people face overwhelming information today. To find and locate the right knowledge, managers need to explore the unknown experts, map the knowledge assets, and build the expert networks in the internal and external environment of organizations.

Acquire knowledge: Knowledge exists not only inside organizations, but also as outside resources. Of course, research and development can be done internally to improve and update knowledge. However, the potential knowledge providers may come from customers, suppliers, competitors, and partners. Therefore, managers should involve stakeholders' knowledge into knowledge management.

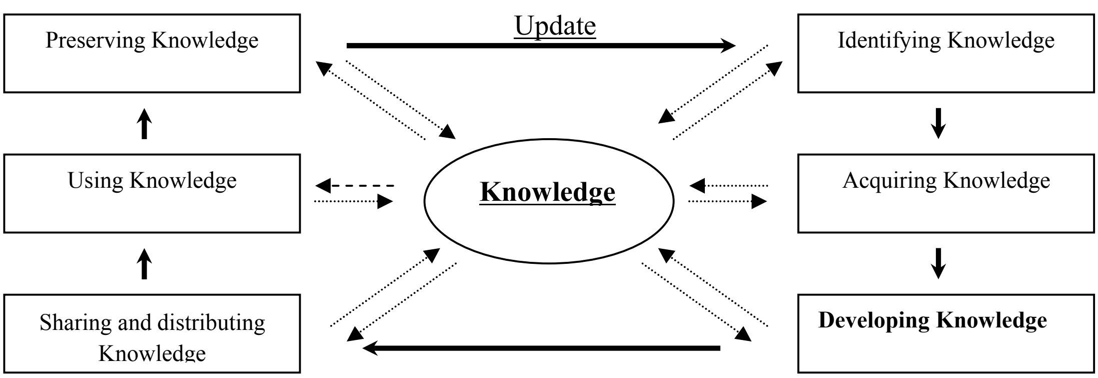
Develop knowledge: A genius is ordinarily 10% inspiration and 90% perspiration. Traditionally, companies use the department of research and development to create new procedures, new products, and more efficient management. In fact, knowledge exists in all areas of the company. High performance teams can bring new management procedures during their problem-solving processes. An employee can bring new and better ideas by his/her creativity. Because of this, companies need to stimulate internal experts' knowledge in order to build new expertise.

Share and distribute knowledge: Sharing and distributing knowledge is getting the knowledge to the right place. In an organization, knowledge sharing is a crucial part of knowledge management to achieve a successful business. Of course, managers should encourage employees to share the knowledge. Indeed, using an electronic device to create knowledge networks can improve the capability of knowledge distribution.

Use knowledge: One of the purposes of knowledge management is utilizing knowledge to benefit the organization. "Knowledge is of no value if it is not applied." For this reason, managers should inspire employees to use knowledge. Further, eliminating the organizational boundary and individual barrier also increases the utilization of knowledge.

Preserve knowledge: Knowledge is an important asset as memory of a company. While employees or experts leave companies, they will take their knowledge and experience away. Consequently, companies will lose employees' skill and experts' knowledge. Therefore, organizations need to find an effective and efficient method to preserve knowledge.

Figure 3: The Process of Knowledge Management



Findings

The combinative model of BCP

To develop a comprehensive BCP, the first challenge is to get the right information. The knowledge base is a good resource that includes individual and organizational knowledge. To create a knowledge base of BCP, companies should set contingency planning policy, form a contingency steering committee, map the existing knowledge of BCP, and involve senior management. Surely, using outside experts and involving stakeholders in BCP are also good ways to develop a knowledge base. Moreover, to find and locate the right knowledge, companies should analyze the existing infrastructure to determine what is the business impact and what is the cost-benefit of counter measures.

The second challenge for developing BCP is getting the information to the right people. To accomplish this task, organizations need to know how to share the knowledge of BCP in order to determine what is the scope and objective of BCP, to develop risk reduction measures and a disaster recovery strategy, and to create emergency response procedures. Further, applying collaborative technology such as a message system and a video-conferencing network can improve the implementation of command, control, and communication in organizations. Of course, delegating the right person to handle an emergency is also a key issue for BCP to address. As a result, a knowledge network from internal employees or external consulting companies can improve the distribution and implementation of BCP.

The final challenge for BCP is getting the right information to the right people at the right time. Certainly, training, exercising, and testing can evaluate BCP to make sure that the right information sends to the right people at the right time. Indeed, they also can increase the utilization of knowledge of BCP to benefit the organization. In order to increase the utilization of knowledge managers should eliminate the organizational boundary and individual barrier. In addition, to prevent BCP to become outdated and to protect the loss of valuable assets, managers should preserve, update, and maintain BCP by using a wide range of storage media.

Figure 4 shows the combinative model of BCP. Table 2 shows the detail of the combinative model of BCP.

Figure 4: The Combinative Model of BCP

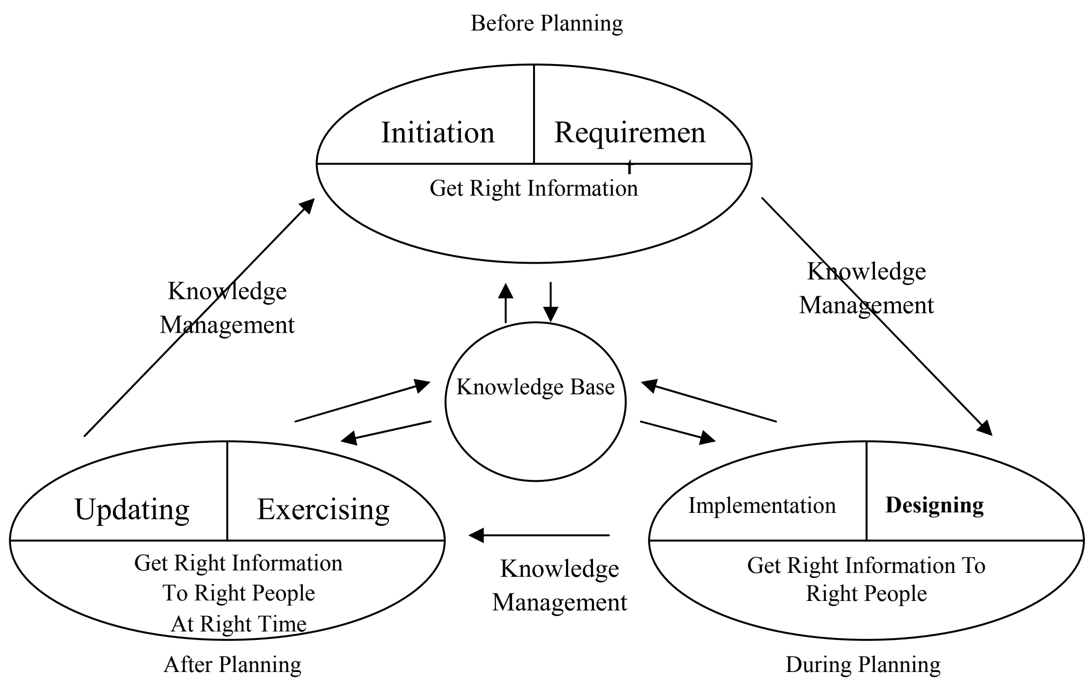


Table 2: The Detail of the Combinative Model of BCP

Get the Right Information	
Initiation Phase	Create Knowledge Base of BCP
	Set Planning Policy
	Form Steering Committee
	Map the Existing Knowledge of BCP
	Involve Senior Management
Requirement Phase	Risk, Business Impact, and Cost-Benefit Analysis
Get the Right Information to the Right People	
Designing Phase	Scope and Objective
	Risk Reduction Measure
	Disaster Recovery Strategy
Implementation Phase	Procedure Development
	Command, Control, and Communication
	Delegation and Resource
Get the Right Information to the Right People at the Right time	
Exercising Phase	Education and Awareness
	Training and Plan Testing
	Eliminate Organizational Boundary and Individual Barrier
Updating Phase	Preserve, Review, and Change Plan

Conclusion

The strategies for business continuity that involves organization, process, and technology are protecting intellectual and tangible facilities, employees, and customers. In a business, organization, process, and technology are three key elements. Building a successful business requires managers to form these elements. Certainly, knowledge management can achieve this goal to integrate organization, process, and technology as a circle.[6] Likewise, to provide business continuity, a good BCP will apply technologies to rebuild and restore organizational processes in order to recover organizations. As a result, applying knowledge management to BCP is a method to ensure business continuity, to improve the capability of emergency response, and to secure the company's intellectual assets.

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Acknowledgments

The author wants to thank Prof. John Harrald and Prof. Annie Green in the George Washington University.

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HOW TO DESIGN, DEVELOP AND IMPLEMENT A SUCCESSFUL BUSINESS CONTINUITY PROGRAM

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Key Words: Crisis, Continuity, Planning, Hazard, Vulnerability

Abstract

Most organizations plan for business success. Yet, few plan for the potentially devastating effects of an event that becomes a crisis. Crises can take many forms; being prepared can be the most effective tool you can employ to assure the survivability of your business.

Connectivity, Speed and Intangible Values are the new driving forces in business today. Traditional business boundaries are blurring as everyone becomes electronically connected. The traditional rules governing the conduct of business are blurred as businesses are redefined, products become services, services become products and business lines change constantly.

As business change accelerates, it is getting more and more difficult for traditional strategists to achieve an accurate focus on the current situation. Strategy, in the traditional sense, is outdated before it can be implemented. Speed, operating at real time, is pushing traditional strategy development, forecasting, competitive intelligence collection and analysis to new limits. For every organization vision, mission and values are important. They shape strategy for the organization. Strategy in turn, is influenced by information in the form of competitive intelligence. Competitive intelligence shapes vision. Due to the speed of business in the modern organization, crisis is prevalent. Every crisis is a violation of vision, mission and values. Every crisis solution demands a modification, if not wholesale reworking, of strategy (vision, mission, values) and competitive intelligence activities. As the strategy and competitive intelligence disciplines come under more scrutiny, the need for a comprehensive crisis management system becomes paramount.

An effective, and well adhered to, business continuity management system provides value for the organization, by allowing it to adapt to the rapidly changing business environment we are faced with today. The speed of response to an event will determine the outcome, either positive or negative, for the organization. The ability to connect all of the elements in an organization during an event is essential for the success of the response. The value achieved through an organized management and response effort to an event is measured by the intangibles: perception, information, relationships, loyalty; it cannot be seen and often it cannot be measured.

Where's your next event crisis coming from? Learn about the key elements for developing an effective crisis management program for your organization.

Introduction

Companies are quickly learning it is important to have a Business Continuity Plan (BCP) in place to both prevent and respond to a variety of calamities that have the potential to create significant business interruption. The challenge for many companies is to determine what kind of Business Continuity Plan they should develop. Many companies will arrive at the answer to this critical question through a series of false starts, trail and error. Other companies often arrive at the answer by first defining what they mean by "*normal*" business operation, identifying the level of business interruption the company can sustain before its survival is threatened and identifying what "*recovery*" should look like for the company. Recovery can be defined as the ability to operate well enough to meet current obligations to one's clients at a level that is acceptable to clients, suppliers, vendors, business partners, your organization and to protect the life safety of your employees.

The ability to effectively respond to and manage the consequences of an event in a timely manner is essential to ensure your company's survivability in today's fast paced business environment. With the emergence of new threats, such as cyber-terrorism and bio-terrorism; and the increasing exposure of companies to traditional threats such as, fraud, systems failure, fire, explosions, spills, natural disasters, etc. an "*all hazards*" approach to Business Continuity Planning may be your best answer. The "*all hazards*" approach, as presented herein, is based on the concept of graceful degradation and agile restoration. By "*graceful degradation*" I am referring to the ability of your organization to identify the event, its consequences, establish minimal stable functionality, devolve to the most robust less functional configuration available in the least disruptive manner possible and to begin to direct initial efforts for rapid restoration of services in a timely fashion. The "*all hazards*" approach embraces consequence management as a key driving force.

Assumptions

Before we can discuss the elements of an "*all hazards*" Business Continuity Plan, some basic assumptions need to be presented. These basic assumptions, once established, will form the framework for the "all hazards" approach.

Assumption # 1: Businesses are complex systems operating within multiple networks
As depicted in figure 1, entitled, "Connections and Interdependencies", modern businesses are complex systems. These complex systems consist of five essential elements of analysis (EEA). The essential elements of analysis (EEA) are human resources, information resources, equipment and facilities. Each of these EEA can be further sub-divided into sub-units that provide measures of effectiveness (MOE) that can be further sub-divided to determine measures of performance (MOP). This subdivision can be continued to the level of raw data.

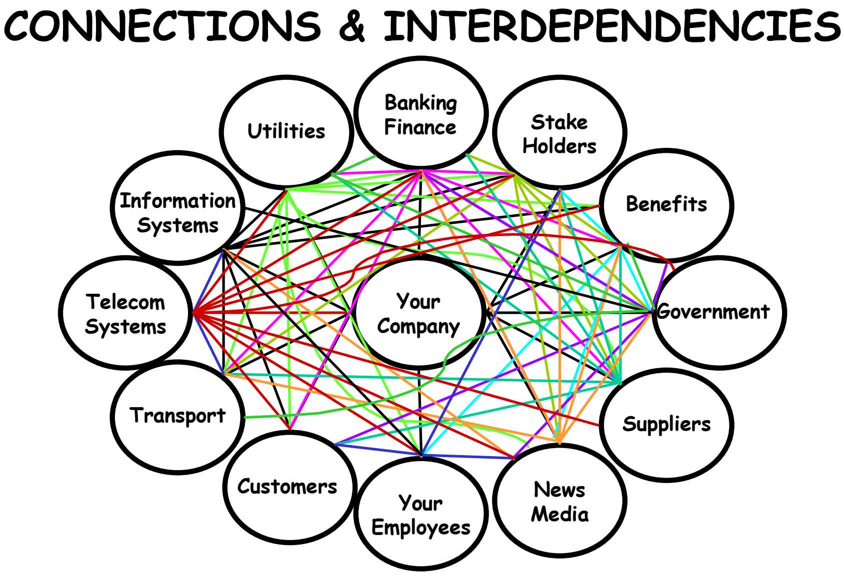
Assumption # 2: there are many layers of complexity
The complex business system can be viewed as being layered, wherein the outer layer is full functionality and the inner core is minimal stable functionality.

Assumption # 3: Due to complexity, analysis of event consequences is critical
All of a system's touch points within a given network must be considered in order to effectively evaluate vulnerabilities, threats, risks, hazards and determine the effects of degradation

Assumption # 4: actions need to be coordinated
Each company's actions within the network will be inadequate unless the entire network responds in kind.

Assumption # 5: Resources and skill sets are a key issues
Most companies lack the resources and specialized skills to know what to do to maximize positive network effects.

Figure 1: Connections and Interdependencies



The Facts

The following facts must be considered when developing an "*all hazards*" Business Continuity Plan.

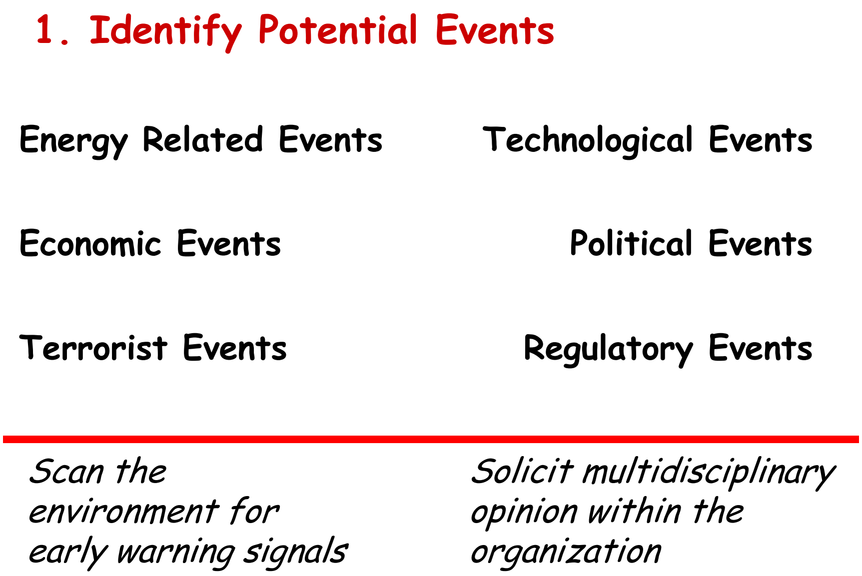
- Events that have been building since the end of World War II, including thousands of terrorist attacks on innocent civilians worldwide, have culminated (so far) in vicious and indiscriminate attacks first by domestic terrorists and now by foreign terrorists on the United States homeland.
- America is not immune from terrorism. Quite the contrary, we are a target rich environment for both domestic and international terrorists. The stakes are high, and the issues are indeed, life, death and economic survival.
- Terrorists are driven to kill people and to destroy property.
- All people and all facilities/operations, and therefore all companies are at risk.
- Priority terrorist targets are those of monetary or strategic value, having high human density and with cultural or symbolic value.
- Corporate headquarters of major corporations are prime targets.
- Corporations must take responsibility for their survival. Most of what has to be done in the corporate environment must be done by the corporation. Indeed, it is the corporation's responsibility to its people, stakeholders and to the public that relies on its products and services.
- Government, on the other hand, must concentrate its efforts on ensuring the protection and preservation of "critical infrastructures" essential to the nation's continued well being. These infrastructures are electric power supplies, gas and oil, telecommunications, banking and finance, transportation, water supply systems, emergency services and continuity of government.

- Corporate America must act now to make key assets (human resources, information resources, equipment and facilities) unattractive targets for terrorists. Failure to do so is be vulnerable to an attack.
- An "*all hazards*" approach to Business Continuity Planning will provide the most effective use of resources, can facilitate risk reduction and minimize the potential disruption to the complex network structure of modern business.

"All Hazards" Business Continuity Planning

The first step in preparing the "*all hazards*" Business Continuity Plan is to determine your organization's exposures. Simple as this may sound determining exposure is a complex process. In order to properly assess your organization's exposure you need to effectively evaluate vulnerabilities, threats, risks, hazards, and determine the effects of degradation to your organization. Figure 2, entitled, "Determining Exposure", provides an example of the initial actions that need to be taken in developing the "*all hazards*" Business Continuity Plan.

Figure 2: "Determining Exposure"



Ask yourself, in your opinion, what would be the ten most devastating surprises for your organization and its operations? In conducting this assessment a variety of scenarios need to be developed to assess the short term, intermediate term and long term effects of a disruption. This assessment should consider the following key factors as depicted in the Table 1, entitled, "LMS' CARVER Analysis Elements." The first element is "Criticality". A determination as to the criticality of the service, product, etc. being supplied via the value chain is essential, if you are going to adequately assess the potential risk exposure. Once criticality is established, an assessment of "Accessibility" is necessary. "Accessibility" refers to how easily one can get access to an Essential Element of Analysis (EEA).

One needs to assess the accessibility to the EEA, the accessibility to and of alternatives that can be substituted and the accessibility of the EEA to disruption. Once "Criticality" and "Accessibility" are established, you need to determine "Recognizability". That is, how readily recognizable is the

EEA with respect to its loss from your organization's value chain. If I am targeting your organization, I am going to look at readily recognizable EEA's that can be accessed and are critical to your operations. Once the first three items' weighting parameters are established, one must determine the "Vulnerability" presented by the potential loss of the EEA in your value chain. For example let's say you are a distributor and are concerned over critical inventory.

Your information systems may be able to accurately depict your inventory. However, if you were to lose access to your inventory supply location or ability to move the inventory to market it would not matter how accurately you could determine the level of inventory, as you and your customers would not be able to access the items. A "Vulnerability" can therefore be defined as the potential for any degradation, interruption or non-recoverability to such an extent that the consequence is likely to result in harm to the organization, harm to others (suppliers, customers, etc.) and/or substantial negative financial impact. A "Vulnerability", therefore, can arise from a: false ASSUMPTION; blocked or altered COMPONENT; blocked or altered FUNCTION; or blocked or altered OPERATION.

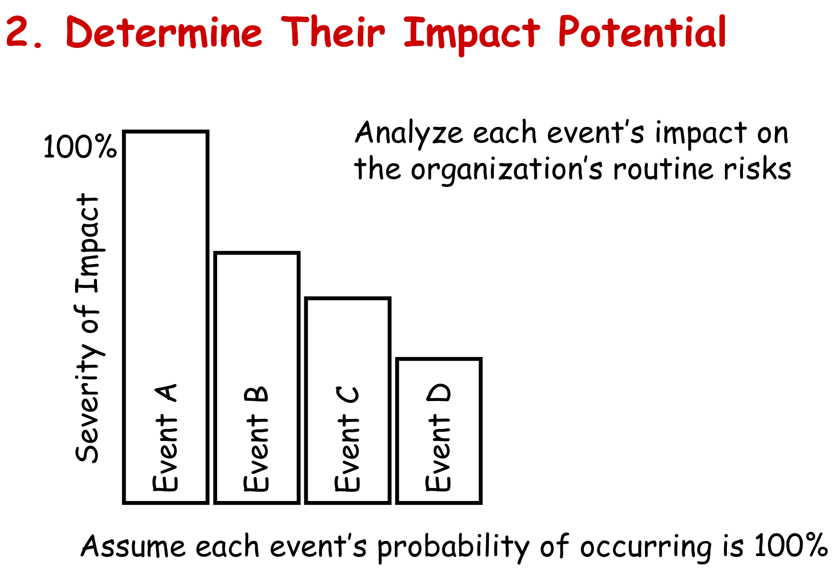
Once you have established, "Criticality", "Accessibility", Recognizability and "Vulnerability" you must determine the "Effect" of the loss of the value chain item. "Effect" can and will generally be associated to the impact of the loss. However, one must consider all aspects of "Effect", there can and may be some positive "Effect" that can arise from the loss or interdiction of the value chain. Lastly, one must determine the "Recouperability" aspects associated with the potential loss or disruption. How resilient is my organization? Can we quickly respond to, manage and recover from a disruption of the value chain? The net result of conducting a "CARVER Analysis" is to be able to determine the potential significance of an event from a consequence management perspective.

Table 1: LMS' CARVER Analysis Elements

LMS' CARVER Analysis Elements
C = Criticality
A = Accessibility
R = Recognizability
V = Vulnerability
E = Effect
R = Recouperability

Once exposures are determined and the CARVER Analysis is conducted, you should have a rank ordering of potential events, or a record of your worst nightmares if you care to think of them in that context. The next step is to put these "*nightmares*" into perspective. Figure 3, entitled, "Determine Potential Impact", depicts the rank ordering of potential events and their worst case outcomes. In analyzing each event's impact on your organization's routine risks and touch points within the network your company operates in, you can begin to develop the focus for the "*all hazards*" Business Continuity Plan.

Figure 3: Determine Potential Impact



Upon conclusion of this step you should have developed decision making model similar to the one depicted in Table 2, entitled, "Decision Making Model".

Table 2: Decision Making Model

#	PROCESS STEP	END POINT RESULT
1	DEFINE THE DECISION	Describe what you need to decide
2	State Alternatives	Compile a list of decision alternatives
3	What are the Objectives	Compile list of desired objectives. State them in terms of what is preferred by you in the final outcome
4	Which Alternatives best meet the Objectives	Evaluate each objective. Rank alternatives, one relative to another, by your opinion as to how well each would meet a single objective. Create a ranking (A = best, B = second best, etc.)
5	Which Objectives are most important	Judge the value of the objectives using the same ranking system
6	Apply Relative Value	Combine judgment steps 4 & 5
7	Identify Best Choice	Add numbers across each row for alternatives
8	Make Decision	Review results; satisfy yourself that these are your best judgments

As you apply the Decision Making Model that you have developed, you should be able to develop a summary of potential events, probability of occurrence and potential impact on your organization. Table 3, entitled, "Disaster Exposure Rating Chart", depicts this product. The following chart summarizes the risks and/or threats to continuation of critical business functions considered relevant to the development of the "*all hazards*" Business Continuity Plan. The risks identified encompass the categories of **natural, technical** and **human** threats. For each risk, an estimate of the impact on critical business functions should be determined in terms of probability, impact (High, Medium, Low) and effect (Long or Short Term).

Table 3: "Disaster Exposure Rating Chart

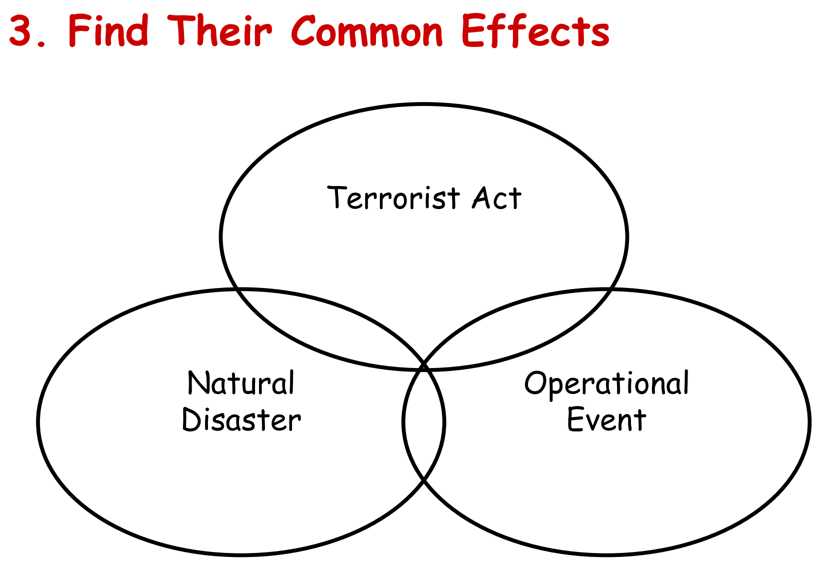
Risks/Threats	Probability	Impact	Effect
BOMB THREAT			
Customer Injury on Premises			
Data Entry Threat/Employee Error			
Disruption of Courier/Delivery Service			
Earthquake			
Explosion			
Fire			
Fraud/Embezzlement			
Heating/Cooling Failure			
Kidnapping/Extortion			
Lightning			
Loss of Critical Personnel			
Natural Gas Leak/Carbon Monoxide			
Power Failure			
Robbery/Assault			
Snow/Ice			
Software Failure/Virus			
Tampering with Sensitive Data			
Telecommunications Failure			
Terrorist Act			
Tornado/Wind Damage			
Unauthorized Access/Vandalism			
Water Damage/Rain Storms			
Weapons of Mass Destruction Event			
Workplace Violence			

The next step in the "*all hazards*" development process is to find the common effects that these events would trigger. As depicted in Figure 4, entitled, "Determining Common Effects", and by using LMS' CARVER Analysis tool, one can begin to determine effective strategies for event response, management, mitigation and recovery of business operations.

Once common effects are determined, developing response strategies can be accomplished. When determining response strategies consideration must be given to obtaining necessary information, determining priorities and values and preparing options for addressing the effects of an event. As depicted in Figure 5, entitled, "Develop Responses", this process entails the answering of six key questions. These questions are:

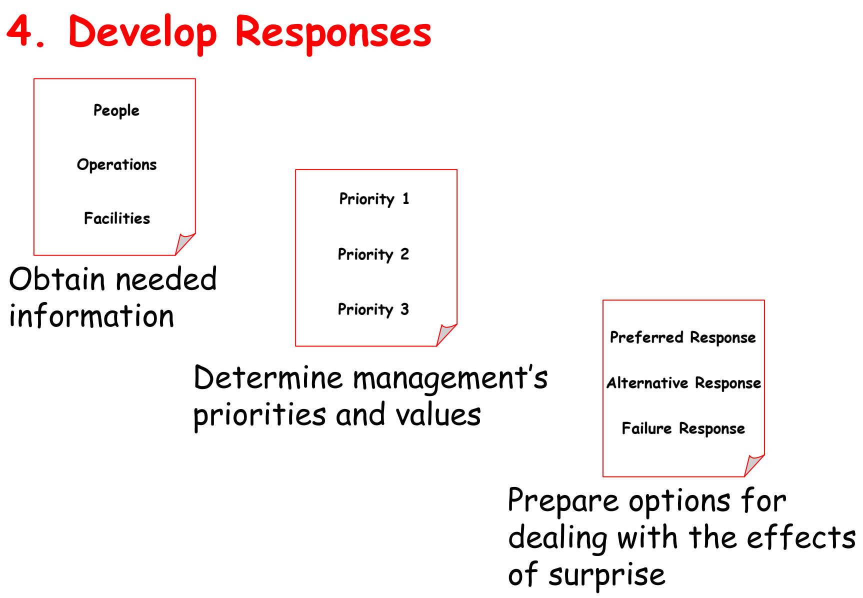
- **STRATEGY**: What are we committed to?
- **CONCEPT OF OPERATIONS**: How will we fulfill this strategy?
- **STRUCTURE**: Do we have the organizational structure that fits our needs?
- **RESOURCE MANAGEMENT**: How will we manage our resources (human, equipment, information, facilities)?
- **CORE COMPETENCIES**: What skills does our organization possess?
- **PRAGMANTIC LEADERSHIP**: How will we optimize authority, decision-making, workflow and information sharing?

Figure 4: Determining Common Effects



Answering these questions is not as easy as it seems. One must realize that in developing the "*all hazards*" Business Continuity Plan, certain commitments are going to be made. Fulfilling these commitments is critical to the success of the "*all hazards*" plan.

Figure 5: Determining Responses



A key point to remember is that response reflects experience. Your organization will respond to events based on its experience in dealing with similar situations. It is therefore imperative that you consider the new threat environment that we are faced with today in determining the response options that you choose for the "*all hazards*" Business Continuity Plan.

"All Hazards" Planning Elements

Once you have accomplished the initial analysis and strategy determination phases, you are ready to begin to create the "*all hazards*" Business Continuity Plan documentation. Documentation of your efforts is critical to your success. You need to continually reinforce the concept of complex systems operating in a network as you develop the written elements of your plan. While there is no prescription for the contents of the plan, I have found that the following elements seem to be common to all plans in varying degrees of detail. These common elements are depicted in Figure 6, entitled, "Common Planning Elements". A brief discussion of each of these elements follows.

Figure 6: Common Planning Elements

Key Elements for Continuity

Event Response/Management

Facilities Activation

Resumption of Critical Processes

Sustained Response/Management

Infrastructure Restoration

Public, Investor, Media Relations

Operations, Information Recovery/Synchronization

Full Function Restoration

Permanent Restoration

Maintaining Preparedness

- **Event Response/Management**: Critical to the success of the "*all hazards*" BCP is the ability to respond and manage an event. Initial response to an event is a critical success factor. How your organization responds and communicates this response throughout the organization and its network is one of the determining factors in how well you will manage subsequent phases of the disruption. This portion of the "*all hazards*" BCP should be designed to provide guidance for key personnel to prepare initiatives for early response to an event affecting the organization and its assets. The primary mission of event response is to assess, evaluate, contain the event and seek to control the outcomes of the event. Total management support through all stages of the event response/management process in order to minimize the adverse impacts of a business interruption to the organization is a critical success factor. As such, a seamless vertical and horizontal communication system based on common terminology and streamlined communication contact needs to be developed to underwrite the BCP. In order to facilitate communication common terminology should be developed for such things as how the organization defines an event, classifies its severity and determines response options. Remember that these definitions need to go beyond the organization and include the network that the organization operates in.

- **Facilities Activation**: Once activated where does the organization conduct its operations? Your plan needs to address the activation of facilities for the overall management of the event, the provision of technical support, business systems relocation, rumor control, and media management to name but a few.
- **Resumption of Critical Business Processes**: Based on the use of LMS' CARVER Analysis and assessments that you have conducted, you will have established a list of critical business functions. You need to determine how you will re-establish your critical business processes. Table 4, entitled, "Phases of Response", depicts common activities to consider when identifying and determining the critical business processes that need to be resumed.

Table 4: Phases of Response

Phases of Response	**Activities**
Initial Response	Incident Notification & Incident Response Activation of CMT. Declare "Crisis" by level of severity
Sustained Response	Command Center Activation. Business Impact Analysis. Recovery Planning.
Recovery Phase 1	Assessment of Actual Damages/Impacts. Identification of Critical Processes and Critical Infrastructures
Recovery Phase 2	Restoration of Critical Processes. Infrastructure Restoration. Info/Ops Recovery/Synchronization
Deactivation/Termination	Full Function Restoration. Permanent Restoration Deactivate & Terminate "Crisis" level of severity

The timeframe of each phase may vary widely, dependent on the event and the resources available to respond to the event. For the purposes of discussion the following timeframes are used as a baseline. The timeframes depicted in Table 5, entitled, "Response Timeframes", are used as guidelines only. Each event should be addressed separately, according to the impact and assessed effects as determined by your organization.

Table 5: Response Timeframes

Response Timeframes	Estimated Duration
Event	One (1) Day
Command Center Activation	One (1) Day
Initial Response	Three (3) Days
Restoration of Critical Processes	Twenty (20) Days
Infrastructure Restoration	Thirty (30) Days
Info/Ops Recovery/Synch.	Twenty (20) Days
Full Function Restoration	Forty Five (45) Days
Permanent Restoration	Ninety (90) Days

Assuming an event lasting approximately one day with an event response lasting approximately three days, an organization should be able to begin Command Center activation (assuming availability of Command Center location) on or about day one. With the additional activation of "Hot Sites" for information technology functions and facility relocation operations, this process is estimated to last approximately five days before the all sites are fully activated and operational. At day five of the "Crisis" the restoration of critical processes is begun. This assumes that critical processes are identified and access to the affected area to accomplish surveys and determine the level of degradation of critical processes. Critical Processes should be operational by day twenty-five of the "Crisis". Commencing parallel to the restoration of critical processes is Information/Operations Recovery and Synchronization. The recovery of information/operations and subsequent synchronization assumes that loss data can be identified, backups are accessible, and access to the affected area is available to determine the amount of loss. Information/Operations Recovery and Synchronization should be accomplished by day twenty-five of the "Crisis". Infrastructure Restoration should be accomplished by day forty-three of the "Crisis", assuming access and availability to required non-Company resources. By day forty-five of the "Crisis", Full Function Restoration can be completed, assuming that Restoration of Critical Processes, Infrastructure Restoration, Information/Operations Recovery/Synchronization have been accomplished or are well underway. Permanent Restoration may take up to ninety days or longer. If the Permanent Restoration process is started by day seven of the "Crisis", it should be accomplished by day ninety-seven.

- **Sustained Response/Management**: Critical to your ability to successfully execute your "all hazards" BCP will be sustaining response and management efforts. In order to sustain response and management functions your organization must take control of the event. Until you are able to take control of the event, your organization will be in a constant state of reaction. Figure 7, entitled, "Elements of Response", depicts some of the key aspects that must be achieved in order to sustain response and management functions.

Figure 7: Elements of Response

Pre-Incident	Reactive	Proactive
Preparation	**Initial Response**	**Sustained Response**
Analysis	Chaos Control	Sustain & Augment
Planning	Identification	Specialize Teams
Resource Identification	Defensive Actions	Offensive Actions
		Forward Planning
Training	First Response	Resource Management

It should be noted that in today's business environment we are seeing a change in the response paradigm. As business change accelerates, it is getting more and more difficult for traditional strategists to achieve an accurate focus on the current situation. Strategy in the traditional sense is outdated before it can be implemented. Speed, operating at real-time, is pushing traditional strategy development, forecasting, competitive-intelligence collection, and analysis to new limits.

Vision, mission, and values are important for every organization. They shape strategy for the organization. Strategy, in turn, is influenced by information in the form of competitive intelligence. Competitive intelligence shapes vision. Due to the speed of business in the modern organization, crisis is prevalent. Every crisis is a violation of vision, mission, and values. Every crisis solution demands a modification, if not wholesale reworking, of strategy (vision, mission, values) and competitive-intelligence activities. As the strategy and competitive-intelligence disciplines come under more scrutiny, the need for a comprehensive business-continuity management system becomes paramount.

The ability to sustain the response to and management of an event provides value for the organization, by allowing it to adapt to rapidly changing situations. The speed of response to an event will determine the outcome, either positive or negative, for the organization. The ability to connect all the elements in an organization during an event is essential for the success of the response. The value achieved through an organized management and response effort to an event is measured by several intangibles: brand image, perception, information, relationships, and loyalty to cite a few. These intangibles cannot be seen, and often, they cannot be measured.

- **Infrastructure Restoration**: Internal and external infrastructure is important to an organization's success during normal operations. Infrastructure is essential to an organization's success during an event. The problem that most organizations face is relatively simple. Your organization does not control, to a great extent, the infrastructures that contribute to the success or failure of event response. Cited earlier were critical infrastructures that have been designated by the Federal government as essential to maintaining national security. These very same infrastructures are essential to your organization's business survival. To briefly recap, they are electric power supplies, gas and oil, telecommunications, banking and finance, transportation, water supply systems, emergency services and continuity of government.

  In order to assure infrastructure restoration in a timely manner, an organization needs to determine the capability of its network to address the restoration of the above identified critical infrastructures and to assess and determine the effort required to restore its internal infrastructure. Without infrastructure an organization is on a path to failure.

- **Public, Investor, Media Relations**: Stakeholders are those that have a vested interest in your organization's success in responding to and managing an event. If this element is not addressed as a part of your current business continuity planning effort, make it a priority to address. The "*all hazards*" concept includes the "*crisis media*" element as an integral part of the overall plan. An inadequate response to the external stakeholders by your organization can negate an effective response.

  The phrase "*Perception is reality*", is never more true that when your organization is under public scrutiny. In order to address this planning element, it has to be addressed early on in the planning process. The following list is an example of stakeholders that need to be considered as you develop your organization's "*all hazard*" BCP.

- **Operations, Information Recovery/Synchronization**: Because of the tremendous importance placed on information management in today's business environment a great deal of emphasis is placed on recovery and synchronization of information systems. Similarly, the same amount of emphasis should be placed on getting operations recovered and running. Most businesses do not do this. It is assumed that the operational portion of the organization will recover.

In today's threat environment this is not the case. It is imperative that the organization seeks to recover and synchronize its operations and information systems. This can be a very daunting task for many organizations. Consider the implications of inventory, transportation, facilities, equipment and you begin to see the need to address operations as strongly as you address recovery and synchronization of information systems.

♦ **Full Function Restoration**: The resumption of business operations following the mitigation of an event requires a transition from response/management to re-entry and recovery. The recovery organization requires different skills and has a different perspective that the response and management organization. Effective recovery planning should be part of your initial planning effort. One of the main goals of your "*all hazards*" BCP should be making effective preparedness activities a way of doing business not an adjunct to the business and/or to a business disruption.

You must address recovery operations in your business planning documents. It is too late to start after the incident has occurred. "How can I know what to plan for?" might be a question that comes to mind as you read this paragraph. Well, if you have performed an effective hazard, vulnerability and risk analysis you should be able to say, "I've got the basis for my recovery planning here in front of me."

What Constitutes a Good Recovery Plan? Herein lies a quandary. A good recovery plan for what? A corporate office complex? A community? A plant site? The list can go on and on. Perhaps we should consider the following definition for recovery planning/post-incident operations before we bound off on the key elements of effective recovery planning.

> **Recovery/Post-Event Operations:** *All operations designed to support the termination, reentry, recovery and humanitarian assistance requirements arising from an event. This may include, but is not limited to: establishing a Recovery Organization, addressing the transition of the response and management organization into an organization focused on reestablishing the primary/normal function of the organization.*

Recovery or Post-Event Operations begin when the event has been brought under control. Notice I did not say "mitigated" or "terminated". "Control" is the operative word. Once you have gotten ahead of the event, you can begin to start refocusing your resources and channeling them to post-event related issues. The key elements for effective recovery planning are Effective Hazard Analyses, Recovery Organization, Recovery Pre-Plans, Strategic Focus, Human Factors Considerations and Superior Communications Capabilities.

Once full function is restored your organization can begin to think about getting back to business as usual.

♦ **Permanent Restoration**: Permanent restoration is accomplished when the organization determines that it is operating at the same level or acceptable levels to declare the event terminated. Generally, the business operations and information systems are synchronized and the organization is capable of normal (pre-event) business activities. During the permanent restoration phase, an assessment should be made to determine performance parameters and to re-evaluate vulnerabilities, threats, risks and hazards. The assessment should also evaluate business network considerations.

♦ **Maintaining Preparedness**: The process of business continuity planning is unending. Once developed, the BCP must be constantly evaluated, updated and maintained current. Part of this process is the development of the human resource component of the organization. A trained and educated workforce can do more to protect your enterprise than you can imagine. Training of personnel is a critical component of the "*all hazards*" approach to business continuity planning. Training and educating your personnel at all levels is one of the critical success factors that must be addressed if an adequate response to an event is to be achieved. A "*Systems*" approach to preparing effective training programs should consist of:

- ***Task analysis**:* When designing an integrated training program, first determine the skills, knowledge, and procedures required for satisfactory performance of each task.
- ***Lesson Development**:* Learning objectives are defined from the skills, knowledge, and procedures developed during task analysis. Instructional plans are then prepared to support the learning objectives.
- ***Instruction**:* Lessons are systematically presented using appropriate instructional methods. Instruction may include lecture, self-paced or group-paced mediated instruction, simulation and team training.
- ***Evaluation**:* Performance standards and evaluation criteria are developed from the learning objectives. Each trainee's performance is evaluated during the course and during field-performance testing.

In addition to formal training programs, a program of proficiency demonstration to validate the training and content of plans is also needed. This can be accomplished by establishing a program that supplements the training with simulations (drills and exercises).

Consider developing programs to educate your employees on basic life safety (first aid, CPR, Evacuation, Assembly, Accountability), what to do if an event occurs and what to do after the event. In addition, a community outreach program can provide your organization with many benefits.

A community outreach program can enhance coordination with local emergency response and law enforcement agencies, put your organization in a positive light in the community and provide your employees more information on community resources.

You cannot stop at classroom training and expect your organization to respond effectively to an event. Corporate America needs to assess how prepared it is to deal with workplace events. The government must focus its attention on the protection of critical infrastructures and international issues.

Corporate America has to address protective measures that ensure its survival; it cannot depend blindly on the government to be there for assistance. Being able to respond appropriately will be essential, however, responding without the proper equipment can lead to failure. You need to equip your workforce with the appropriate emergency response equipment, such as first aid kits, fire extinguishers, event response kits, and evacuation, assembly, accountability procedures.

You should also understand that when you purchase the equipment and train your personnel on its use, you have to develop and implement a maintenance program to assure that the equipment is there and that it works when it is needed.

Critical Functions in the "All Hazards" BCP

The ability to implement the "*all hazards*" BCP concept is based on a flexible plan and a focus on critical functions to be performed, not on organizational line an block type charts. An organization must address the development of a response/management and recovery organization based on performing critical functions during and after an event. This may be the most difficult task for an organization to accomplish, especially with reorganization and down-sizing to contend with.

The critical functions that an organization must address can be categorized into eight areas. Figure 8, entitled, Critical Functions", illustrates these. A brief discussion of each function that must be address is provided herein.

- **Management**: Someone has to be in-charge. However, the organization needs to determine who and at what level and in-charge of what. This leads us back to our six key questions. Recall the last question, regarding the optimization of authority, decision-making and information sharing? The Management function has to address this issue. Without effective decision-making, optimization of authority and information sharing chaos has an excellent chance of prevailing.

  Some of the key Management functions that need to be addressed are optimization of authority, decision-making, communication, assessment of event conditions and classification of the event as to severity. Other Management functions should focus on determining legal requirements and identifying issues that need to be resolved. Management is never put more strongly to the test than in a crisis situation. The objectives are immediate and the results have long term implications. Today, individuals responsible for the management of businesses and public agencies must be prepared to deal effectively with threats that could not be conceived of prior to September 11, 2001.

Figure 8: Critical Functions

Critical Functions

Management	Logistics
Planning	Finance
Operations	Administration
Infrastructure	External Relations

Once the Management function is defined, the next area to address is the Planning function. The Planning function embraces, long-term strategic planning, as well as, short-term tactical planning. Incorporated in the Planning function should be an analysis of competitive intelligence with regards to the information that your organization may potentially give up as a result of how it responds to and manages the event. Most of the value-added in business today is created by knowledge-based service activities, such as research and development, marketing research and customer information to cite a few. The development and implementation of a Strategic Plan charts the course your organization will use to move into the future. Mission, vision and values are reflective of Strategy. Competitive Intelligence, the acquisition and/or denial of information, is an integral part of the Strategy process.

Business Continuity Planning (crisis management in a broad sense) is the ability to deal effectively with events that threaten the operation of business, is an integral part of the Planning function.

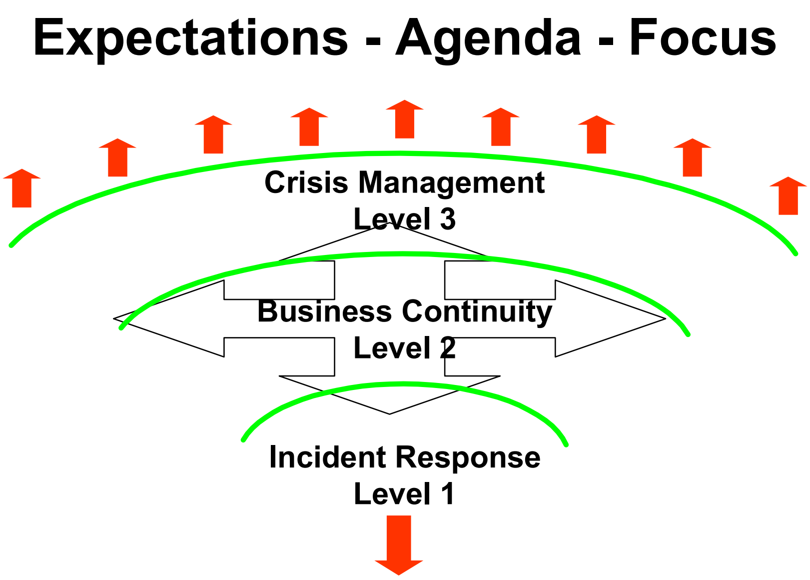
Vision is important to organizational success. Competitive Intelligence shapes vision. Crisis is prevalent in modern organizations. Every crisis your organization experiences is a violation of Strategic Vision. Every crisis therefore demands a modification of Strategy and Competitive Intelligence Initiatives.

- **Operations**: Once the Management function and the Planning function are addressed, the Operations function must be considered. The Operations function is relatively straightforward. This function must take in to account affected operations and unaffected operations. The focus should be on event mitigation, support of response operations, preventing the event from cascading and continual evaluation of options.
- **Infrastructure**: With today's dependence on internal and external infrastructures, it is important to designate this a critical function with the BCP. The Infrastructure function should consider all available internal and external infrastructure requirements. A close liaison with external infrastructure providers should also be addressed by this function.
- **Logistics**: The old saying is, "An army lives on its stomach", or some words to that effect. This is true with your organization and its ability to respond to an event. The Logistics function should address the short-term needs of the organization and any long-term needs that the organization requires. These include, but are not limited to, equipment needs, facilities requirements, human resource needs, housing (temporary and long-term), and communications needs.
- **Finance**: Establishing a cost tracking system to determine how much is being spent and where it is being spent is important to the long-term survival of the organization. During an event unchecked costs can cripple an organization. Delays in getting financial resources to involved entities can cause the response, management and recovery efforts to grind to a halt. The Finance function should be focused on establishing a streamlined finance and accounting system that can track expenses and expedite payments.
- **Administration**: The Administration function should focus on resource management, documentation and other administrative aspects. Often overlooked as a critical element, the Administration function provides tremendous support to the success of response, management and recovery efforts. And, as someone once confided to me, "they know how everything works!"
- **External Relations**: The External Relations function serves as a liaison to all entities with a vested interest in the organization's response, management and recovery from the event. Often restricted to media relations, this function should be expanded to perform liaison and information sharing with all stakeholder entitles.

Figure 9, entitled, "Expectations, Agenda and Focus", provides an example of the various levels within an organization where the above-cited critical functions need to be tiered and replicated. At the event response level, the critical functions are primarily focused on event containment and mitigation. The expectations at this level are for assistance from the next level in the form of resources and support. The agenda and focus at this level is relatively simple – contain and mitigate the event. At the next tier or level, the expectations, agenda and focus change. The critical functions need to begin to manage upward and to address horizontal issues, such as the prevention of the cascading of the event. The expectation is to get sufficient information communicated from the event scene to enable decision-making that enables the unaffected portions of the business to continue to operate unencumbered. The agenda and focus have expanded to include longer term assessment, unaffected operations and expanded communications. At the top level, the expectations, agenda and focus are completely different than at the event level. At this level the expectations are for information that can be useful in addressing stakeholder concerns. The agenda and focus are almost totally directed outwards toward external audiences. It is critical that effective communications is part of the "*all hazards*" BCP. Seamless vertical and horizontal communications does not mean, just the ability to connect. It means that a common terminology is employed to ensure that the communications are understood by all who receive them.

As depicted in Figure 9, there are a series of waves that overlay the three levels. These waves represent the cumulative effect of an event as it ripples through an organization. It should be noted that the further away from the event the greater the effect of the wave. What this means is that the higher an event gets within an organization the greater the repercussions and effects that are felt. Again, an effective communication system based on common terminology, coupled with an effective event classification mechanism can serve to facilitate more effective response, management and recovery operations.

Figure 9: Expectations, Agenda, Focus



Concluding Remarks

In almost every instance of successful response to an event, response, management and recovery activities consisting of sound operating execution coupled with superior communication predominate.

Operational response is essential. It is the one that saves lives, property and other assets. The ability to communicate is no less important. It is the one that saves the business.

The simple fact is *perception is reality*. Public perception of your company's reaction to an event is as important as your operating response. Lessons learned from a wide range of events occurring over the past thirty years validate the need for a dynamic business continuity plan.

An effective BCP consists not only of the plan documentation, but also of the human, equipment, facilities, operations and information elements; and the critical functions that must be addressed. An effective BCP is one that: provides a shared, organized system of management; is a template for doing things right; is a comprehensive process with a common and easily understood terminology; provides effective coordination of activities among entities, early warning and clear instructions for action; and provides continued consequence assessment.

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Author Biography

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SECTION 9:

EARTHQUAKES & EXTREME NATURAL EVENTS

COLLECTION, SYNTHESIS AND QUALITY ASSESSMENT OF RESPONSE DATA REGARDING 1999 TURKEY EARTHQUAKES

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Keywords: earthquakes; human impacts; disaster response; humanitarian relief; service delivery; mass-care; emergency management; perishable data.

Abstract

Two massive earthquakes struck the northwestern part of Turkey in 1999 - the magnitude 7.4 Kocaeli earthquake on August 17th and the magnitude 7.1 Düzce earthquake on November 12th. Both earthquakes resulted in heavy casualties and displaced hundreds of thousands of people from their homes. Government and non-government organizations faced with meeting the human needs following especially the Kocaeli earthquake were overwhelmed by the demand for their services. It was essential that the data describing the service delivery activities of these organizations be collected and synthesized before these data were lost or the ability to interpret data degraded. The analysis of these data will enhance the ability to anticipate the scale of human needs (medical, sheltering, feeding, supplies) following future earthquakes in Turkey and elsewhere. This paper will summarize the process used to collect, synthesize and assess data and some of the findings from the resulted data products. The work described in the paper was funded by The National Science Foundation.

Introduction

Two massive earthquakes struck Turkey in 1999 - the magnitude 7.4 Kocaeli earthquake on August 17th and the magnitude 7.1 Düzce earthquake on November 12th. Both earthquakes were caused from ruptures of the North Anatolian fault, with the Kocaeli earthquake lasting 45 seconds and rupturing 126 km of that fault, while the smaller Düzce earthquake produced a surface fault rupture of only 39 km.

The Kocaeli earthquake resulted in 17,480 deaths, 43,953 injuries, and 66,441 collapsed or heavily damaged housing units. Estimates of losses range from $7 billion to $40 billion. An additional 763 deaths, 4,948 injuries, and 26,704 collapsed or heavily damaged housing units occurred as a result of the Düzce earthquake (Ozmen 2000).

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The August 17, 1999 Kocaeli earthquake tragically illustrated the inability to cope with the result of poorly controlled development and rapid population growth in disaster-prone regions. The price of increased vulnerability and inadequate preparedness was the loss of thousands of lives, the displacement of hundreds of thousands of people from their homes, and the economic impact of over $20 billion. Government and non-government organizations faced with meeting the human needs following the Kocaeli earthquake were overwhelmed by the demand for their services.

Research Goals and Objectives

The purpose of this effort was to identify, collect, synthesize and quality assure data describing the response to human needs following the 1999 Turkey earthquakes before these data were lost or the ability to interpret data degraded. The resulting databases have been made available on the Internet for researchers and emergency planners and can provide the basis for developing models capable of predicting the service delivery capability required to meet human needs following future earthquakes in Turkey.

The analysis of these data will enhance the ability to anticipate the scale of human needs (medical, sheltering, feeding, supplies) following future earthquakes in Turkey, the U.S. and elsewhere, and will support the development of adequate plans, procedures, and service-delivery capabilities.

These service-delivery needs are strongly determined by demographic and socio-economic factors in addition to the sustained physical damage. The estimation of service-delivery demands requires a linked set of modeling activities, data to populate the models, and expert judgment to interpret the quality, meaning, and limitations of available data. This scenario-based needs estimation is an essential precursor to the development of adequate response and recovery strategies, plans, and organizational structures.

The project had four research objectives:
1. To identify the sources of data necessary for estimating potential damage and for determining the attributes of the potential impacted population for a selected set of future Turkey earthquake scenarios.
2. To build a database describing the medical, feeding, sheltering, material distribution services delivered after the August 17 and November 12 earthquakes.
3. To assess the quality and limitations of this data.
4. To develop a preliminary conceptual model for the estimation of service delivery demands.

Loss prediction models are designed to predict the physical damage to buildings and infrastructure. This damage may then be used to predict the resulting human impacts and service-delivery needs (Perkins et al. 2000). The estimation of response requirements must be based on estimation of service-delivery demands. These demands are determined by human needs. Estimating the conditional probabilities implied by this relationship requires viable data in four distinct areas: housing damage and functionality, infrastructure damage and functionality, human impacts, and service delivery demands. Data describing the impact of 1999 Kocaeli and Izmit earthquakes provide a unique opportunity to provide the basis for populating and calibrating models that may be used to predict the service-delivery needs for future earthquakes in Turkey.

Research Procedure

Activities that responded to human needs were conducted by agencies of the Turkish central government, the provincial government, municipal governments, the Turkish Military, Turkish NGOs, international NGOs, and government teams. The project team cooperated with Turkish scientists, governmental officials, and emergency responders in identifying and collecting those data that were essential for the purposes of this project. During the study period several important data and information sources have been obtained and were used as a basis for an initial effort to build a comprehensive database.

The most useful documents were the damage statistics published by the General Directorate of Disaster Affairs of the Ministry of Public Works and Resettlement (Ozmen/GDDA 2000), the Prime Ministry's Crisis Management Center's daily situation reports describing the daily progress of the response and provision of mass-care and a summary report on the damage statistics, casualties and the service delivery (Prime Ministry 2000), the International Federation of Red Cross/Red Crescent daily situation reports, and Results of a survey on the statistics of the displaced population conducted by the State Institute for Statistics (SIS 1999). Data were retrieved from the original sources and were extracted and entered into databases. The complete products of this research have been posted on a web site maintained by The George Washington University Institute for Crisis, Disaster, and Risk Management. The URL for the project web site is www.seas.gwu.edu/~icdm/turkey

Findings and Conclusions

Although detailed analysis of the data collected was not the primary purpose of this project, several observations were made using only basic descriptive analysis techniques:

- As illustrated on Figures 1, 2 and 3, time-phased displays of data describing damage and displaced persons illustrated that information describing the impact after the Kocaeli earthquake was initially very incomplete. Early estimates were inaccurate; in some cases it took a significant period of time (weeks and months) to obtain an accurate measure of the disaster's impact.

Figure 1: Reported Death Figures by Day – Kocaeli Earthquake
(Source: Turkish Prime Ministry's Crisis Management Center, 1999.)

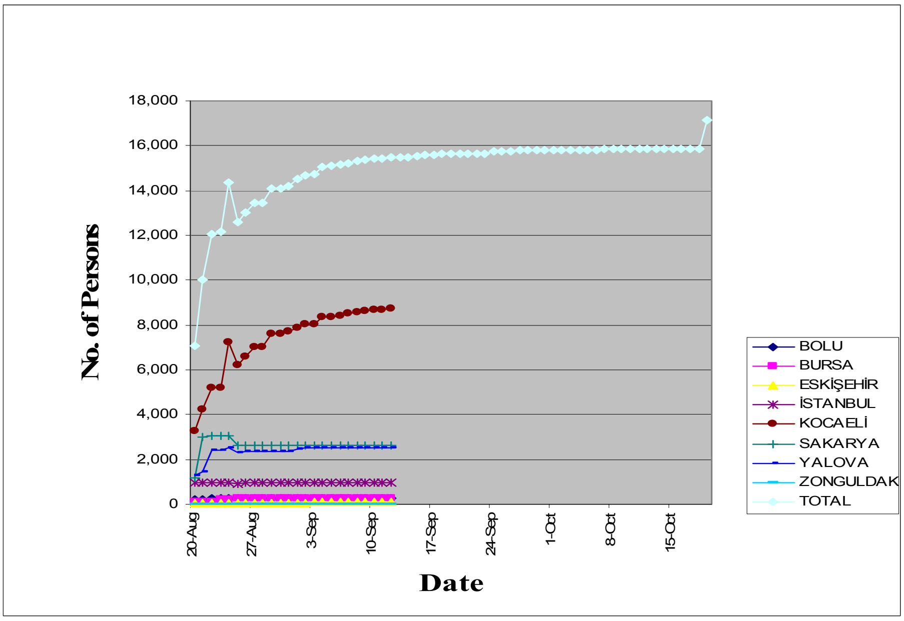


Figure 2: Reported Injury Figures by Day – Kocaeli Earthquake
(Source: Turkish Prime Ministry's Crisis Management Center, 1999.)

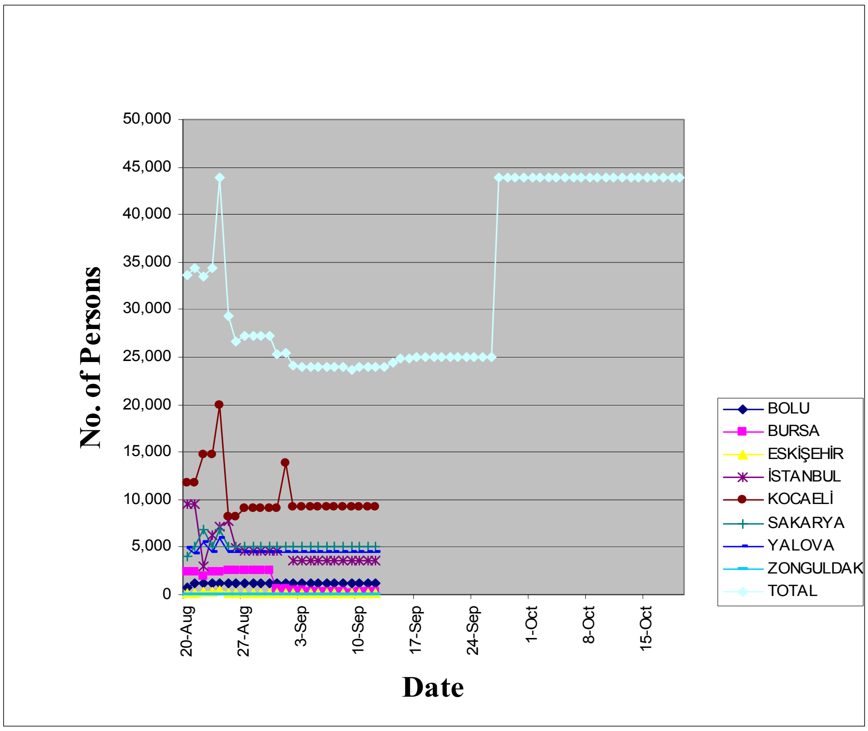
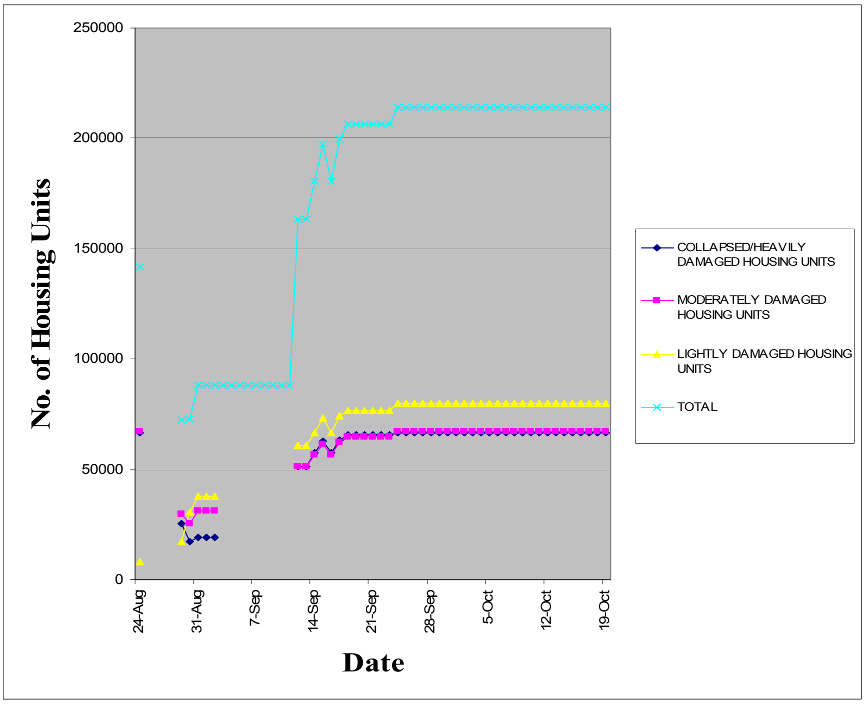


Figure 3: Reported Housing Damage Figures by Day – Kocaeli Earthquake
(Source: Turkish Prime Ministry's Crisis Management Center, 1999.)



- Time-phased data figures as depicted on Figures 4 and 5, also show that mass-care response to the Kocaeli earthquake (provision of tents and feeding) was slow but that the response to the November earthquake was more rapid and better documented.

Figure 4: Reported (Cumulative) Number of Tents in the Disaster Region by Day – Kocaeli Earthquake
(Source: Turkish Prime Ministry's Crisis Management Center, 1999.)

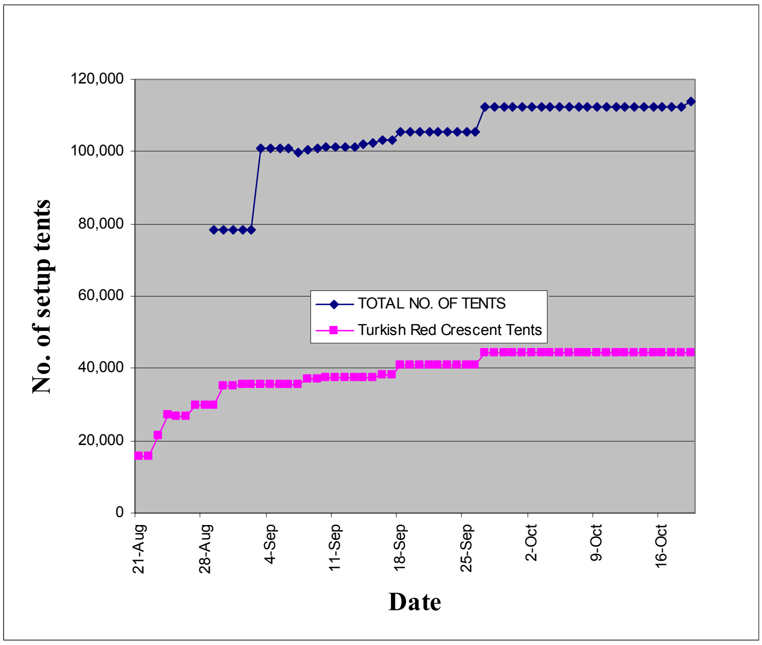
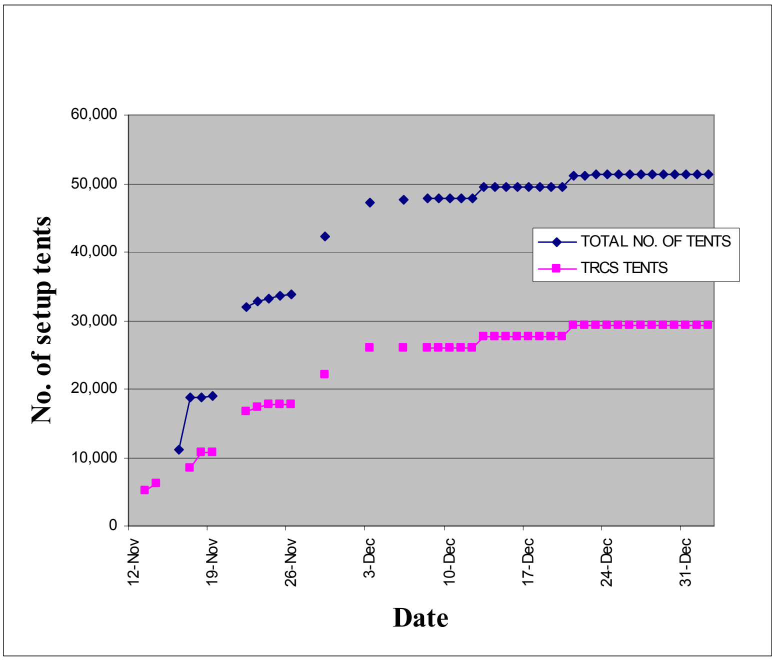


Figure 5: Reported (Cumulative) Number of Tents in the Disaster Region by Day – Düzce Earthquake
(Source: Turkish Prime Ministry's Crisis Management Center, 1999.)

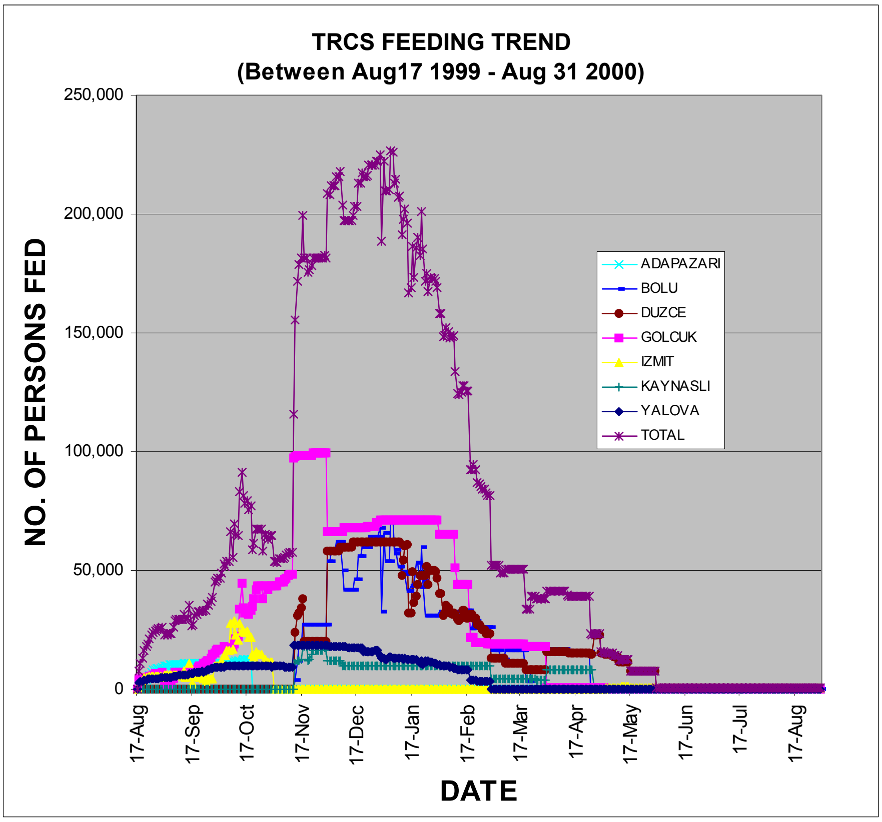


- The data describing the distribution of damage and the distribution of services provided should be analyzed for relationships and anomalies. Descriptive analysis provides some indication of these relationships.
- Not all the data needed for needs analysis are available. The extent of the distribution of bulk food supplies by the Turkish Armed Forces and civilian sources during the early days of the relief effort is not clear from the data collected. There is no way to ensure that the efforts of all non-governmental organizations that participated in the relief effort are captured in the statistics of the Turkish government, the IFRC, and the TRCS.

"Numbers change over time"

One way that numbers change over time is that the number of people needing care (feeding, shelter, etc.) can vary from day to day. For example, the Turkish Red Crescent set up their mobile kitchens one day after the August earthquake and increased their capacity as more victims populated the tent cities and temporary shelters. The feeding activity reached its initial peak (91,000 persons/day) 2 months after the August earthquake. It then declined until the November 12 earthquake strikes, at which time the trend shows an increase with the highest peak attained (226,000 persons served meals/day) approximately 5 months after the August 17 earthquake and 2 months after the November 12 earthquake. (See Figure 6 below).

Figure 6: TRCS Feeding Trend
(Source: Turkish Red Crescent, 2000.)



Another reason numbers can change over time is the quality and accuracy of data improves. For example, the Turkish Prime Minister's Crisis Management Center web site's press releases about the situation assessment and their response efforts provide insight into the scope of the difficulties faced by response organizations in mobilizing their resources, especially during the initial stages of the disasters. In particular, the press releases document information on changing estimates of housing damage and casualty figures, search-and-rescue efforts, the mass-care efforts (number of persons that were sheltered and fed), and the medical services provided to the victims of the disaster. All of this information was subject to update and revision as more information became available. Figures 4 through 8 show the temporal evolution of selected aspects of the response effort. Tents were still being erected and basic relief supplies such as blankets, sleeping bags, and stoves were still being distributed a month after both the August and November earthquakes. In the United States, peak shelter populations are typically experienced 3-7 days after a major earthquake (Perkins et al., 2000). It is apparent that peak populations of temporary shelter populations were experienced in tent cities months, not days, after the earthquakes in Turkey.

<u>Assessment of form and completeness of data</u>

The original data drawn upon in this project was collected and stored by organizations that were responding to an unexpected catastrophic event. In the aftermath of any significant natural disaster, attention is focused on providing essential rescue, medical, and mass-care services to victims. Government and non-governmental organizations do the best they can with what they have until adequate response resources can be mobilized. Keeping track of who is providing what service is clearly of lower priority than responding to critical needs. This means that if the responsibility and mechanism for collecting data are not in place prior to the event, that data will be collected in a haphazard manner and that the data collection will be driven by the motivations of hundreds of unique organizations. It is not surprising that the data available on the initial response to a catastrophic event may be incomplete and inaccurate. In the case of the Turkey earthquakes, the completeness of the data describing the response to human needs were affected by the following:

- Original data were collected/stored by an individual organization. Efforts to integrate and reconcile data from different sources were made after a significant time delay. Integrated data that has been reconciled and aggregated are typically available only in paper form.
- Data were collected by different organizations using different selection criteria (e.g. per person, per family, per unit of service delivered) and by differing geographic levels of decomposition (provincial, district, municipal)
- Data definitions were determined by organizations collecting data and it is difficult to determine if definitions are compatible between sources.

<u>“Services are not delivered in a vacuum”</u>

Recovery occurs within the context of the economic and social fabric of the region affected. In the U.S. it has been observed that when industrial operations are lightly impacted, employees of those companies are more likely to remain and require shelter for longer periods. On the other hand, if companies go out of business, the employees no longer have jobs and are thus more likely to leave the area. In the Turkish earthquakes, major manufacturing facilities survived and resumed operation relatively quickly. Thus, the need for sheltering was greater than it would have been if more damage to industrial facilities had occurred.

<u>Why are data currently collected?</u>

Local governments collected data on structural damage to make decisions on safety related to occupying or reoccupying those structures. Various non-governmental organizations (NGOs) collected data on the number of meals served or tents erected and compiling macro-data for use in fund raising. Although many structural engineers focused their efforts on case studies, other researchers collected statistical data on structural damage that will be of use to those modeling future damage potential. Similar techniques need to be employed by those doing research on human needs.

What should be collected and by who?

Two organizations in Turkey appear to have both the organizational authority and responsibility to establish a coherent information management capability that would include standardizing data definitions, geographical boundaries, and collection procedures: the Turkish Emergency Management Agency (TEMAD) and the Turkish Red Crescent Society (Kizilay). Kizilay, like the American Red Cross, has functioning units throughout the country that will be on scene for any earthquake or other major disaster. Supported by the American Red Cross, the IFRC and other national societies, Kizilay is upgrading its ability to collect and manage information during major disaster operations. A coordinated TEMAD/Kizilay effort to ensure that data describing the response to human needs is collected after future earthquakes will significantly improve the development of response and recovery plans and capabilities. The database created in this project provides guidance on the type of data that could be collected in a coordinated effort.

What opportunities exist for using these data?

The data collected in the aftermath of earthquakes like these will enhance earthquake preparedness and planning and will improve the risk and vulnerability modeling capability in Turkey, the United States and elsewhere.

Figure 7 shows the types of data that are needed to populate damage models (Perkins, 1995, Perkins et al., 1996, Perkins et al., 2000). Building inventory data, data describing actual ground shaking and liquefaction, and structural damage data for the two Turkish earthquakes has been collected by the Turkish government agencies and universities. The focus of this project was on the perishable event specific data shown in Figure 8. The estimation of response requirements must be based on estimation of service delivery demands. These demands are determined by human needs and modeling this relationship requires viable data in four distinct areas: housing damage and functionality, infrastructure damage and functionality, human impacts, and service delivery demands. The most immediate challenge for future analysis is to investigate whether or not the data available are adequate to support this type of modeling. Where data are not adequate, methods of obtaining and utilizing expert judgment may be another promising approach.

Figure 7: Pre-Disaster Data Required For Loss Estimation

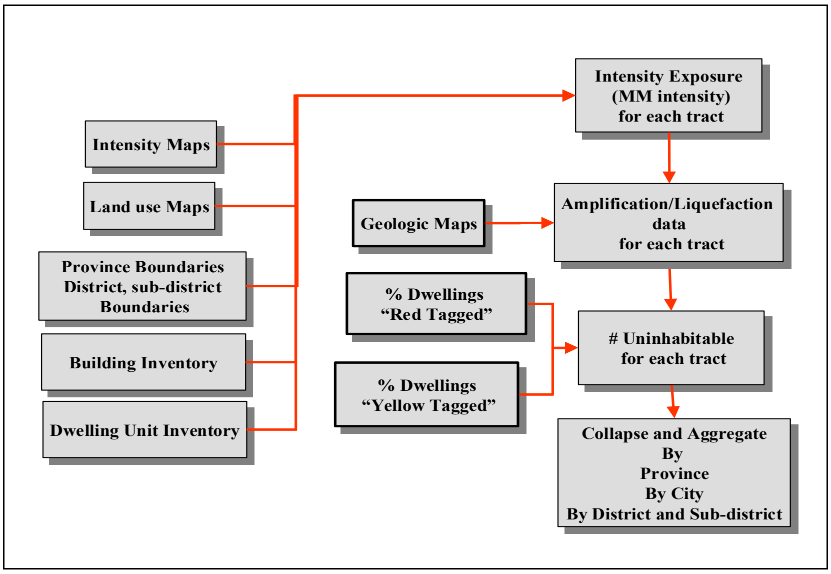
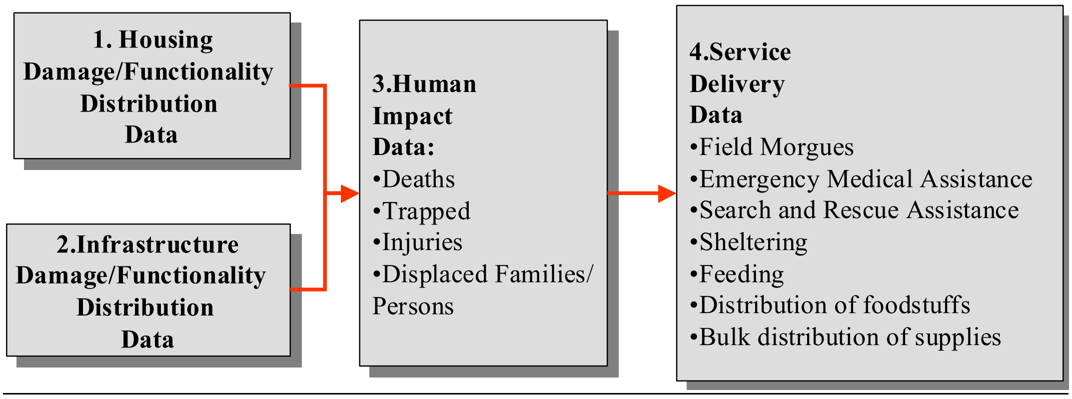


Figure 8: Scenario-Specific Data for Determination of Human Needs and Service Delivery Demands

Event & Location Specific Data



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Note: This article was based on the authors' report, Quick Response Report "The Collection, Synthesis, and Quality Assessment of Data Describing the Response to Human Needs Following the 1999 Turkey Earthquakes", completed with a grant from the National Science Foundation.

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HOSPITAL CRITICAL NONSTRUCTURAL SYSTEMS, DEPARTMENTS AND EQUIPMENT DURING AND FOLLOWING MAJOR SEISMIC EVENTS

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Keywords: disasters, earthquakes, hospitals, nonstructural systems, Hospital Critical Nonstructural Systems, Departments and Equipment, During and Following Major Seismic Events

Abstract

Hospitals and other critical care facilities play a critical role in provision of emergency and other health services following a major disaster. Earthquakes are among the most unpredictable of natural disasters, and higher magnitude events in urban areas have the potential for significant injury and damage to persons and facilities. Recent earthquakes have revealed that nonstructural failures are emerging as a critical factor limiting the continued functionality of hospitals and critical care facilities at the time their services are most needed.

In an effort to assess the vulnerability of hospitals and critical care facilities to reduced functionality due to nonstructural failures, a series of research inquiries sought information from engineering and medical personnel. This research also identified which nonstructural systems were critical to support the functioning of the critical hospital departments and medical equipment over the life cycle of a major seismic event. This paper reports the results of survey research and in-person, in-depth interviews with doctors, nurses, leaders of major hospital departments and facility engineers who were on-site during or shortly after major seismic events in Los Angeles, Seattle, Taiwan, and Turkey to identify the major causes of reduced functionality due to nonstructural failures and damage to equipment and medical supplies.

Introduction

Recent earthquakes in Japan, Taiwan, Turkey and the United States have focused attention on the role and function of hospitals during and following major seismic events. In the 1971 San Fernando Earthquake, 85 percent of the fatalities occurred in hospitals and Steinbrugge et al. (1980) estimate that in a large-scale earthquake in the San Francisco region, approximately one-third of the deaths would occur in hospitals. While improved building codes and increased code enforcement have reduced the susceptibility of the structures to catastrophic failures, similar improvements in the performance of nonstructural systems have not been realized. Failures of

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structural and nonstructural components continue to cause the deaths of patients and staff (USC, 2000).

FEMA notes that the functionality of a hospital is highly dependent on the functioning of most of its nonstructural elements and many of these are highly susceptible to damage in even a fairly mild earthquake (FEMA, 1989). In 1983 the Coalinga Earthquake's, (6.7 magnitude on the Richter Scale) damaged the district hospital's X-ray equipment, computers, laboratory analyzers, emergency radio equipment and emergency generators (Tierney, 1983). The Loma Prieta Earthquake caused little structural damage but had a significant impact on the nonstructural components. Elevators suffered significant damage, communication systems failed, patient records were spilled, laboratory equipment was damaged and laboratory chemicals fell and pharmaceuticals were strewn all over the floor (California Seismic Safety Commission, 1991).

While life safety remains the primary focus of seismic design, recent experience suggests that the damage to nonstructural systems and the building contents is an important and as yet unresolved concern. Indeed, experience from other earthquakes suggests that nonstructural damage is a major factor affecting the functionality of hospitals and other health care buildings (Seismic Safety Commission, 1984). They indicated that damage to these elements can disable an otherwise structurally sound building while posing risk to those who are in the building at that time. Experience with the 1994 Northridge earthquake revealed that failure of backup emergency power was a factor in one patient's death and other nonstructural failures, notably damage to sprinklers, domestic water and chiller lines, led the evacuation of over nine hundred patients (Seismic Safety Commission, 1994). While Olive View Hospital, which was severely damaged in the 1971 San Fernando Earthquake and rebuilt to revised earthquake standards experienced minimal structural damage in the 1994 Northridge Earthquake, 377 patients were evacuated because of nonstructural failures.

Critical Hospital Systems

In a severe earthquake, acute care hospitals and facilities must remain functional to respond to the needs for medical attention and critical care. To do so, not only must the building structures remain safe for continued occupancy, but their nonstructural systems must remain functional as well. While improvements in the structural performance of hospitals have been made in recent years, similar steps to improve the nonstructural systems remain elusive. A major factor noted by FEMA (1989) is the lack of consensus on which items are essential to the continuing functioning of hospitals. Following the 1971 San Fernando Earthquake the Veterans Administration identified nine areas that were either high hazard or high priority functional concerns (Stone Marraccini and Patterson, 1976). In a systematic examination of two case study facilities McGavin and his associates (1986) examined over 160 hospital equipment items deemed representative of a community-based medical center. From these 15 were identified a life support equipment. Still opinions continue to differ as to which systems or components are critical or essential in maintaining the functionality of hospitals and critical care units (FEMA, 1989).

<u>Methods</u>

In order to evaluate the vulnerability of nonstructural components and to assess their importance to the continued functioning of hospitals, researchers from the schools of engineering, medical and health management sought to identify which nonstructural systems were critical in maintaining the functioning of a hospital during and following a major earthquake. A review of policy studies, research and engineering reports that examined damage to the nonstructural components of hospitals and critical health care facilities caused by earthquakes in the United States was conducted. Most of the recent published findings concentrated on the San Fernando (1971), the Loma Prieta (1989) and Northridge (1994) earthquakes. These findings, particularly the analyses of the Northridge event, were used to identify nonstructural systems that may be critical to the functioning of hospitals following a major earthquake. The systems identified in these studies were presented to two panels of experts with experience in hospital design and construction. They were asked to indicate, using a survey instrument, which systems were critical to ensuring the continued functioning of a hospital following a major seismic event (USC 2000). To provide a medical perspective, two group interviews with nurses, doctors and administrative personnel at two major public hospitals evacuated due to nonstructural failures were also conducted.

Information from these interviews were used to construct a five part survey questionnaire to identify the types of problems hospitals faced during and following an earthquake and to indicate the impact of these on the ability of the hospitals to remain functional following that event. The first three parts of the questionnaire were designed to be completed by the hospital's disaster coordinator, safety officer or facilities director. The fourth and fifth parts of the questionnaire were to be completed by department heads of major hospital departments. The questionnaire was pretested using a sample of hospitals which were not proximate to the epicenter. As a result of the pretest several questions were rewritten, several dropped or were modified to allow for comments or clarifying information.

A sample of hospitals proximate to the epicenter of the Northridge Earthquake was identified and asked for their assistance in the completion of the survey instrument. After reviewing the questionnaire those hospitals felt they would not be able to complete the survey either because the key people were no longer at that facility, they felt that the survey would take more time than they could provide, or a general reluctance to participate in another survey of the earthquake and the subsequent damage. However, some of the hospitals were willing to assist us and agreed to arrange for in-depth interviews with staff who were at the facility at the time of the earthquake. Two of these facilities had suffered significant nonstructural damage leading to the evacuation of patient care areas, two suffered some structural damage and nonstructural damage and three sustained mainly nonstructural damage to their patient care units. Those interviewed included administrative, medical, nursing personnel for key patient care departments as well as leaders from diagnostic and support departments.

While these interviews were underway, a major earthquake struck Turkey (August 17, 1999). Shortly thereafter, 10 public hospitals from the provinces of Kocaeli, Sakarya, Bolu and Yalova were contacted by USC-affiliated research associates to see if they would participate in our research study. The researchers explained the purpose of the research and they agreed to complete the five part survey questionnaire examining the extent of damage or loss they experienced, the impact of this damage on the operation of the hospital and their assessments of the importance of different medical systems to the functioning of the hospital during and following the earthquake. Following the second Duzce Earthquake on November 19, the USC-Affiliated research team contacted hospitals in the Bolu province and obtained additional survey information from 6 more hospitals.

At the same time the Turkish surveys were underway, a magnitude 7.6 earthquake struck central Taiwan. Colleagues at the Nongovernmental Hospital Association were contacted to see if they could assist in surveying a sample of the hospitals damaged by the earthquake. With their assistance 10 hospitals, representing a mix of small and large public and private facilities, agreed to complete our survey questionnaire. Instead of using interviewers to complete the survey, as was done in Turkey, participants were mailed a copy of the survey, which had been translated into Chinese. All completed and returned the survey to our associates in Taiwan. These data were augmented by two visits to the surveyed hospitals in Taiwan to collect additional in depth information about from medical, nursing and administrative personnel in the most severely damaged of the hospitals in Taiwan. These interviews, paralleling those completed in the United

States, were conducted in Chinese by medical, management and engineering researchers from the National University of Taiwan and the United States.

The final set of interviews occurred following the Nisqually Earthquake in the state of Washington (2000). Three hospitals, one proximate to the epicenter and two in Seattle were contacted and agreed to participate in the study. As with the previous interviews, physicians, nurses, clinical staffs from the laboratory, radiology, pharmacy, and dietary departments, along with personnel from support units such as central supplies, plant and maintenance, engineering and biomedical engineering participated in the study.

Findings

Overall, more than two hundred personnel, 131 from medical care departments and 84 administrative and support departments contributed information about critical nonstructural systems, departments and equipment (Table 1). Fifty-four worked in academic medical centers, 111 were from major medical centers and 50 were from community hospitals.

Interview and survey information were used to identify critical nonstructural systems. As the information in Table 2 indicates, power followed by water and communication was most frequently mentioned as critical to their functioning. While damage to piping has been a source of diminished functionality of hospitals, the need for electrical service to support patient care equipment, diagnostic and treatment functions is clearly apparent.

Table 1: Title and Hospital Affiliation of In depth Interview Participants

Type of Facility	Physician	Nurse	Other Medical	Administration	Engineering	Other Non-Medical
Academic Medical Centers	17	15	4	3	5	10
Major Medical Centers	13	29	23	10	21	15
Community Hospitals	5	13	12	4	9	7
TOTAL	35	57	39	17	35	32

Changes in medical treatment and the role of technology in the treatment and care of patients has increased the use of monitors, ventilators and other critical life support items. These responses seem to reflect these changes.

Table 2: Critical Life Line Systems

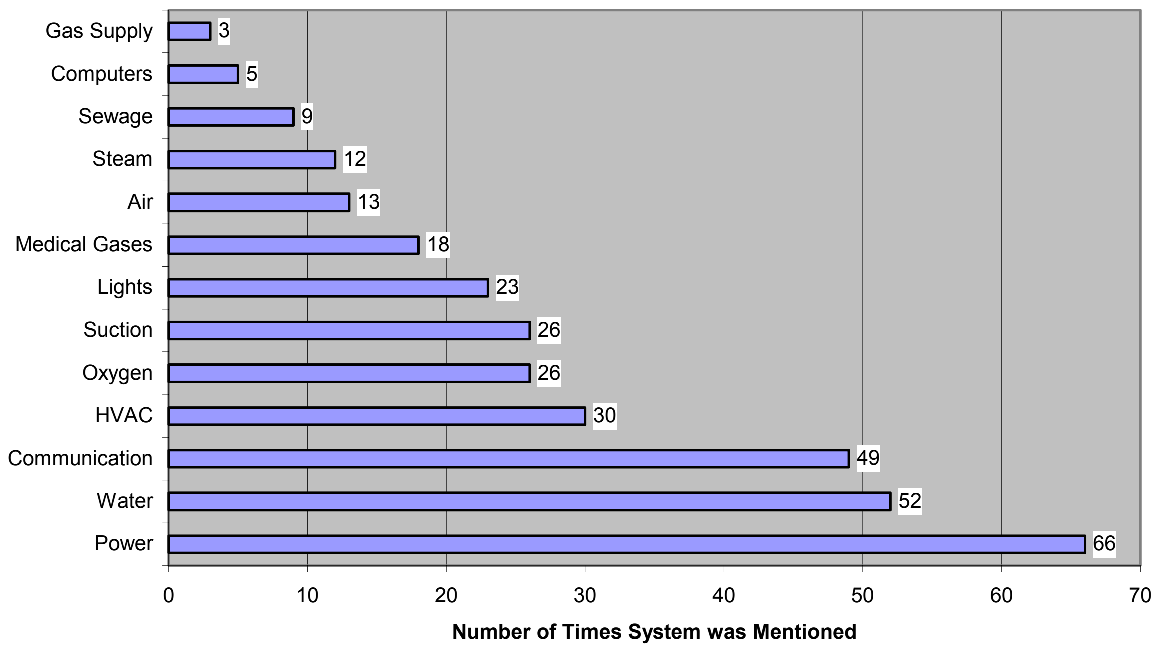


Table 3 lists the critical equipment identified by medical and non medical personnel. Unlike the responses for critical lifeline systems, there is a considerable range and variation in the equipment items identified as critical. These variations reflect the differences in the role and the need for life support equipment in the various clinical and patient care areas. Monitors (22) and ventilators (22) were the most frequently mentioned items and are also among the most frequently used life support items. X-ray (17), defibrillators (16) and anesthesia machines (13) were the next frequently mentioned items, followed by sterilizing equipment (13), refrigerators (11) and computers (11). Interestingly these items were infrequently mentioned as being damaged in the earthquakes we studied.

Respondents also mentioned a number of departments that were critical to their functioning (Table 4). Eight appear to make up the critical core of the hospitals we studied. Interesting, pharmacy was mentioned most frequently by the respondents. Pharmacies are critical to the functioning of most patient care activities including nursing units, surgical and treatment areas and many diagnostic services. Laboratory (23), radiology (23), the emergency room (22), ICU (22), operating rooms (21), central supply (17) and nursing care units (16) appear to be part of this critical patient treatment core.

A final element of this research was to determine whether there were differences in the importance of certain medical systems at different points of time following and earthquake.

Table 3: Critical Life Support Equipment

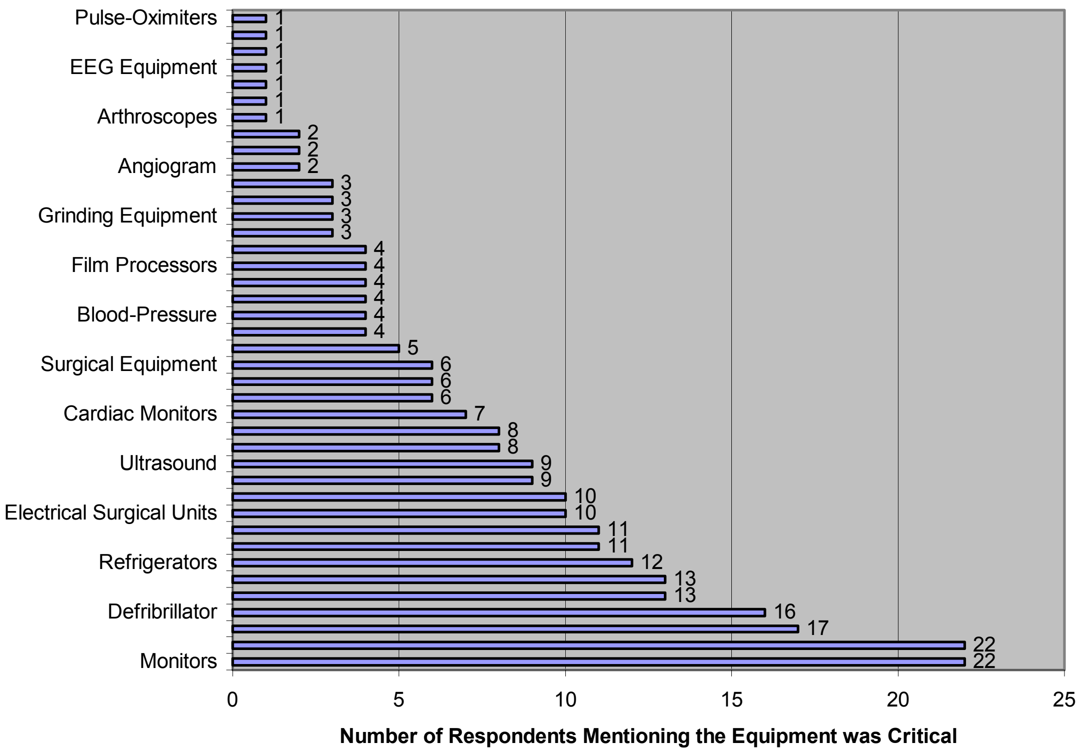
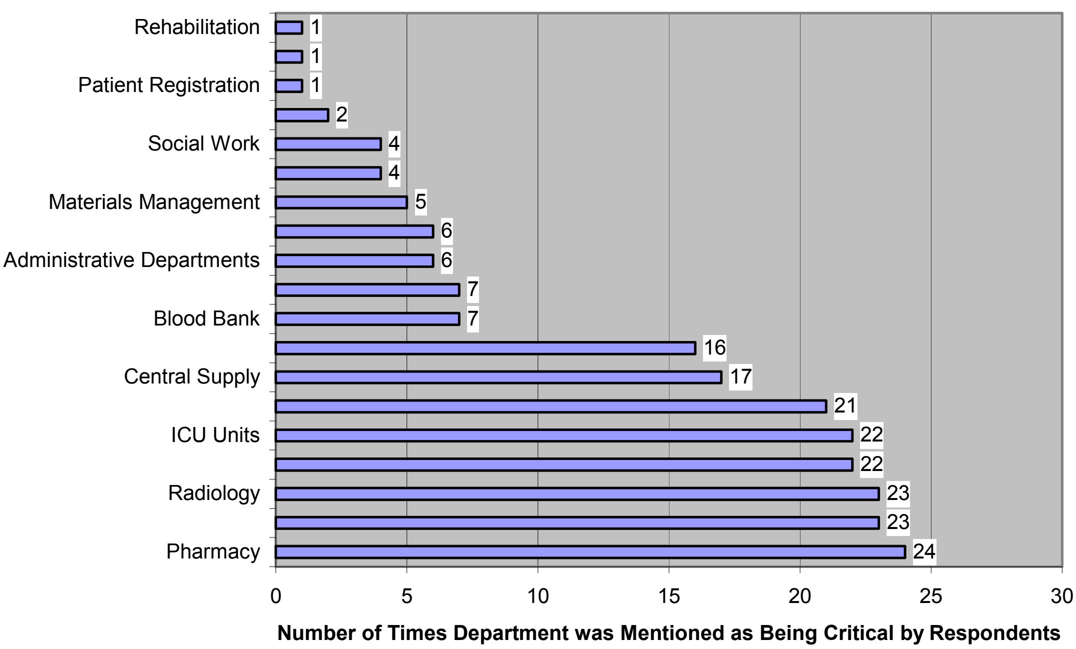


Table 4: Critical Hospital Departments



As Table 5 indicates, there is significant variation in the importance of different hospital departments at different phases of an earthquake. Immediately following an earthquake four departments were identified as essential[3] to the functioning of the hospital. These results support the interview finding which also identified pharmacy as the most important department. Further, it was the only department that these respondents indicated was essential for the functioning of the hospital at any point of time following an earthquake. Nursing care units' functionality was nearly as important at pharmacy.

Five departments—ICU/CCU, blood bank, nursing care, pharmacy and communications systems were identified as being essential to the functioning of a hospital immediately following an earthquake. During the stabilization period, two departments were mentioned by all respondents as being essential to the functioning of a hospital during the stabilization phase following an earthquake. During the cleanup and recovery phases, nursing care and pharmacy departments were mentioned by all respondents as being essential to the functioning of the hospital. These same departments also were identified as essential during the transition to normal operations.

Table 5: The Importance of Departments at Different Points of Time Following an Earthquake

Systems	Immediately Following the Earthquake	During Stabilization	During Recovery & Cleanup	Transition to Normal Operation
Medical Systems				
Emergency Room	1.10	**1.00**	1.10	1.10
Operating Room	1.11	1.11	1.11	1.11
Recovery Room	1.33	1.33	1.33	1.22
ICU/CCU	**1.00**	1.14	1.25	1.14
NICU	1.40	1.50	1.43	1.33
Blood Bank	**1.00**	1.22	1.44	1.33
Diagnostic Systems				
Laboratory	1.80	1.70	1.30	1.20
Radiology	1.60	1.50	1.20	1.10
Imaging (MRI/CT Scan)	1.67	1.56	1.56	1.44
Patient Support Systems				
Nursing Care	**1.00**	1.10	**1.00**	**1.00**
Central Supply	1.30	1.10	1.10	1.10
Pharmacy	**1.00**	**1.00**	**1.00**	**1.00**
Housekeeping	2.00	1.60	1.30	1.30
Medical Records	1.50	1.30	1.10	1.10
Laundry	2.38	2.11	1.67	1.44
Dietary	1.75	1.78	1.56	1.33

[3] 1=Essential to the functioning of the hospital at this point following the seismic event, 2=important but not essential to the functioning of the hospital at this point following the seismic event, 3=useful but not important to the functioning of the hospital at this point following the seismic event, 4=not needed at this point following a seismic event.

Overhead Services				
Data Processing	1.78	1.67	1.44	1.22
Maintenance	1.67	1.44	1.33	1.44
Purchasing	1.38	1.56	1.22	1.11
Business Office	1.56	1.44	1.33	1.33
Security	1.33	1.44	1.44	1.44
Biomedical Engineering	1.75	1.75	1.75	1.75
Communication Systems	**1.00**	1.11	1.11	1.11

Other departments identified as being almost as important to the functioning of a hospital during the different phases of an earthquake include the trauma department, operating rooms, central supply, and communications systems. All in all, nine departments—trauma, operating room, ICU/CCU, central supply, nursing care, pharmacy, medical records and communications were seen as improbable to the functioning of a hospital throughout the earthquake event. Combining the results from the interviews and hospital surveys, six medical care areas (pharmacy, nursing care units, central supply, operating room, ICU/CCU and emergency room) emerge as the core areas essential to the functioning of hospitals.

Conclusions:

While the research literature may not agree on which systems and components are critical or essential in maintaining the functionality of the hospital this study of 40 hospitals in three countries suggests that if the hospitals remain structurally sound in the core patient care and support areas (trauma, operating room, ICU/CCU, central supply, nursing care, and pharmacy) and are provided with a communications capacity, have electrical services, water and are able to dispose of waste products they may well be able to meet their patient care obligations following a major earthquake. All of this assumes that sprinklers systems and water lines do not have significant damage, that staff members are able to report for duty or remain on the premises, that patients are able to access the facility and that needed supplies and other consumables are able to be replenished. At the same time, it is important to recognize the adaptive capacity and inventive abilities of the staffs of health care facilities to respond to structural and nonstructural elements. Even when parts of hospitals suffered catastrophic structural failures or experienced major damage to sprinklers or water systems, or the significant interruption in the electrical and communication systems, services were provided and patients were treated.

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The International Emergency Management Society
9th Annual Conference Proceedings
University of Waterloo, Canada, May 14-17, 2002

GUJARAT, INDIA AND WASHINGTON STATE, USA: A CONTRAST IN EARTHQUAKE PREPAREDNESS

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Keywords: Natural Disaster, Emergency Management, Earthquakes, Earthquake Preparedness, Earthquake Damage

Abstract

On January 26, 2001, at 8:46 a.m. Indian Standard Time, a major earthquake occurred in the State of Gujarat, India. The Richter magnitude 7.7 earthquake was centered approximately 20 km north of the city of Bhuj, India, and occurred at a depth of 23.6 km. Authorities estimate that around 25,000 people lost their lives, 60,000 people were injured and some 200,000 were rendered homeless. Damage estimates from the temblor were estimated to be around $1.3 billion (US). Knowledgeable sources indicate that the Bhuj earthquake was so deadly because contractors did not use adequate construction practices or materials. Also, although building codes in India have provisions for construction in earthquake prone areas, they have been used as recommendations and not requirements. In contrast, on February 28, 2001, at 10:55 a.m. Pacific Standard Time, a major earthquake occurred in the State of Washington, USA. The Richter magnitude 6.8 earthquake was centered approximately 20 km northeast of the city of Olympia, Washington, at a depth of 52 km. This event, termed the Nisqually earthquake, killed one person (heart attack), injured more than 400 people and caused an estimated $2 billion (US) in damage to homes, businesses, roads, and government buildings. Although the geological setting of the Nisqually earthquake was thought to have played a role in buffering the resultant effects, it is believed that strict adherence to the earthquake building codes for new structures, a retrofitting program, and an earthquake hazard awareness campaign contributed to the low injury rate and no deaths. This paper compares and contrasts the two areas affected by the earthquakes and the local approach to protect structures and minimize the effects on the people living in the area.

Introduction

Earthquakes have been an integral component of our geologic evolution. Since the dawn of history, mankind has been continually reminded, usually without warning, of the ruinous power of earthquakes (Berlin, 1980). An earthquake is a series of shock waves that are generated following the brittle failure of rocks within the earth's crust or upper mantle as a result of a build-up of stress. Failure occurs at a point or in a fairly small subsurface zone known as the focus with the epicenter being the point on the earth's surface directly above. Once failure has occurred, movement may persist along a zone of weakness (known as a fault) for a considerable distance occasionally as much as 1000 Km. (The University of Edinburgh, 2002)

There are two important measures of the size and effect of an earthquake. The first is a quantitative measure of an earthquake's seismic wave and the second is a semi-qualitative assessment of the

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resultant damage caused by an earthquake. In 1935, Charles Richter developed the first earthquake magnitude scale based upon the logarithm of the maximum amplitude of the seismic wave. The Richter magnitude is known as the local magnitude (M_L). Because the scale is logarithmic, there is a ten-fold increase in wave amplitude, as measured with a seismogram (the record of the motion of the ground during an earthquake), with a unit increase of magnitude or about a 30-fold increase in the amount of energy released. In other words, a magnitude 6.7 earthquake releases over 900 times (30 times 30) the energy of a 4.7 earthquake. There is no beginning or end to this scale. However, rock mechanics seems to preclude earthquakes smaller than about -1 or larger than about 9.5. A magnitude -1.0 event release about 900 times less energy than a magnitude 1.0 quake. Except in special circumstances, earthquakes below magnitude 2.5 are not generally felt by humans. (NEIC, 2002)

Since the development of the Richter scale, several other methods have been derived to describe large earthquakes and distant earthquakes. These methods include the surface wave magnitude or M_S scale, the body-wave magnitude or M_b scale, the seismic moment or M_O, and the moment magnitude or M_W scale. The moment magnitude scale is being used more and more to describe moderate to large earthquakes (Yeats et al, 1977).

The intensity of an earthquake is the measure of the resultant effects of the event. The intensity of an earthquake is calculated by the damage to structures, the land, and the effects on humans. The intensity at a point depends not only upon the strength of the earthquake (magnitude), but also upon the distance from the earthquake to the point and the local geology at that point (NEIC, 2002). Typically, such information is collected by experts that canvass the area and from interviews of those living in the affected areas. Experts then construct maps showing the various levels of intensity. In 1902, Giuseppi Mercalli proposed an intensity scale that has since been revised several times and is known as the Modified Mercalli scale (MM) (Yeats et al, 1977). Table 1 shows approximate relationship between Richter magnitude and the maximum intensity from the Modified Mercalli scale.

Table 1: Approximate Relationship Between Richter Magnitude and Maximum Intensity from the Modified Mercalli Scale (Gere and Shah, 1984).

Richter Magnitude	Maximum MM Intensity	Typical Effects
2.0 and Under	I-II	Not generally felt by people.
3.0	III	Felt indoors by some people; no damage.
4.0	IV-V	Felt by most people; objects disturbed; no structural damage.
5.0	VI-VII	Some structural damage, such as cracks in walls and chimneys.
6.0	VII-VIII	Moderate damage, such as fractures of weak walls and toppled chimneys.
7.0	IX-X	Major damage, such as collapse of weak buildings and cracking of strong buildings.
8.0 and Over	XI-XII	Damage total or nearly total.

A great earthquake, with a magnitude of greater than 8.0, can be expected to occur every 8 to 10 years, but a significant number of smaller earthquakes, which are still capable of destruction, occur each year. Table 2 shows data from the United States National Earthquake Information Center (NEIC) and describes the worldwide frequency of earthquakes based on observations made since 1990. According to the NEIC, it is estimated that several million earthquakes occur in the world each year. However, many go undetected because they strike remote areas or have very small magnitudes. The NEIC now locates about 50 earthquakes each day, or about 20,000 a year. (NEIC, 2002)

The largest recorded earthquake in the United States was a magnitude 9.2 (Mw) event that struck Prince William Sound, Alaska, on Good Friday, March 28, 1964. The largest recorded earthquake in the world was a magnitude 9.5 (Mw) event in Chile on May 22, 1960. Table 3 shows the number of recordable earthquakes that have occurred since 1997 and the estimated death toll. As can be observed in the table, earthquakes have the potential for catastrophic consequences.

Table 2: Frequency of the Occurrence of Earthquakes (NEIC, 2002).

Descriptor	Magnitude	Annual Average
Great	8.0 and Higher	1
Major	7.0 - 7.9	18
Strong	6.0 - 6.9	120
Moderate	5.0 - 5.9	800
Light	4.0 - 4.9	6200 (estimate)
Minor	3.0 - 3.9	49000 (estimate)
Very Minor	< 2.9	Magnitude 2 -3: About 1000 Per Day Magnitude 1- 2: About 8000 Per Day

Table 3: Worldwide Earthquakes 1997 - 2001 (NEIC, 2002).

Descriptor	Magnitude	1997	1998	1999	2000	2001
Great	8.0 and Higher	0	2	0	4	1
Major	7.0 - 7.9	20	14	23	16	14
Strong	6.0 - 6.9	125	113	123	153	130
Moderate	5.0 - 5.9	1118	979	1106	1345	1152
Light	4.0 - 4.9	7938	7303	7042	8045	8214
Minor	3.0 - 3.9	4467	5945	5521	4782	6137
Very Minor	< 2.9	6204	7332	7017	7911	7977
Total Number of Earthquakes		19872	21688	20832	22258	23625
Estimated Death Toll		2907	8928	22711	231	21358

Bhuj Earthquake

The subcontinent of India is a union of 25 states and 7 centrally administered territories. The State of Gujarat was created in 1960 and lies in the western part of India (Figure 1). Gujarat has a total population of about 50.6 million people or about 5% of the population of India and occupies about 196,000 km^2 (about 6% of India's total surface area). Gujarat is one of India's wealthiest states, with industrial complexes as well as thriving village handicrafts.

Figure 1. Map of India (The University of Texas, 2002).

On January 26, 2001, at 8:46 a.m. Indian Standard Time, a major earthquake occurred in the State of Gujarat, India. The Richter magnitude 7.7 earthquake was centered in the Kutch region approximately 20 km north of the city of Bhuj and occurred at a depth of 23.6 km. This event was termed the Bhuj or Kachchh earthquake. Authorities estimate that around 25,000 people lost their lives, 60,000 people were injured, and some 200,000 were rendered homeless. In Kutch, major towns such as Bhuj, Anjar, Bhachau, and Rapar were almost totally destroyed. Damages from the temblor were estimated to be around $1.3 billion (US) (USGS 2002). Table 4 shows a summary of the damage to villages and towns in Gujarat.

Table 4: Settlement Profile and Number of Building Affected by Earthquake in Gujarat, India (TARU, 2001 and Census of India, 1991).

Settlement Profile				**Buildings Affected by Earthquake (000's)**			
District	Area, 10^2 km	Villages	Towns	Residential Houses	Commercial & Industrial	Public & Institutional	Total
Kachchh	457	884	10	350	30	11	391
Rajkot	112	841	13	561	71	8	630
Jamnagar	141	694	18	371	36	6	413
Mahesana	90	1093	15	758	81	11	851
Surendranagar	105	648	11	291	33	8	331
Ahmadabad	87	646	25	1186	146	10	1342
Gandhinagar	6	73	3	95	5	1	101
Banas Kanatha	127	1368	7	450	34	5	490
Sabar Kanatha	74	1363	8	380	48	3	431
Kheda	72	965	21	758	97	7	862
Bharuch	90	1116	10	367	32	5	403
Surat	77	1185	14	723	128	5	856
Vadodara	78	1639	21	593	84	5	708
Bhavnagar	112	865	17	460	58	7	525
Junagadh	106	1034	23	567	53	8	633
Amreli	68	595	12	253	27	4	284
Panch Mahals	89	1889	9	448	93	2	543
Valsad	52	821	25	423	57	3	483
The Dangs	18	309	2	24	8	0	32
Total	**1960**	**18028**	**264**	**9075**	**1127**	**109**	**10311**

In addition to the devastation to villages and towns, it was reported that damage occurred to the railway system; 100 km of the National Highway had been damaged with moderate to severe damage to major and minor bridges; there was severe destruction to the telecommunications infrastructure with 82,000 lines and 147 telephone exchanges damaged; there was reportedly severe damage to the power transmission and distribution system in Kachcch; and major structural damage was reported at Kandla Port (TARU, 2002).

According to the Gujarat Relief Engineering Advice Team that investigated the earthquake areas, most people were killed or badly injured because of the following (Patel et al, 2001).

- Poorly constructed buildings either totally or partially collapsing.
- Walls collapsing within narrow streets, burying escaping people.
- Untied roofs and cantilevers falling onto people.
- Free-standing high boundary walls, and balconies falling due to severe shaking.
- Gable walls falling over.
- The failure of modern reinforced structures with large open spaces at ground to first floor level. For example garage or shop spaces, collapsing and burying occupants (soft story collapse).
- Inhabitants not knowing how to respond to the shaking and collapse of walls around them.

Earthquakes and their devastating effects are not new to India as 16 significant events (magnitude 6.0 or greater) have occurred in the 1900's; four of these events occurred in the 1990's and are summarized in Table 5. Following the earthquake, there was a myriad of discussions in the engineering community in India as to the reasons for the large-scale damage in some of the communities.

Table 5: Major earthquakes in India during the 1990's (India Meteorological Department, 2002).

Date	Earthquake Name	Magnitude	Death Toll
October 20, 1991	Uttarkashi	6.6	769
September 30, 1993	Latur	6.3	7610
May 22, 1997	Jabalpur	6.0	39
March 29,1999	Chamoli	6.8	103

The development of formalized Indian seismic building codes date back to the 1960's and modifications have since been made several times. Furthermore, seismic zone maps that delineate risk areas within the subcontinent have also been developed and have been modified after significant earthquake events. Unfortunately, the Indian seismic codes are not mandatory and considered only as construction guidelines. According to educators in India, construction is governed by the municipal by-laws and the seismic provisions have yet to be incorporated into the by-laws. Since a majority of the building construction activity in the country is carried out in an informal manner, with no involvement of engineers, most of it is done without regard to seismic safety. On the other hand, the governmental departments and public sector organizations manage a large fraction of the formal sector constructions (large dams and nuclear power plants) and are formally committed to follow the seismic codes. (Jain and Nigam, 2000).

Figures 2 and 3 are photos showing damage from the Bhuj earthquake.

Figures 2 and 3: Photos of damage from the Bhuj Earthquake.

According to the Gujarat Relief Engineering Advice Team, the building damage was caused by a combination of effects (Patel et al, 2001).

- Old decaying buildings predating modern construction practices.
- New buildings not being designed to Indian seismic building codes.
- Lack of knowledge, understanding, or training in the use of Indian seismic building codes by local engineers.
- Unawareness that Gujarat is a highly seismic region.
- Buildings erected without owners seeking proper engineering advice.
- Improper detailing of masonry and reinforced structures.
- Poor materials, construction, and workmanship used, particularly in commercial buildings.
- Alterations and extensions being carried out without proper regard for effects on structure during and earthquake.
- Buildings having poor quality foundations or foundations built on poor soils.
- Little or no regulatory authority administering or policing the seismic building codes.

Nisqually Earthquake

The Unites States is a democratic union of 50 states. Washington achieved statehood in 1889 and is situated in the far western part of the United States (figure 4). Washington State has a total population of 5.9 million people or about 2.1% of the population of the United States and occupies about 172,000 km^2 (about 1.9% of the United States' total surface area). Washington state ranks 15th in gross state product in the United States. (USBC, 2000)

Figure 4: Map of Washington State (The University of Texas, 2002).

More than 1,000 earthquakes occur in Washington annually. Washington has a record of at least 20 damaging earthquakes during the past 125 years. Large earthquakes in 1946, 1949, and 1965 killed

15 people and caused more than $200 million (1984 dollars) in property damage. Most of these earthquakes were in western Washington, but several, including the largest historic earthquake in Washington (1872), occurred east of the Cascade Crest. (Walsh et al, 2001) Therefore, earthquake events are not uncommon to this area.

On February 28, 2001 at 10:55 a.m. Pacific Standard Time, a major earthquake occurred in Washington. The Richter magnitude 6.8 earthquake was centered approximately 20 km northeast of the city of Olympia, Washington, at a depth of 52 km. This event, termed the Nisqually earthquake, killed one person (heart attack), injured more than 400 people and caused an estimated $2 billion (US) in damage to homes, businesses, roads, and government buildings. (USGS 2002)

The effects of the earthquake were as follows (EMD, 2002 and EQE, 2002).

- The effects of the earthquake were observed in homes over a 25 county area and impacted 25 Native American tribes.
- Many businesses were disrupted and widespread damage occurred, but most businesses were able to work around the damage and continue to operate.
- Schools fared well, with most students getting an unexpected holiday. No student injuries were reported in large part due to extensive training on ' duck, cover, and hold' training.
- The Washington State Ferries Coleman Dock reported minor damage.
- Railroad traffic was interrupted, 700 miles of railroad lines had to be inspected before passenger and freight traffic was allowed to resume.
- The Capital Campus, which housed most of the State buildings, was heavily damaged. The Legislative Building, (the State Capital building), was considered unsafe for occupancy.
- Due to the relatively moderate ground motions, damage to modern structures was very light, consisting of damage to nonstructural components. Where structural damage did occur, it was generally at sites with soft soils or outdated construction with known seismic vulnerabilities.
- Puget Sound, which is a hub for many industries, experienced light damage and resumed operations rapidly.
- The water utilities in the epicenter reported little or no damage. Wastewater treatment facilities were able to maintain full operation.
- Approximately, 217,000 customers lost electrical power. Within 6-hrs of the earthquake only 6,000 customers remained without power.
- Wire and wireless communications were overloaded for about two days. In the first few hours after the event, cable Internet access provided the only means of communication. AT&T rejected about 7 million calls within 24-hrs of the event.
- Only one gas leak was detected in the regional natural gas transmission system.
- The SeaTac International Airport, located 40 km from the earthquake epicenter, experienced extensive damage to the control tower. The airport was partially reopened within a day of the earthquake.
- The Interstate Highway System in the area experienced minor damage overall, however, two modern bridges on the Interstate Highway System failed. Local bridge damage was limited to aging structures approaching the end of their service life.

Figures 5 and 6 are photos showing damage from the Nisqually earthquake.

Figures 5 and 6: Photos of damage from the Nisqually Earthquake.

The reasons for the very small loss of life from the Nisqually earthquake can be attributed to several factors. First, from a geological perspective, the hypocentral depth of the Nisqually earthquake was 52 km below the surface and was more than twice as deep as the Bhuj earthquake. In the Nisqually earthquake, there was a large expanse of "very strong" shaking, but no reports of "severe or violent shaking" even in those places nearest to the epicenter. Within the first week of the Nisqually earthquake, only a few aftershocks had been recorded, and the largest was a magnitude 3.4 event. It is common in earthquake devastated areas for moderately sized aftershocks to damage already weakened structures, so the lack of aftershocks must have been a mitigating factor in minimizing the total loss. (SCEC 2002)

Second, in 1985, The U.S. Geological Survey, the Federal Emergency Management Agency, the Washington Department of Natural Resources, and the Washington Department of Community Development, Division of Emergency Management, began a multi-year cooperative earthquake hazards reduction program to investigate earthquake potential, hazards mitigation, and preparedness efforts in the Puget Sound area. In 1987, the program was enlarged to include the Portland Oregon area. (Noson et al, 1988)

Third, the local government in the Washington State area has taken proactive steps to control the magnitude of earthquake damage by regulating land use through building permits, zoning provisions, and ordinances. The Seattle Greenbelt Ordinance is an example of local regulations that can be used to control and limit land use to reduce earthquake hazards. Another example is the King County Sensitive Areas Ordinance 4365. This ordinance can limit land use in areas that are landslide prone or contain significant earthquake hazard. (Noson et al, 1988)

The Uniform Building Code, is in common use in the Western United States and focuses on protection of the occupants. In the area of the Nisqually earthquake, there were 14 structures with control systems that were affected by the earthquake. Although not all of the control systems were activated by the quake, in those that were activated, all of the structures remained fully functional after the quake.

Summary and Discussion

It is impossible to directly compare the resultant effects of the earthquakes that occurred in Gujarat, India, and Washington, USA because of the dramatically different geological settings, the differences in earthquake magnitude (the Bhuj earthquake released more than 32 times the energy of the Nisqually earthquake), and the depths of the two events (Bhuj earthquake- 23.6 km versus Nisqually earthquake - 52 km). One can however observe the dramatic differences in earthquake preparedness. In Washington State, the federal, state, and local governments are making earnest attempts to retrofit old structures, effectively legislate and enforce seismic building codes for new construction, and educate the public. To meet this need, several group have been formed to address earthquake issues. For example, one group, Contingency Planning and Recovery Management (CPARM), was originally a public/private collaboration and is now part of Seattle's larger disaster program, Project Impact, which is sponsored by the Federal Emergency Management Agency. Seattle's Project Impact is a public-private partnership whose overall goal is to make communities more resistant to the damaging effects of disasters. Project Impact encourages people to take action before a disaster occurs through initiatives promoting safer homes, schools, businesses, and better earthquake and landslide hazard mapping. Perhaps, the people living in Washington State have learned much from the experience of its nearby neighbors in California State, where earthquake events and mitigation are a common way of life.

The conditions in India, on the other hand, are much more challenging because of the less formal approach of integrating the engineering profession into the construction industry, the lack of seismic building code enforcement options, and the myriad of buildings that exist, which are already structurally deficient. The key to improving conditions in India is to develop and implement a long-range plan that effectively utilizes the knowledgeable engineering professions (which already exist in the country), develop comprehensive up-to-date hazard maps and enforceable seismic building codes and diligent construction inspections, and educate the public about earthquake hazards, and sensible methods of mitigation. An Indian educator summarized the nature of the problem in India succinctly. "Earthquakes don't kill people; it is the structures built by man that kill people. With frequent reminders of moderate earthquakes staring into our eyes, India is at the crossroads of earthquake preparedness. It has only two options to choose from - prepare now or pay later." (Murty 1998).

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SUPPRESSION OF POWERFUL CLOUDS AND PREVENTION OF DESTRUCTIVE TROPICAL AND EXTRATROPICAL CYCLONES, SEVERE THUNDERSTORMS, TORNADOES, AND CATASTROPHIC FLOODS

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Keywords: suppression, prevention, thundercloud, tornado, hurricane

Abstract

Tropical cyclones and storms, hurricanes, powerful thunderclouds, which generate tornadoes, destructive extratropical cyclones, which result in catastrophic floods, are the powerful cloud systems that contain huge amounts of water. According to the hypothesis proposed in this paper, an electric field coupled with powerful clouds and electric forces play a cardinal role in supporting this huge mass of water at a high altitude in the troposphere and in the stability of powerful clouds, sometimes during rather a long time duration. Based on this hypothesis, a highly effective method of volume electric charge neutralization of powerful clouds is proposed. It results in a decrease in an electric field, a sudden increase in precipitation, and subsequent degradation of powerful clouds. This method, based on the natural phenomenon, ensures the prevention of the intensification of tropical and extratropical cyclones and their transition to the storm and hurricane (typhoon) stages, which makes it possible as well to avoid catastrophic floods. It also ensures the suppression of severe thunderclouds, which, in turn, eliminates the development of dangerous thunderstorms and the possibility of the emergence and intensification of tornadoes.

1. Introduction

Destructive tropical storms, hurricanes (in the Atlantic Ocean), typhoons (in the Pacific Ocean), tornadoes, severe thunderstorms, and extratropical cyclones and storms result in catastrophic floods, death and injury, and result in huge material damage in many countries. Here are several examples. On 22-27 August 1992, the Hurricane Andrew, with a wind speed up to 280 km per hour, passed over the Bahamas, southern Florida and Louisiana, causing improbable destruction. "Andrew's legacy is appalling: 62 dead, 160000 homeless, property damage estimated at $30 billion..." (Becker, 1993). The total number of deaths attributed to the devastating Hurricane Mitch, a category 5 monster with a wind of more than 320 km per hour, during its two weeks of life (21 October-5 November 1998) is estimated at 11 000. It also resulted in huge damage in the Central American countries of Honduras, Guatemala, and Nicaragua.

In addition, up to 2000 tornadoes are observed annually on the Earth. More than half make land fall in the United States. The most fearful example is the Tri-State Tornado on 18 March 1925 that passed along southern Missouri, southern Illinois, and southwest Indiana, and killed 698 people.

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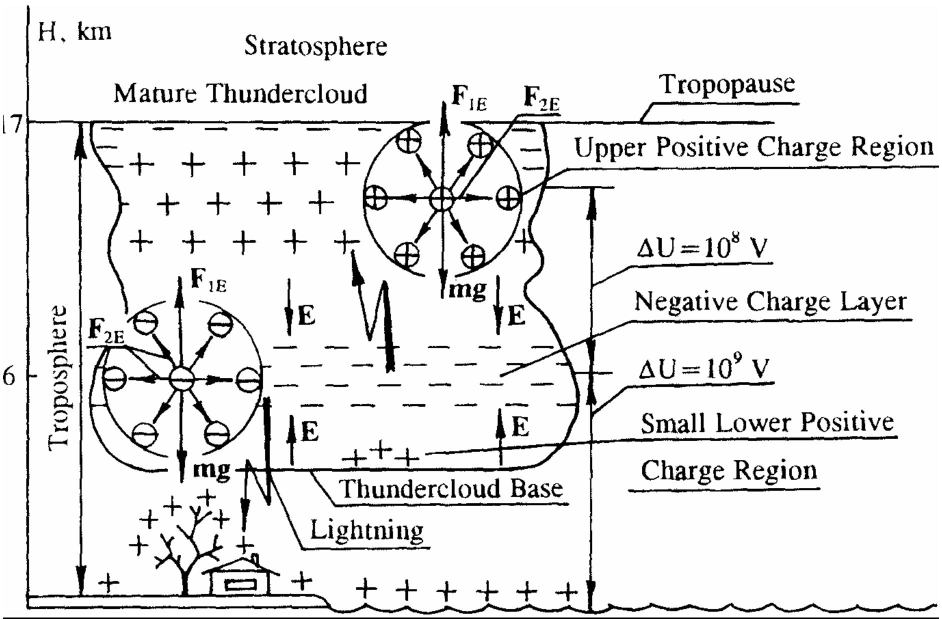
Severe thunderstorms also present a serious problem since they result in deaths from lightning, fires, aircraft crashes, power plant damages, and so on. The destruction and the large number of deaths are caused annually by catastrophic floods brought about by abundant and long-lasting rains, drenching continents, and from oceans brought about powerful extratropical cyclones and storms. The catastrophic flood of July-August 1993 in the midwestern United States claimed 40 lives, and the cumulative damage was $45 billion. In July-August 1997, much more damage was caused by the catastrophic flood in Europe (especially in Germany, Poland, and the Czech Republic). In October-December 2000, the destructive extratropical cyclones and storms resulted in devastating floods, deaths, and huge damage in England, France, Germany, Portugal, Spain, and other countries in Europe. The previous examples show that these awful phenomena result annually in thousands of deaths, destruction, and damage in excess of billions of dollars. A legitimate question is whether there is a possibility to prevent the beginnings and formation of tornadoes, the intensification of tropical cyclones, and to facilitate their transfer to the storm and hurricane stages, and to suppress dangerous thunderstorms. The answer from the author's point of view must be undoubtedly positive. But in order to develop an effective method and means for the prevention of these destructive phenomena, scientists must completely understand their physical nature. Thus, a specific question is in order: "Is there a definite understanding by the scientists concerning the physical nature of intense atmospheric vortices (tropical cyclones, hurricanes, and tornadoes)?"

The answer has been given by the leading scientists working in this field. Here are several of their affirmations. Ooyama (1982), "At times, communication among investigators has seemed to have presented as difficult a problem as the tropical cyclone itself. Some views of the theoretical progress are misleading"; Davies-Jones (1995), "The storms that spawn twisters are now largely understood, but mysteries still remain about how these violent vortices form." and "we have yet to pin down why tornadoes are the result of surface friction. This observation seems paradoxical because friction generally reduces wind speeds"; Snow (1984), "In spite of such recent advances, understanding of tornadoes remains in some ways quite limited. There also seem to be several other processes that can yield the concentration of spin needed to generate a tornado, and the details of these mechanisms and the relations among them remain puzzling." In order to describe the intensification of tropical cyclones and tornadoes, many completely different models have been proposed which are based on principally different physical processes. Evidently, there is a doubt about the adequacy of the models proposed since all of them still describe one and the same phenomenon. Moreover, they all contradict the observational data. For example, according to Snow (1984), "Tornadoes form in the updrafts of thunderstorms", and Davies-Jones (1995), "A region of updraft one to three miles in radius may begin to rotate with wind speeds of 50 miles per hour or more, forming a mesocyclone. The storm may then develop low-level rotation and even a tornado". At the same time, they assert, "Doppler radar observations have shown that the rotation begins in the mid-troposphere, at altitudes of four to eight kilometers. Once the rotation has begun at mid-levels, it builds down toward the ground" (Snow, 1984), and "the first Doppler measurements were confirmed in 1971. This circulation, first apparent at a height of about three miles, is followed by rotation at much lower levels, preceding the development of any intense tornado" (Davies-Jones, 1995). Here, another question is in order: "Which assertion is correct?" These contradictory statements reflect the current condition of the understanding of the physical nature of intense atmospheric vortices. From the author's point of view, this nebulous situation has quite an explainable basis.

It may be a paradox, but contemporary meteorology has been divided in two completely detached parts. The first one is "traditional meteorology" which analyzes the intensification processes of tropical cyclones and tornadoes (and other processes in the troposphere) considering thermodynamic and hydrodynamic processes only. The second part is the electrophysics of the troposphere and the electric features of clouds. It is very surprising, but the first part does not consider nor account for the occasional abnormal electric features of powerful clouds and the processes caused by the action of strong electric fields coupled with the clouds. So, for example, the maximum electric potential gradient in thunderclouds reaches 1.5 x 10^6 V/m (Chalmers, 1967). At this value, 1 m^3 of air containing water drops and ice crystals with an electric charge density ρ = 5 x 10^{-5} cm^{-3} at the height of 5 km has the acceleration (e.g. directed downward) of **a** = 97.4 ms^{-2}. The total electric charge (of any sign) of an average sized hurricane amounts to 10^{10} C, which is more than 17000 times as large as the Earth's total electric charge (Krasilnikov, 1997). These

Fig. 1. Structure scheme of a single mature thundercloud cell (forces acting onto charged particles located in middle of circles are shown).



Ground Surface

Ocean Surface

abnormal electrical properties are obviously observed nowhere else in the Earth's nature. Thus, electric and electromagnetic forces could be greater than all other forces. This circumstance completely eliminates the possibility of an understanding of physical nature with respect to the processes that stipulate the intensification of tropical and extratropical cyclones and tornadoes. This, in turn, rules out the possibility of any adequate physical and mathematical model development. To confirm the aforementioned discrepancy, one notably expository example is considered further. According to the concept accepted in traditional meteorology, during the formation of any powerful cloud, the temperature of the moist air lifted upwards from the ocean (sea, lake) surface changes adiabatically. The measurement data of the air temperature in the upper part of the powerful clouds have shown that it is much lower than the temperature calculated in conformity with the adiabatic process. For an explanation of this discrepancy, a hypothesis has been accepted about entrainment of dry and cold air from the cloud environment that ostensibly absorbs the thermal energy, thereby reducing the temperature of the warm moist air (Sedunov et al., 1991). However, during the formation of any cloud, an electric field coupled with it appears and strengthens as the cloud increases. The electric field energy of a mature thundercloud cell (Fig. 1) with the electric charge (of any sign) q = 1400 C (Wormel, 1953) amounts to $W_E \approx 10^{12}$ J. Where has this energy come from? Undoubtedly, this energy is subtracted from the energy released in the process of vapor condensation and in the transition of water drops to ice crystals in a cloud. This is indeed the real and only cause that explains the aforementioned temperature discrepancy.

Consequently, a hypothesis is proposed that an electric field coupled with powerful clouds plays a cardinal role in their formation and stability. Based on this theory, an effective method of the neutralization of a volume electric charge of powerful clouds is suggested. This method, based on

Table 1. Comparison of electric force and gravity

r, mm	q, C	E, V/m	mg , N (water)	mg , N (ice)	F_E, N
1.5	$2.25x10^{-9}$	10^6	$1.39x10^{-4}$	$1.27x10^4$	$2,25x10^{-3}$
1.0	10^{-9}	10^5	$4.11x10^{-5}$	$3.77x10^{-5}$	10^{-4}
0.5	$2.5x10^{-ll}$	$5x10^4$	$5.14x10^{-6}$	$4.71x10^{-6}$	$1.25x10^{-5}$
0.1	10^{-11}	$5x10^3$	$4.11x10^{-8}$	$3.77x10^{-8}$	$5x10^{-8}$
0.05	$2.5x10^{-12}$	$2.5x10^3$	$5.14x10^{-9}$	$4.71 x10^{-9}$	$6.25x10^{-9}$
0.01	10^{-13}	$2x10^2$	$4.11x10^{-11}$	$5x10^{-11}$	$3.77x10^{-8}$

r is the particle radius; q is the particle electric charge;
E is the electric field strength; F_E is the electric force directed vertically upward.

the natural phenomenon, ensures the prevention of the intensification of tropical and extratropical cyclones and their transition to the storm and hurricane (typhoon) stages, which makes it possible to avoid catastrophic floods. In addition, it ensures the suppression of severe thunderclouds, which, in turn, eliminates the development of dangerous thunderstorms and the possibility of the emergence and intensification of tornadoes.

2. Action of electric forces in clouds

The electric field in the Earth's atmosphere is known to exist in the absence of clouds. At an altitude of 6 km, the electric potential reaches 2.2 x 10^5 V (Clark, 1957). However, during the arising and increasing of any cloud, an electric field coupled with it is formed and strengthened. Many studies have been conducted into the nature of this electric field. This problem includes three main aspects. The first two are related to the processes of the formation and separation of electric charges in the clouds. In spite of extensive and prolonged studies (Chalmers, 1967; Workman, 1950; Vonnegut, 1953), there is still no common viewpoint with respect to the mechanism of electric charge formation during cloud formation and with respect to the process of their separation. However, numerous studies of the third aspect show that the electric structure of a mature thundercloud (Fig. 1) is the tripole one (Chalmers, 1967; Williams, 1989; Byrne et al., 1989). At an altitude of about 6 km (according to different authors, the range is from 3 to 8 km; Chalmers, 1967) above the Earth's surface, where the air temperature is about -15° C, there is the center of the negatively charged layer. Its height, as a rule, does not exceed 1 km. The positively charged area occupies the upper part of a thundercloud. The third small positively charged area is placed in the very lower part of a thundercloud (the reason for its formation is not established yet). The Earth's surface under a thundercloud has an induced positive charge. The potential difference between the negatively charged layer and the ground surface is 10^9 V, and between the negatively charged layer and the top part of a thundercloud (Fig. 1) is 10^8 V (Shonland, 1964). Inside a thundercloud, the largest values of the electric potential gradient are located at the upper and caudal boundaries of the negatively charged layer and change from 1.5 x 10^5 to 2 x 10^6 V/m (Norinder and Salka, 1951; Imianitov et al., 1971; Ziegler and MacGorman, 1994; Marshall and Rust, 1995). These values correspond to the conditions where lightning takes place. Data of measurements and estimates of the maximum volume electric charge density in thunderclouds attain values in the range of 10^{-9} - 10^{-4} cm^{-3} (Byrne et al., 1989; Imianitov et al., 1971; Ziegler and MacGorman, 1994; Matveev, 1984). It should be noted that measurement data about the electric features of clouds in tornadoes and hurricanes are completely absent. Powerful clouds contain a huge amount of water in the form of drops, vapor, and ice crystals. For instance, according to Riehl (1979), the volume of water absorbed in a hurricane of an average size with the radius $R \sim 500$ km from the ocean's surface per day amounts to 16 km^3, which is equivalent to the Colorado River's annual runoff. This corresponds to the mass of water equal to 16 billion tons per day and the overall hurricane's water mass reaches 10^{12} tons. The apparent question follows: "What forces support this huge mass of water at a high altitude in the troposphere?" The answer is obvious, "It is the force of an electric field coupled with powerful clouds".

The aforementioned values correspond to powerful thunderclouds. From the author's point of view, the role that an electric field plays in the formation, development, and stability of powerful clouds to date has not been understood. In connection with this, a hypothesis is proposed here: any cloud can exist only if there is enough of a strong electric field coupled with it. Herewith, the electric field strength increases proportionally to a cloud capacity. The main force supporting a huge mass of water in powerful clouds (in the form of vapor, drops, and ice crystals) at a high altitude in the troposphere is the force of an electric field directed vertically upward. This force ensures the stability of any cloud which can last for a long time. In addition, in the negatively charged layer and the positively charged area, the repulsive (Coulomb) force acts, which, in turn, prevents the development of the coagulation process which, in turn, conduces the stability of the clouds as well.

Table 2. Estimation of vertical wind

r, mm	H, km	T, K	ρ_{air}, kg m^{-3}	$\nu \times 10^{-4}$, m^2 s^{-1}	C_w	Re_d	W_{vert}, m/s
0.25	5	256	0.736	0.221	1.4	57.0	2.52
0.25	10	223	0.414	0.351	1.75	42.8	3.0
0.25	15	219	0.2	1.250	3.2	12.8	3.2
0.5	5	256	0.736	0.221	0.8	213.2	4.7
0.5	10	223	0.414	0.351	0.82	176.6	6.2
0.5	15	219	0.2	1.250	1.5	52.8	6.6
1.0	5	256	0.736	0.221	0.52	748.0	8.27
1.0	10	223	0.414	0.351	0.53	622.2	10.9
1.0	15	219	0.2	1.250	0.775	207.9	13.0
1.5	5	256	0.736	0.221	0.395	1577.2	11.5
1.5	10	223	0.414	0.351	0.395	1324.8	15.5
1.5	15	219	0.2	1.250	0.54	457.5	19.1

r- is the drop's radius; H is the height in the troposphere; T and ρ_{air} are the temperature and air density at the height H*;* ν is kinematic viscosity; C_w is the resistance coefficient; Re is the Reynolds number; W_{vert} is the vertical wind speed.

To confirm the hypothesis proposed here, the comparison of an electric force $\mathbf{F_E}$ and the gravity **mg** acting on particles in the clouds is presented (Table 1). The calculated values are based on measurement data of particle charges in the clouds (Gunn, 1947, 1950; Smith, 1955; Phillips and Kinzer, 1958), which gives the values in the range of $q = 10^{-13}$-10^{-9} C. The particles with a radius of r = 1 mm may exist at the electric field strength of $\mathbf{E} = 10^5$ V/m in Nimbostratus and Cumulonimbus. However, higher values of the potential gradient of an electric field and, therefore, of the force $\mathbf{F_E}$ may exist in thunderclouds. The smallest particles with r = 0.01 mm that exist at $\mathbf{E} = 5.0\text{x}10^2$ V/m correspond to conditions at the initial stage of the cloud formation or in small clouds.

It should be noted that according to the conventional viewpoint in meteorology, the abnormal mass of water in powerful clouds is supported at a high altitude in the troposphere only by updrafts rising upwards from the ocean and ground surface. Herewith, any powerful cloud from its emergence, up to its degradation, passes through three development stages. At the initial stage, updrafts dominate. The second stage is a period of cloud maturity, in which updrafts play a dominant role, but downdrafts appear as well. In the third stage, when degradation takes place, downdrafts dominate. This representation from the author's point of view is incorrect, in principle. In fact, at the initial stage, updrafts play the dominant role in the formation of clouds. But from the appearance of any cloud, an electric field coupled with it is formed and strengthened, along with an increase in cloud capacity and plays a cardinal role in the stability of clouds. As for the stage of maturity, the role of updrafts is not essential and, a fortiori, determinant. For the stability of powerful clouds at this stage, only the forces of the electric field have the main significance and the electric field determines the cloud's existence, which can last for a long time. The lifetime at this stage of both tropical and especially extratropical cyclones can amount to several days up to two weeks and more. For example, in July-August 1997, a powerful extratropical cyclone from the Atlantic passed over Europe during its maturity stage. The pathway was more than 1000 km up to Germany and more than 1500 km up to the Czech Republic and Poland, where it had brought abundant and continuous precipitation and caused a devastating flood.

Calculation results of the vertical wind required to support water drops and ice crystals in equilibrium in powerful clouds (Table 2) are the obvious disproof of the representation of the role of updrafts in classical meteorology. The results correspond to an equilibrium of a segregate water drop in the form of a sphere under the action of gravity **mg** and the aerodynamic resistance force $\mathbf{F}_{\mathbf{res}} == c_W \pi R^2 (\rho_{air} W_{vert}^2/2)$. The Archimed's buoyancy force was not accounted for due to its small value. Real ice crystals have forms corresponding to significantly higher values of the resistance force. It should be noted that 1 m^3 of air in powerful clouds contains several hundreds of particles (Sedunov et al., 1991) and under this condition vertical wind values must be significantly higher. The wind data shown in Table 2 represent the minimum limit values. The maximum limit value of the vertical wind can be evaluated if, for example, a hurricane is considered as an impenetrable

Table 3. Number of non-self-maintained discharges required to completely neutralize a volume electric charge of a powerful cloud

S,m²	E, V/m	Q , C	n
2.5xl0⁷	10⁴	4.4	0.15
2.5xl0⁷	10⁵	44.25	~1.5
2.5xl0⁷	5xl0⁵	221.25	~7.5
2.5xl0⁷	10⁶	442.5	~15.0
10⁸	10⁴	17.7	0.6
10⁸	10⁵	177.0	~6.0
10⁸	5xl0⁵	885.0	~30.0
10⁸	10⁶	1770.0	59.0

S is an area of a square in the horizontal plane; Q is the volume electric charge of a powerful cloud; N is a number of non-self-maintained discharges; E = 10^6 V/m corresponds to a thundercloud.

cylinder with the radius *R* = 200 km and a mass of water (vapor, drops, ice crystals) m = 10^{15} kg (Riehl, 1979). Equilibrium is achieved when $\mathbf{mg}=\pi R^2(\rho_{air}W_{vert}{}^2/2)$. The value of the vertical wind in this case amounts to 395 m/s. Obviously the real required vertical wind value must be higher than the minimum value and less than the maximum one, but in any case, it must be significantly higher than the vertical wind values observed in nature.

3. Annihilation of electric fields of powerful clouds

Tropical and extratropical cyclones and thunderclouds resulting in thunderstorms and generating tornadoes always represent conglomerations of powerful clouds which are coupled with strong electric fields. In nature, degradation of any cloud (according to the hypothesis proposed in this paper) is conditioned by the neutralization of its volume electric charge, which is realized by two different physical processes. The first is a coagulation process that is associated primarily with turbulence and the diffusion of charged particles in clouds. It should be emphasized that coagulation is the process that stipulates the infringement of a force balance and hence the intensification of precipitation and the degradation of nonthunderstorm clouds only. Action of this process continues for a long time. The second process is the lightning discharge, which ensures the neutralization of a volume electric charge in thunderclouds only. The lightning discharge represents the self-maintained discharge arising in a strong electric field (higher than 10^6 V/m) in conformity with the Paschen's law. The average charge neutralized by one lightning discharge is about 30 C and in very strong thunderstorms, it is up to 100 C (Wormel, 1953; Bruce and Golde, 1942; Shonland, 1964; Chalmers, 1967). The effectiveness of this natural neutralization mechanism is high. So in the last mature stage, after a period of intense lightning flashes, a sudden increase in precipitation with the subsequent degradation of the thundercloud is observed (Moore et al., 1962, 1964). Herewith, the total volume electric charge (negative or positive) of a single mature thundercloud cell amounts to 1400 C (Wormel, 1953). An estimation of an electric charge value of a powerful mature thundercloud on the basis of the Gauss' law ($\int Eds=q/\varepsilon_0$) at **E** = 10^6 V/m and the sizes in the horizontal plane S = 10^4 x 10^4 =10^8 m^2 amounts to Q = 1770 C, which agrees with the aforementioned value. So approximately 60 lightning discharges can completely neutralize the volume electric charge of the thundercloud. However, the neutralization of even a part of a powerful cloud's volume electric charge will inevitably result in an essential reduction of an electric field, the infringement of a balance of forces acting on charged particles in the vertical direction, and the partial or complete degradation of the thundercloud and cloud clusters of tropical and extratropical cyclones. This conclusion is very important, and it allows one to formulate a highly efficient method of the effect of powerful clouds. This method consists of the following.

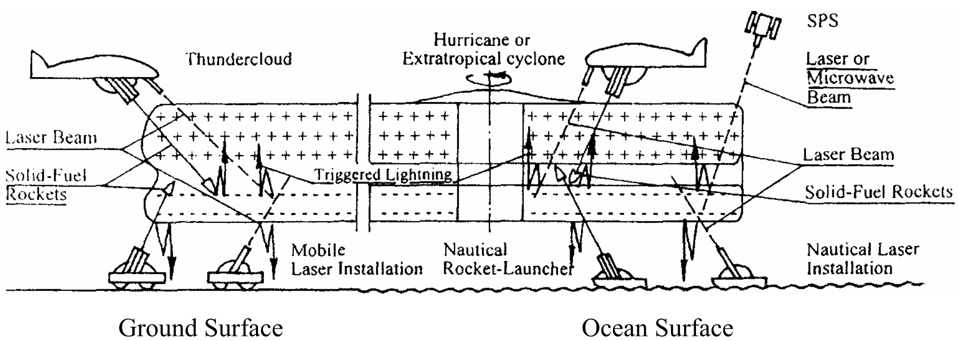
It is necessary to create a non-self-maintained discharge by the creation of an ionized zone with electrical conductivity in the interspace between the negatively charged layer and the Earth's surface, or between the negatively charged layer and the positively charged area in a powerful cloud. The number of non-self-maintained discharges must be enough to neutralize a necessary part of a volume electric charge of a powerful cloud in order to induce its partial or complete degradation. The non-self-maintained discharges will induce the process of neutralization of a volume electric charge of powerful clouds, which, in turn, will result in a decrease in an electric potential gradient and the force F_E, and as a consequence, the balance of forces acting on charged particles in the vertical direction will be destroyed. Further precipitation will be vastly increased with subsequent inevitable degradation of the thundercloud. The non-self-maintained discharge, from the viewpoint of electric charge neutralization, is similar to the natural lightning discharge, and the artificial ionized zone created by it is an analog of the "stepped leader", which represents the initial phase of the lightning discharge. The principal distinction exists in that the lightning discharge is formed when the potential gradient in the negatively charged layer attains 10^6 V/m and of more, whereas the artificial ionized zone will be able to produce the non-self-maintained discharge at considerably smaller values of the electric potential gradient. This conclusion is supported by two examples. When Saturn V with Appolo 12 was launched on 14 November 1969, it induced two triggered lightning discharges (Godfrey et al., 1970) inside a powerful cloud (it should be emphasized that it was not a thundercloud). The first lightning was induced near the caudal border and the second one was induced near the upper border of the negatively charged layer of the cloud. The Saturn V was not destroyed. The same effect was observed at the launching of the Atlas-Centaur 67 on 26 March 1987; however, in this case, the rocket was wrecked (Perala et al., 1987). To ensure the development of the non-self-maintained discharge in powerful clouds, several important conditions must be fulfilled. It is obvious that recommendations with respect to these conditions can be derived from numerous studies of lightning discharges (Chalmers, 1967; Wormel, 1953; Shonland, 1964; Workman et al., 1960; Kitagawa et al., 1962). The lightning discharge is known to begin with the "stepped leader" near the caudal and upper borders of the negatively charged layer, since at these points, maximum values of an electric field potential gradient takes place, where a maximum volume electric charge density occurs. The average length of the first step of the "stepped leader" amounts to 50 m. A channel diameter has values in the range of 0.2 - 16 cm, and its life duration is about 1 μs. So an artificial ionized zone, with a form of a beam (or any possible form) and approximately the same parameters, should be created to induce the non-self-maintained discharge. It should be located above the top border or below the caudal border of the negatively charged layer. However, since the ionized zone is placed in the strong electric field $\mathbf{E} = 10^4$-10^6 V/m, a triggered lightning can be initiated at some distances from the upper and caudal borders of the negatively charged layer. The simplest way of creating the focused ionized zone in the form of a beam is the launching of small solid-fuel rockets from the Earth's surface or the ocean's surface, or from airplanes or helicopters. A large number of similar solid-fuel rockets are launched annually at numerous fireworks. The exhaust gas has a rather high temperature and is weakly ionized. To increase the ionization degree of the exhaust gas, a very small amount of easily ionized material (e.g. potash) can be added in that part of a solid-fuel charge, which will form an ionized beam near the negatively charged layer. A solid-fuel rocket, with a thin metal wire following it, can be used as well. Such small rockets have been used in the lightning discharge studies (Newman, 1965; Horii, 1982; Idone et al., 1984; Eybert-Berard and Barret, 1984; Hubert et al., 1984; Horii and Sakurano, 1985; Akiyama et al., 1985). The average value of the electric charge transported by each triggered lightning discharge was 35-50 C (Newman, 1965; Hubert et al., 1984). Calculation results based on the Gauss' Law and a charge neutralized with one non-self-maintained discharge at 30 C (Table 3) show what number of solid-fuel rockets are required to completely neutralize a volume electric charge of a powerful cloud cell, but in fact, number of rockets must be significantly less. Efficiency of the method can be increased by the delivery of a batch containing several tens of small solid-fuel charges in the area of a negatively charged layer. Hereafter, they are launched from a batch at different angles to the normal.

A more effective way of creating non-self maintained discharges in powerful clouds is the use of focused beams of electromagnetic radiation in laser and microwave frequency ranges. There are many studies in this area (e.g. MacDon-ald, 1966; Zarin et al., 1996). An alternative electric field in these beams creates a high enough degree of ionization with the electron density up to $n_e = 10^{17}$ cm^{-3} (Zarin et al., 1996). It should be noted that permeability of the troposphere and especially clouds with respect to laser and microwave beams is the important problem. However, the atmosphere is known to be practically transparent for electromagnetic radiation in the range λ = 10-30 cm. For some types of lasers, the troposphere and to some extent clouds are also transparent (e.g. the florin-heavy hydrogen laser with the wavelength λ = 3.8 μm and the chemical laser on iodine with the wavelength λ = 1.3 μm). Some attempts have been undertaken to develop lasers (e.g. infrared and ultraviolet types, Diels et al., 1997) to produce triggered lightning discharges, but these types have notably poor permeability in the troposphere and especially in clouds. Another problem is the maximum power, which is required for the generation of a focused beam. The following example shows that the average power may be quite acceptable. If one accepts the diameter of a beam d = 10 cm and the specific power $P_S = 10^2$ Wcm^{-2} (which is enough for the initiation of a microwave discharge in the air, Zarin et al., 1996), then the power of the beam will be $P_{max} = 7.85 \times 10^3$ W. Furthermore, if the effective time of the pulse is τ_{ef} = 10 μs, the pulse period-to-pulse duration ratio is $S = 10^6$, and the efficiency of transformation and transmission of the energy is η= 1% then the average power will be P_{av} = 0.785 W.

4. Suppression of dangerous thunderclouds and prevention of tornadoes

Tornadoes are known to be generated by very powerful thunderclouds only that occupy in height sometimes practically the whole troposphere, up to the tropopause. Herewith, Doppler radar observations show that intense rotation in tornadoes begins in the mid-troposphere at altitudes approximately 6 km (Snow, 1984; Davies-Jones, 1995) in the area of the negatively charged layer. Formation and intensification of a tornado, as well as the formation of its runnel, are conditioned by the action of the electromagnetohydrodynamic (EMHD) mechanism (Krasilnikov, 1997), which emerges and develops inside, namely the negatively charged layer. Herewith, electric and

Fig. 2. Scheme showing influence means intended for suppression of powerful thunderclouds producing tornadoes (the left side) and for suppression of destructive tropical and and extratropical cyclones and prevention of hurricane development.



electromagnetic forces can determine these processes. But it should be emphasized that tornadoes are always generated by very powerful thunderclouds only. However, powerful thunderclouds generate dangerous thunderstorms, and they themselves represent serious danger. So about 10 000 severe thunderstorms are reported in the United States each year, and the resulting damage annually amounts to 1÷3 billion dollars (Golden and Snow, 1991). Therefore, the effect must be directed onto powerful thunderclouds directly in order to undoubtedly prevent tornado emergence and the decrease in thundercloud power up to an innocuous level (or provide their complete degradation).

For the creation of non-self-maintained discharges in order to induce triggered lightning discharges, solid-fuel rockets or batches with many small solid-fuel charges and laser beams directed from the Earth's surface from mobile and stationary installations, or from airplanes or helicopters can be used (Fig. 2). The number of non-self-maintained discharges is determined by the size (in the horizontal plane) and power (a vertical size) of a thundercloud. For example, if the total volume negative electric charge of a powerful thundercloud amounts to 1400 C (Wormel, 1953), and one discharge neutralizes 30 C (Newman, 1965; Hubert et al., 1984), then it will be sufficient to create 25-30 non-self-maintained discharges simultaneously to ensure the complete degradation of the thundercloud, but in fact, this number must be significantly less.

5. Prevention of tropical and extratropical storms

Tropical cyclones are known to form in the narrow tropical zone. Riehl (1979) has formulated six conditions for the formation of tropical cyclones, one of the most important is in that the temperature of the ocean surface must not be less than 26-27° C. Riehl has emphasized that these conditions are necessary but not sufficient conditions. Therefore, they realization is not enough for the formation and intensification of tropical cyclones and for the transition to the storm and humcane stages. For the intensification to occur, three additional conditions are necessary. These conditions are sufficient and are formulated as follows (Krasilnikov, 1997): first, it is necessary that the initial cyclonic disturbance emerge in a powerful cumulus, containing layers of charged particles with a high volume electric charge density. The second condition is that the initial cyclonic disturbance must be localized in the middle troposphere, at an altitude where the negatively charged layer is located, since this is the very area where the EMHD mechanism is realized to a maximum extent. Third, the initial cyclonic disturbance should not be too weak (the initial tangential velocity should not be less than 15-20 m/s). The probability of the simultaneous realization of all these conditions, including the additional ones, is extremely low. Therefore, from several thousand cloud clusters existing in the inner tropical zone on average, 40÷50 hurricanes and typhoons are formed annually (Riehl, 1979; McBride, 198 la, 1981b; McBride and Zehr, 1981).

The strongest winds are observed in the right frontal quadrant of cyclones, hurricanes, typhoons (Riehl, 1979), and in this part of a cyclone, non-self-maintained discharges should be created. The necessary number of these discharges depends on the power of a cloud system of a cyclone. For the initiation of triggered lightning discharges, solid-fuel rockets or batches with many small solid-fuel charges and laser beams (the most perspective means) directed from the ocean surface or from airplanes, and laser and microwave beams directed from a Space Power Station (e.g. similar to the SPS offered by Glaser (1968), but with vastly less power) can be used (Fig. 2).

Extratropical cyclones are known to form outside the tropical zone; they are formed more frequently (several thousands annually; Riehl, 1979) and have larger sizes than tropical cyclones. Therefore, attenuation or complete suppression of extratropical cyclones should be realized selectively, with a focus on only those that represent a danger as destructive storms or as possible sources of devastating floods. To influence extratropical cyclones, the same means as in the previous case should be used (Fig. 2); the influence should be directed to a powerful part of the cyclone at a distance from the coast, which is sufficient enough to provide the necessary degree 58 of attenuation. Degradation of an electric field will stipulate abundant precipitation and degradation of cyclone clouds and hence, a significant decrease in the rotating mass of the cyclone. Ultimately, this will cause considerable decrease in the mass of water in the cyclone, a reduction of its destructive power, or complete degradation.

6. Conclusion

A simple and highly effective method for the prevention of destructive tropical and extratropical cyclones, hurricanes, typhoons, tornadoes, and severe thunderstorms is proposed. This method is based on the mutual consideration of multiple studies on the electric properties of clouds and the concepts adopted in traditional meteorology. It should be emphasized that it is based on using of a natural phenomenon.

The main findings of the paper ensure an opportunity for transferring the problem of the prevention of destructive hurricanes, typhoons, extratropical cyclones, tornadoes, and dangerous thunderstorms to the practical area. The up-to-date technical level makes it possible to demonstrate the method presented in this paper (at least by using very simple solid-fuel rockets) immediately.

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Vladimir Gridin has a Dr. of Philosophy: 1972, Moscow State Aviation Institute and a Dr. of Science (Technical): 1985. He has held the Position of Professor: 1985, Dignity of Professor: 1989, and the Laureate of the Russian Presidents Stipend for distinguished scientists in 1999-2001. His area of Science Interests include Analysis and Modeling of Complicated Technical and Other Systems and Computer Aided Simulation of Complicated Systems. Prof. Gridin has published more than 130 papers and 5 monographs. He is the Director of R&D Center of Computer Aided Design, Russian Academy of Sciences and a member of specialized scientific councils of the All-Russian Attestation Commission. Prof. Gridin is a Professor at the Moscow Institute of Electronic and Mathematics (Technological University).

SECTION 10:

URBAN INFRASTRUCTURE & WATER

A CONCEPTUAL FRAMEWORK FOR ASSESSING ECONOMIC IMPACTS OF MITIGATION STRATEGIES ON WATER SYSTEMS

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The George Washington University

Keywords: civil infrastructure systems; water supply and distribution systems; earthquakes; disasters; life cycle cost; mitigation

Abstract

In the face of increased development, civil infrastructure systems are increasingly vulnerable to catastrophic failures as a result of aging, overuse and poor planning when disasters such as earthquakes strike. Water supply systems are among the most vulnerable infrastructure systems and, arguably the most essential for human existence. Investment decisions regarding the retrofitting or rehabilitation of the existing systems have long-term impacts on the amount of direct and indirect economic losses that would be incurred should catastrophic events occur. Owners of public structures are faced with choices and trade-offs concerning the costs of operation and maintenance, whether recurring or uncertain, as they seek to assure that those structures perform well over their planned life cycle and the total costs over that period will be reduced. This paper describes a framework for assessing the economic consequences of key investment decisions regarding mitigation against damage to water supply systems due to earthquake effects. The framework is implemented by means of prototypical software which employs algorithms that simulate earthquake occurrences and magnitudes based upon probability distributions and models damage and costs based upon empirical studies derived from the existing literature.

Introduction

Civil infrastructure systems in the US and elsewhere in the world are becoming more vulnerable to catastrophic failures when natural disasters such as earthquakes and floods strike. Water supply systems represent a particularly critical component of infrastructure as every stage of response and recovery is dependent on the supply of adequate amounts of fresh water as well as sanitary disposal of wastewater. Exposure, aging, misuse, overuse, mismanagement and neglect are the main reasons for deterioration and vulnerability to catastrophic failures (Hudson et al. 1997). There is generally a lack of a systems approach in public sector policies for operation and maintenance (O & M) that encompasses future uncertainties such as changes in use, ownership and disaster risk (National Research Council 1991). This paper describes a systems approach governing the O&M including retrofitting and rehabilitation that would provide cognizant agencies with a basis for planning, analysis and comparison for the purpose of mitigating losses associated with natural disasters.

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Although US building codes contain natural hazard provisions, they do not require one hundred percent resilient structures due to economic concerns. In conventional standards-based design approaches, there is a trade-off between cost and resiliency. However, designers and owners of public structures are still faced with choices and trade-offs between initial construction costs and O & M costs, whether recurring or uncertain, so that those structures perform well over their assumed life cycle and the total costs over that period will be minimized.

Public structures require important investment decisions in anticipation that the returns on such investment may continue for hundreds of years. In practice, however, publicly owned structures usually have been designed on the basis of low construction costs rather than true life-cycle costs that would include future retrofitting/ rehabilitating of components due to natural disasters (Hudson et al. 1997). Those publicly owned structural systems that are designed by considering certain life cycle costs usually have a missing component, which is the assessment of vulnerability in economic terms (Chang and Shinozuka 1995; Hawk and Eng 1998).

Background

The research and development needs in the area of critical infrastructure in the US were clearly pointed out in the 1st Critical Infrastructure Protection R&D Workshop that was held in August 1999. The Clinton Administration's Executive Order 13010, issued on July 15, 1996 established the Commission on Critical Infrastructure Protection in order to develop a national strategy for protecting infrastructures from various threats and to assure their continued operation. This later led to the Presidential Decision Directive (PDD63) of 1998. Water Supply Systems were named in the Executive Order 13010 as one of the three vital human services (VHS) along with emergency and government services. National experts from academia, government, and industry were brought together in an R&D workshop to review policies and identify needs and to make recommendations pertaining to the protection of critical infrastructure. They concluded that there is a lack of understanding of how individual elements are interconnected to form complex infrastructures and a lack of strategies to help determine priorities in restoring services back to their original use should catastrophic failures occur (OSTP and NIPC 1999).

According to the findings of a recent report on the nation's infrastructure assets issued by the American Society of Civil Engineers (ASCE 2001), the nation's 54,000 drinking water systems face staggering funding needs over the next 20 years -annual shortfall of at least $11 billion for replacing aging facilities- and those funding needs do not account for any growth in the demand for drinking water. The major problem is lack of strategies to replace and maintain the aging facilities that are near the end of their useful life. One of the specific policy recommendations made by ASCE on this issue is to encourage the use of life cycle cost analysis principles to evaluate the total costs of alternative actions.

The researcher hypothesized that there is a trade off between alternative mitigation policy options given the effects of future uncertain events on water systems. A framework was developed by the researcher in order to analyze and assess the long-term effects of those events on the system under different states as prescribed by those policy options.

This paper describes a framework that provides measured assessments of the effects of decisions made earlier in the life cycle to the overall resiliency of a water system and its future life cycle costs. Due to the fact that earthquakes have effects that are more significant on structures, especially underground networks consisting of buried pipelines, than any other hazard, the study presented here considers only earthquake risk but could easily be adapted for application towards LCC implications of other hazards.

The model is implemented by means of a computer program that allows rapid simulation of disaster effects on the life cycle cost (LCC) of the system based upon competing mitigation and response strategies.

Water Supply Failure Chain of Events

To describe what can go wrong resulting as a result of earthquakes, an illustrative approach was taken as a first step in the analysis. Shown below is the cause-effect path for disruption of water supply systems adapted by the researcher from a framework for probabilistic risk assessment of dynamic systems[2]. It illustrates the dynamics of mitigation as applied to water supply systems. Figure 1 shows the causes leading to a disruption of water supply service and Figure 2 shows the same concept together with appropriate control measures (interventions) that are applied at certain points along the causal chain to reduce the likelihood of causes leading to water supply disruption. The figures illustrate a systematic path of causes, effects, mitigating measures and potential remedies that come into play.

[2] The causal chain method (Harrald et al. 1999) has been effectively adapted and used by the researchers of the Institute for Crisis, Disaster and Risk Management of the George Washington University for maritime risk assessment.

Figure 1: Causal Chain Framework for Water Supply Disruption

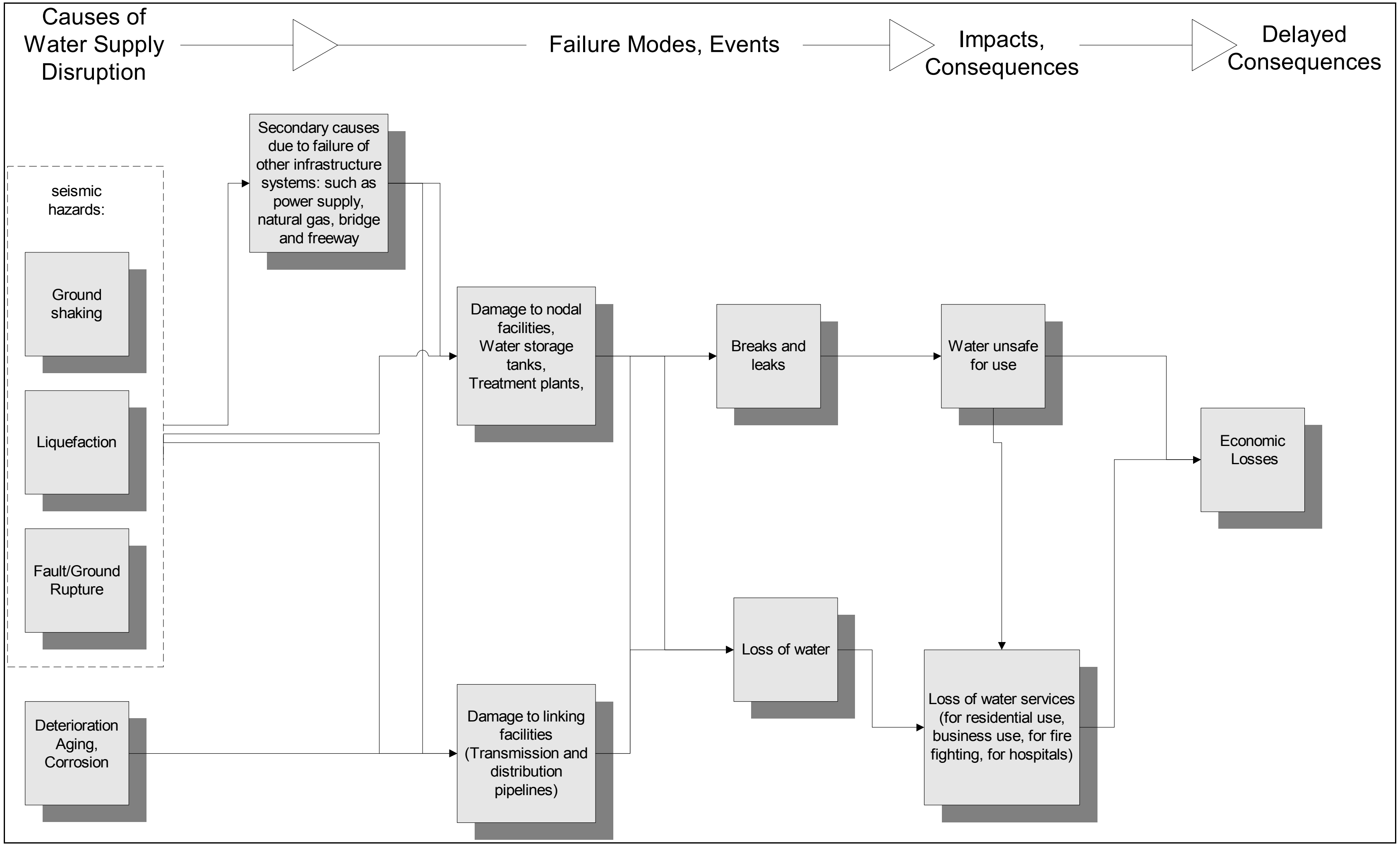
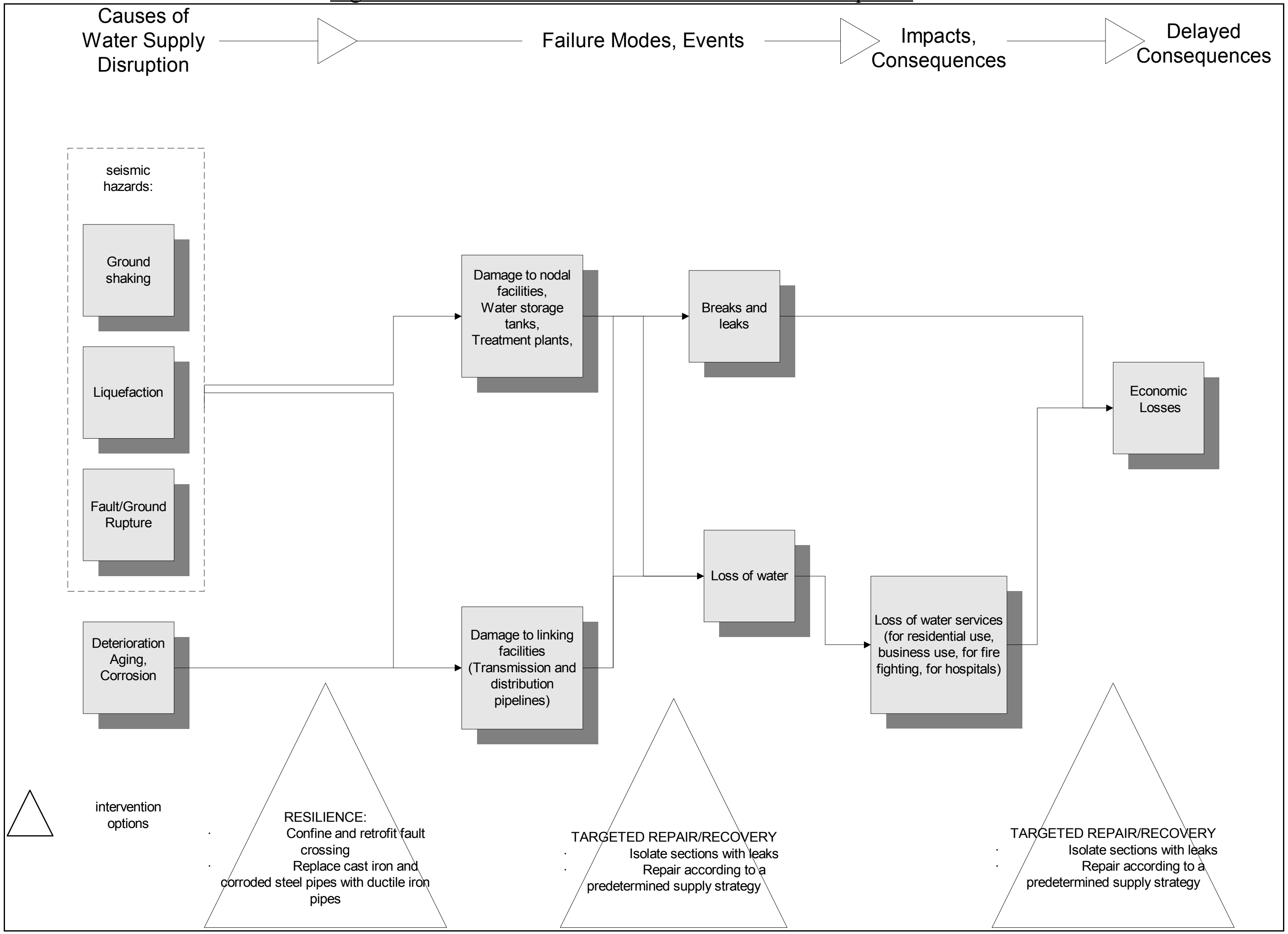


Figure 2: Causal Chain Framework with Intervention Options



Model for Simulation

A model was formulated and developed by the researcher in order to analyze and assess the long-term effects of uncertain seismic events on the water system under different states as prescribed by the following policy options:

Option 1: Do nothing now, wait until an earthquake strikes, and for failures to occur. Invest in targeted recovery only. (i.e. Repair the system as damage occurs).
Option 2: Do not wait for the earthquake and consequent failures to occur. Act now and upgrade the existing components that are deemed as weak against seismic forces (such as replacing corroded steel pipes with ductile iron or PVC pipes).
Option 3: Do not wait for the earthquake and consequent failures to occur. Act now and invest in redundant systems (pipelines and or alternative storage tanks) parallel to the existing facility.
Option 4: Invest in increased manpower and equipment to respond effectively in the event of an earthquake and decrease the time to restore the system (that would allow to lessen the unwanted economic impacts due to disruption of water service)
Option 5: Some combination of the above

The alternative strategies may consist of either one of the above or a combination depending on the system under consideration and depending on system O&M budgetary constraints. For each system under each option, the performance objectives should be stated. These performance objectives are used as postulates in order to be tested against the simulated failure results.

Computerized algorithms allow rapid simulation of disaster effects on life cycle cost (LCC) of the system based upon a wide range of potential economic and seismic input variables. The software simulation tool (LCCSim-Water1.0) performs the following functions:

- Simulates the occurrence of seismic events based upon a Poisson distribution of independent arrivals over the remaining economic life cycle of the water system
- Simulates the magnitude of seismic events based upon an exponential distribution
- Processes damage assessment on a link by link basis based upon pipe material, joint type, size, and soil type
- Performs present value cost analysis based upon direct and indirect costs, escalation factor, labor cost indexes and interest rate
- Conducts two different and separate modes of simulation 1) a one-time scenario simulation 2) repeated simulations in a Monte Carlo fashion of up to 1000 trials, over an extended time frame based upon a common set of water supply system data, earthquake distributions, damage models, and cost models.

This model includes only water transmission and distribution pipelines with different pipe characteristics (in terms of materials, size and age) and the effects of soil characteristics on pipes (corrosive or non-corrosive). It does not cover facilities that include storage tanks, treatment plants, pumping stations. Computing case specific damage patterns to these facilities that may include structural failures and mechanical failures (e.g. reliability issues of pumps) are left for future studies. Dams or source water facilities such as lakes, rivers, streams and wells are also left outside the scope of this study.

Historical evidence has shown that for buried pipelines, seismic hazards are twofold: 1) wave propagation hazards and/or 2) permanent ground deformation hazards. Wave propagation hazards (PGV) are characterized by the transient strain and curvature in the ground due to traveling wave effects. PGD (such as landslide, liquefaction induced lateral spread and seismic settlement) hazards are characterized by the amount, geometry and spatial extent of the PGD zone. The fault-crossing PGD hazard is characterized by the permanent horizontal and vertical offset at the fault and the pipe-fault intersectional angle (O'Rourke and Liu, 1999). The simulation model assumes that the damage to pipelines occur due to both PGV and PGD. The model simulates the damage patterns on water supply and distribution pipelines by means of the semi-empirical correlations between observed seismic damage and a measure of ground motion that were developed by Kamiyama et al. (1999) and Youd and Perkins (1987).

<u>Data Requirements</u>

The model requires data on seismicity of a sample region, system data parameters and cost data.

Relevant historical seismic data is obtained from the National Earthquake Information Center's seismology online database based upon input parameters of longitude and latitude, a timeframe that can extend backward over 200 years and a radius of activity that is relevant to the water supply system under consideration. The query result is a long list of earthquakes that occurred within the specified area with occurrence dates, latitude/longitude parameters of the epicenter, and magnitudes. This information condenses readily into average earthquake arrival rates and average earthquake magnitudes for use as input to the earthquake simulation module of the water supply system life cycle costing tool that will be developed for the proposed study.

Life Cycle Cost Parameters

The model considers the initial, recurring and emergency response costs in two categories similar to the categories that Hudson et al. (1997) used:
1. Agency costs, and
2. Non-agency costs

Agency costs are those costs that appear in agency's budget. They include:
1. Initial capital costs of construction (for the purposes of this research, only for redundant system construction)
2. Costs of maintenance, rehabilitation, renovation, and reconstruction (M, R&R): *Periodic (planned) maintenance*: *Cleaning and lining* (includes cost of excavation, bypass piping, valve replacements) and *Cathodic protection* (includes costs of testing, mobilization, anode material, installation, power lines, rectifiers, O&M labor and power), *Repairing of leaks and breaks, Pipe replacement*
3. Salvage return or retention residual value (may be a negative value) at the end of the analysis period,
4. Engineering and administrative costs
5. Costs of borrowing (if projects are not financed from current revenue)

Non-agency costs would typically be incurred by either users of the system or by non-users. For the case of water systems, they would include the following:

Non-agency costs (User Costs):
6. Disruption due to breaks and leaks
7. Disruption due to M, R & R activities

The decisions taken at some point in time will show their effects in the form of dollar losses, given future earthquakes. The model allows adjustments for inflation indexes based on Engineering News Record's (ENR) Building and Construction Cost Indexes and an escalation rate is also factored in for forecasting future cost figures. The LCC is expressed in terms of present worth (PW). PW gives the amount of money required now to fund the alternative strategy for the entire analysis period. The discount rate is considered as the minimum real or net rate of return, after inflation, to be achieved by public sector investments (Office of Management and Budget 1972).

A detailed study on cost estimates for maintenance, repair and replacement of water distribution systems have been conducted by USACE (Walski 1984). The model draws upon the empirical relationships obtained by regression methods of that study. The cost modeling portion of the model relies upon certain constants that have dependencies on current labor and material costs and therefore provides the means for controlling or updating these constants or even treating them as variables impacting a long term LCC analysis.

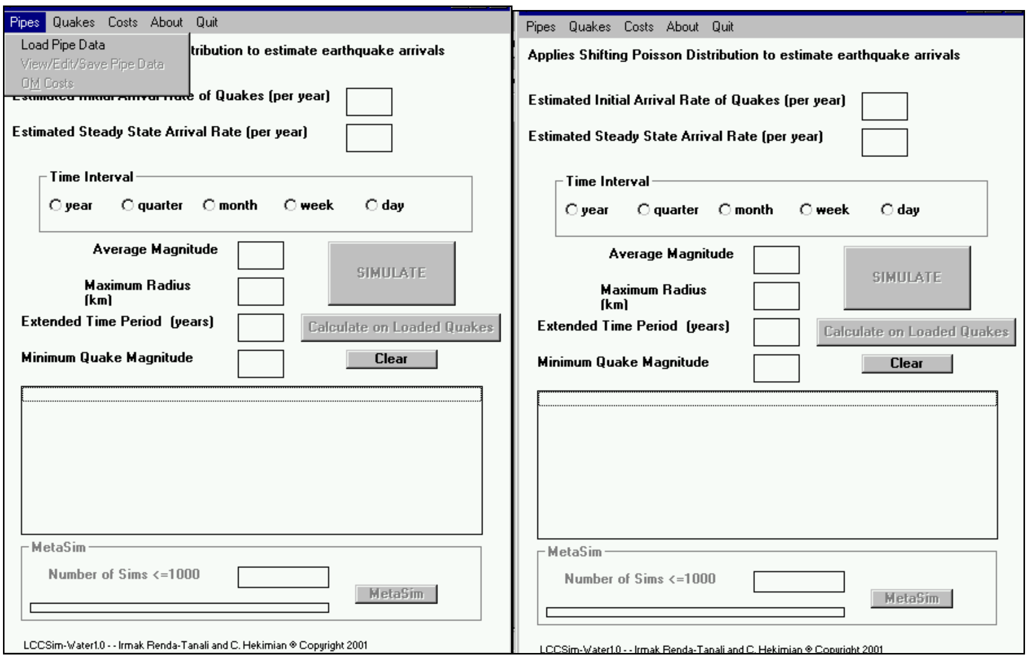
Inputs

In order to conduct the simulation of earthquake occurrence and the associated costs, the user enters the following input parameters related with the earthquake occurrence and damage prediction:

1) Pipe data
2) Estimated initial arrival rate of quakes per year (from historical records)
3) Estimated steady state arrival rate of quakes per year (from historical records)
4) Time interval that defines the granularity (default parameter is 'days')
5) Average magnitude (from historical records)
6) Maximum radius (based on a rule based judgment)
7) Extended time (the remaining life cycle of the existing system or the future time period that an economic analysis needs to be conducted)
8) Minimum quake magnitude (defining the magnitude threshold below which an earthquake is assumed to cause negligible damage)

Figure 3 below shows the input data view of LCCSim-Water1.0:

<u>Figure 3: Input Data View of LCCSim-Water1.0</u>



Outputs

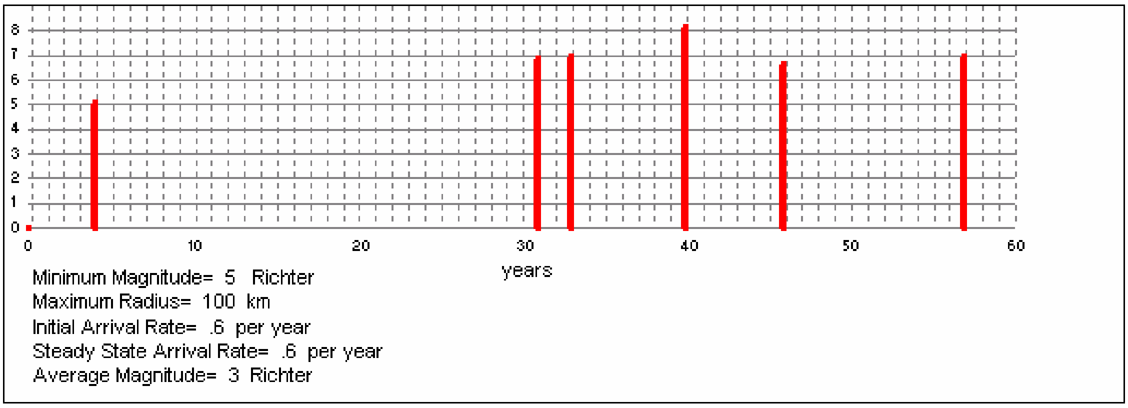
One-time Simulation

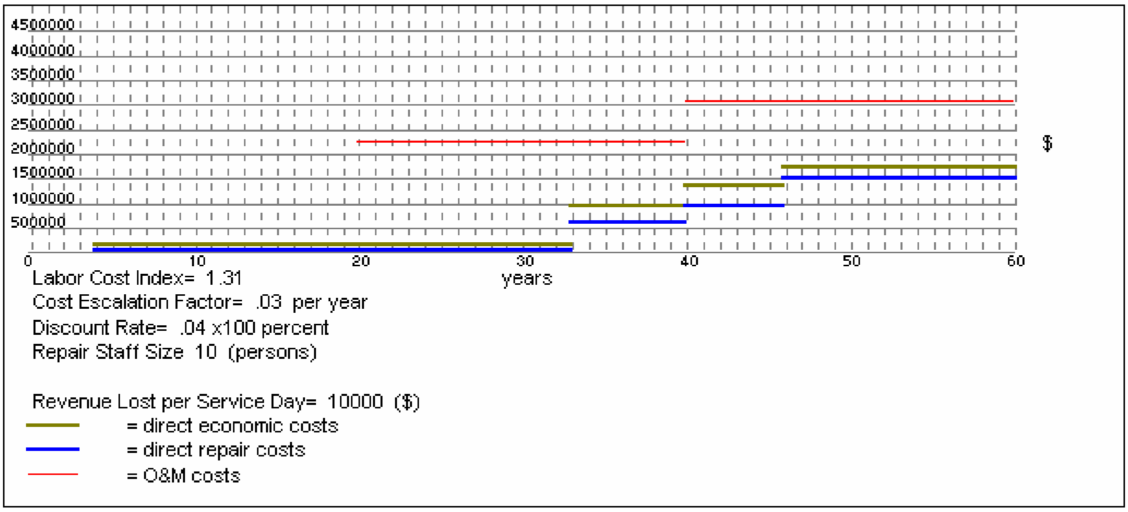
A simulation is run once for the remaining system life cycle, generating earthquake occurrences, magnitudes and distances from epicenter, all based upon their own probability distributions. Damage to pipelines is calculated based upon tabulated data and formulae governing peak ground velocities (PGV) and permanent ground deformations (PGD). The pipe damage in breaks/feet for each link is processed by the repair cost model. The total number of breaks for each link is calculated and its associated costs. The output includes the following:

1. The year and day on which each of the earthquakes occur, the corresponding magnitudes and distances from the source
2. For each earthquake within the system life span:
    - 2a) damage to the pipes, i.e. the number of breaks per thousand feet on a link by link basis
    - 2b) damage to the pipes, i.e. the number of breaks per thousand feet for each pipe type
    - 2c) total number of breaks for each pipe type
    - 2d) repair costs for each pipe type
    - 2e) direct economic losses (in dollar values) for each pipe type
    - 2f) total repair costs
    - 2g) total direct economic losses
3. Total direct costs of earthquake related loss
4. Total direct economic losses (in dollar values)
5. Total O&M Costs
6. A time-line plot of earthquakes showing date and magnitude
7. A plot of cumulative costs over the entire life cycle

Figure 4 shows the timeline plot of a sample scenario run and corresponding cumulative costs over a life cycle for a sample system.

Figure 4: Timeline Plot of a Sample Scenario Run





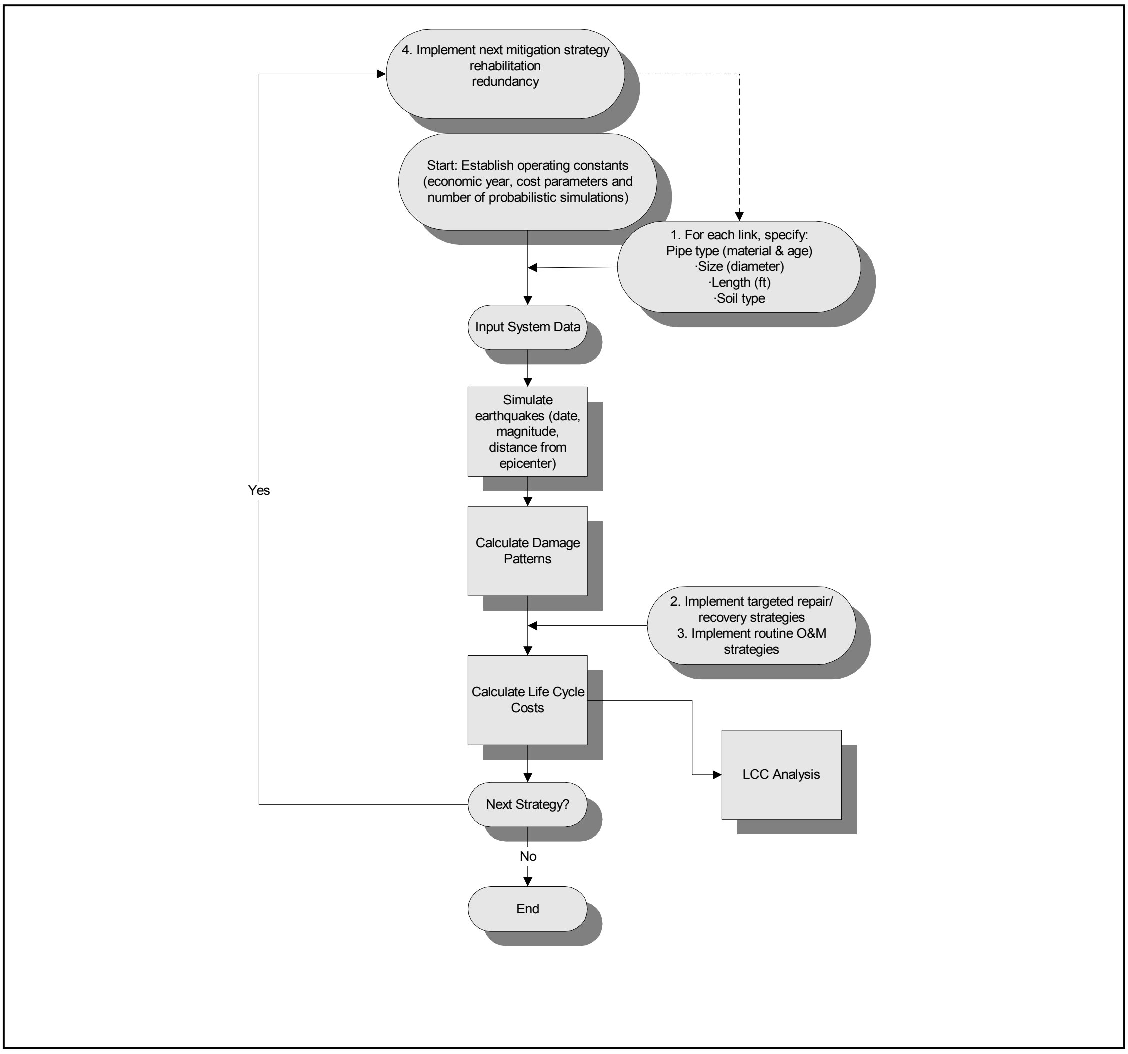
<u>Monte Carlo Simulation of Life Cycle Costs</u>

A Monte Carlo function processing up to 1000 one-time simulations at once is facilitated for the purpose of LCCA. Each simulation generates earthquake occurrences, magnitudes and distances from epicenter, all based upon their own probability distributions. Damage to pipelines is calculated based upon corresponding peak ground velocities (PGV) and permanent ground deformations (PGD). The damage output in breaks/feet for each link is then processed by the repair cost model. Each unit break is multiplied by the entire length of the link and by the unit cost of repair. The output includes:
1) The average radii (over X number of simulations)
2) Average magnitude with its variance
3) Average number of breaks per foot for each pipe type
4) Average total number of breaks
5) Average total repair cost per foot of pipe
6) Average total repair cost
7) Average total direct economic loss
8) Total cost of O&M
9) Average total costs

The simulation results can be used in order to:
1. Predict future system damage patterns
2. Predict future costs of operating and maintaining the systems
3. Compare competing mitigation strategies
4. Conduct sensitivity analysis

Figure 5 presents the algorithmic structure that was implemented for the one-time simulation. The Monte Carlo simulation feature allows the algorithms to be applied repetitively up to 1000 times while collecting the mean values and the deviances from the mean.

Figure 5: The Algorithm



Conclusions

The results of the research can be applied directly to decisions regarding retrofit of operational water supply systems in seismically active areas so as to support the concept of mitigation. The system effectively serves as a linkage between high level planners and operations level water supply systems responders. The model provides a repeatable and traceable avenue of accountability for decisions regarding water supply system repair and retrofit based upon clearly defined parameters. This model makes two unique contributions: 1) The research's perspective is that of the owner of a critical infrastructure and the results of the modeling will support the strategic decisions required as the infrastructure owner determines how to best deal with the risk of extreme events. 2) The perspective and methodology described in this paper, although demonstrated for water supply systems and earthquake risk, are applicable to other critical infrastructure and other threats including the threat of deliberate sabotage or attack. Methodologically, it integrates the disciplines of emergency management, engineering economy, and engineering towards a time critical problem. The analytical tool combines existing models for earthquake occurrence, ground motion and deformation, pipeline fragility, associated direct and indirect costs due to pipe damage and loss of service, and costs related to routine operation and maintenance. The system delivers life cycle cost specific data pertinent to decisions regarding repair and retrofit of water supply system components on a routine basis or after a catastrophic failure due to natural or man-made hazards in a seismically active region. The tool employs stochastic techniques that provide instant life cycle cost model results over extended time periods in such a way that critical response and recovery decisions can be made in the context of complete overall system life cycle. The integrated model supplies projected life cycle costs associated with competing investment strategies as directed towards system strengthening measures. The integration of the results of several models provide timely decision support for most advantageous return on mitigation investment. The perspective and methodology described in this paper, although demonstrated for water supply systems and earthquake risk, are applicable to other critical infrastructure and other threats including the threat of deliberate sabotage or attack.

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Note

This article was based on the author's doctoral dissertation work-in-progress entitled "*Life Cycle Cost Analysis of Water Systems as Critical Lifelines"* to be defended in Summer 2002 at the George Washington University Department of Engineering Management and Systems Engineering.

Acknowledgments

The author greatly acknowledges *Mr. Christopher Hekimian* for his technical assistance in regards to the development of the simulation model discussed in this paper.

Author Biography

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KNOWLEDGE MANAGEMENT, FLOODING, THE WATERSHED APPROACH AND THE CITY OF WATERLOO, ONTARIO, CANADA

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Keywords: Knowledge management, Laurel Creek watershed, City of Waterloo, flooding, watershed approach

Abstract

We apply a knowledge management perspective to explore how concern over flooding was folded into a holistic watershed approach in the City of Waterloo, Ontario, Canada. The framing of the Laurel Creek Watershed Study in the early 1990s is pivotal in defining flood mitigation as one of a suite of environmental concerns most effectively addressed by a comprehensive approach to watershed planning and management. Amending the City of Waterloo's Official Plan to incorporate recommendations from the Laurel Creek Watershed Study constitutes a milestone in using watershed planning to underpin municipal land use planning.

The significance of this research to the natural hazards community is twofold. First, it is novel in applying a knowledge management perspective to a natural hazards issue. Second, it explores how and why concern about a natural hazard, in this case flooding, becomes a non-stand alone issue in local agenda setting.

Introduction

In Canada, provincial statutes principally determine the responsibilities of local municipalities for water and related land management. Municipalities typically locate, store and distribute water for municipal use and maintain water distribution systems (Conservation Ontario 2001). In Ontario, municipalities through the Planning Act are responsible for local land use planning. Municipalities must be responsive to the element in the Act's Provincial Policy Statement requiring that:

> The quality and quantity of ground water and surface water and the function of sensitive ground water recharge/discharge areas, aquifers and headwaters will be protected or enhanced (Ontario 1997 9).

Long before the Provincial Policy Statement came into force, municipalities were sensitive to water concerns in their communities. Indeed, a number of communities in Ontario came into being as a direct result of the economic opportunities presented by exploiting local waters. For example, 110 kilometers southwest of Toronto, in 1808 Albert Erb built a dam for a sawmill on Laurel Creek that created Silver Lake. This was the beginning of UpTown Waterloo. With the creation of Waterloo

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Park, the area became a focus of community life, leading to the fairly rapid development and urbanization of the eastern half of the Laurel Creek watershed (Thomas 1992).

In this brief paper, we apply a knowledge management perspective to explore how concern over flooding was folded into a holistic watershed approach in the City of Waterloo, Ontario, Canada. We begin by discussing information and knowledge to highlight Innes' (1998) idea of employing information as a lens for viewing policy issues. Highly selected, episodes in the history of the City of Waterloo are presented as a background to the Laurel Creek Watershed Study. This study has proved pivotal in defining flood mitigation as one of a suite of environmental concerns most effectively addressed by a comprehensive approach to watershed planning and management. A decade later, the City is still guided in its planning and management by the recommendations from the study. In concluding, questions are raised from a knowledge management perspective about the implications of a holistic watershed approach for flood mitigation.

Information, knowledge decision making and influence

Information according to Peter Drucker (1989 209) "is data endowed with relevance and purpose." Albert Simard (2000) defines knowledge as new understanding derived from synthesizing information from multiple sources. In a decision making context, knowledge comes from putting information into productive use, from making information actionable.

Bukowitz and Williams (1999) interpret knowledge management to be a means to help people share what they already know they know and about helping people share and articulate what they know but don't realize they know it. The lack of awareness of this knowledge by those who have it occurs because this knowledge is embedded in how they work and so has become routine and can be done without thinking about it. Innes (1998) argues that embedded information, information that is invisibly part of the assumptions and definitions of those who hold it, is the most influential form of information. Information then is a lens rather than what is viewed and formally evaluated. To become influential in policy, information must reflect socially constructed, shared understanding created by the actors in a policy community. The process of creating such understanding, in turn, can shape how people understand an issue and what they do about it (Innes 1998).

The City of Waterloo, flooding and the Laurel Creek Watershed Study

The Waterloo area in which Albert Erb settled in the early 1800s prospered. By 1848 there were nine operating grist mills and by the 1880s the number of operating mills in the area peaked at 48. By 1910 80% of the forest cover in the Laurel Creek Watershed was cleared to make way for agriculture. By 1946 increasing urbanization resulted in more problems with erosion and flooding (Trushinski 1992).

In the 1960s the primary interest of the City of Waterloo in Laurel Creek Watershed was flood control. As a result, in 1966 Laurel Creek Reservoir was built to provide flood water storage. At the same time, the harmful effect of pollution on all the areas through which water flowed was recognized (Bailey 1966).

In 1989 the City of Waterloo adopted an "Environment First" approach promoted by then Mayor Turnbull. The underlying philosophy of the approach was to consider potential environmental impacts before making recommendations and decisions. One outcome was to develop strategies that the City could employ, in areas where it had a fair amount of legal control, to enhance, protect and manage the natural environment (Trushinski 1991). The City went on to pursue its "Environment First" approach beyond what it could do on its own.

To develop a comprehensive watershed plan for Laurel Creek and its four tributaries; Monastry, Beaver, Clair, Cedar and Forwell Creeks, in 1991, the City of Waterloo joined in a roundtable partnership involving formal representation from the Grand River Conservation Authority, the Province of Ontario, Waterloo Region, the City of Kitchener, the Townships of Wilmot and Wellesley, Laurel Creek Citizen's Committee, the University of Waterloo, Trout Unlimited and the development industry (Thomas 1992). The overall purpose of the Laurel Creek Watershed Study was to comprehensively assess the natural resource features of the 74 km^2 watershed and the ecosystem functions they perform. The study was intended to guide local and regional authorities in planning land use development and in protecting, enhancing and rehabilitating the natural environment (Trushinski 1992).

The Laurel Creek Watershed Study was undertaken because of three concerns. One concern was that the negative impacts of past and current urban and rural land use development were adversely affecting the overall health of the watershed. The second concern was the potential for increased levels of flooding in the City of Waterloo, including UpTown, from new development upstream, such as on the City's west side. The third concern was the need for better understanding of the ecological connectivity and functioning of natural environments and land use so as to "avoid" negative impacts from further development (Trushinski 1992). In this paper, it is the second concern that will be highlighted.

The first of the watershed study's five goals was "To minimize the threat to life and the destruction of property and natural resources from flooding, and preserve or reestablish natural floodplain hydrologic functions" (Thomas 1992 6, 11). The roundtable identified several areas where storm events could lead to risk to life and property damage. This situation arose from building in the floodplain and flow surges caused by development lacking stormwater management. Ten flood damage areas were identified in the watershed; the most significant in terms of buildings exposed to flood risk was UpTown Waterloo. The roundtable recognized that existing reservoirs feature in controlling flood risk, that natural storage areas in the upper watershed helped to reduce downstream flooding and that the natural floodplain contributed to controlling flood flows. Runoff from existing urban areas was identified as a major cause of flooding in UpTown Waterloo. Unless runoff flows, volume and timing were controlled effectively, the roundtable thought new development on Waterloo's west side or in the neighboring Townships would increase flooding (Thomas 1992).

The roundtable made a series of recommendations to address flooding (Thomas 1992);
1) To reduce flood risk at ten flood prone sites using structural or non-structural measures, including stream rehabilitation and restoration, roadway culvert replacement, storage, flood proofing and land use policies,
2) Not to permit new development that would be subject to flood damage except as laid out in the Special Policy Area policies,
3) To carry out subwatershed studies and stormwater management plans as part of development plans. These studies should demonstrate
   a) that as specified in the Laurel Creek Watershed Study, stormwater management for the proposed development meet watershed flow targets, such as peak, volume and timing, and
   b) that an increase in flooding in any of the flood prone areas, including UpTown Waterloo will not be caused by flows from the development,
4) Incorporate infiltration practices into stormwater management plans for new development and retrofit in existing development. Emphasize source controls,
5) Design stormwater management plans in new urban development areas to maintain existing flow characteristics and to emphasize at source controls and infiltration,
6) Undertake sub-watershed studies as communities are planned, and
7) To not build on the floodplain when undertaking new development.

Recommendations from the Laurel Creek Watershed Study were incorporated into the official plan for the City of Waterloo via an official plan amendment completed in 1994. As a result, City of Waterloo land-use and planning decisions are integrated with watershed management because all new district plans, new draft plans to subdivisions, the zoning bylaws, and site plan approval guidelines must correspond to the approved watershed policies (Joliat 1999 16-17).

The Laurel Creek Watershed Study, the watershed approach, flooding and knowledge

The year and a half long Laurel Creek Watershed Study was a landmark knowledge management exercise. The Study has enduring implications for how the City of Waterloo approaches watershed management and the ecological functioning of natural environments throughout the City. A decade after the study's release, the City continues to be guided by its insights. By following through on the study's recommendations, new development has not necessarily increased the risk of flooding.

The Laurel Creek Watershed Study highlights how for a public issue, knowledge is a precondition for intervention (Handmer 1999). The study was a means to synthesize existing understanding by having people draw on their own individual and organizational knowledge as well as tapping into the understanding of other individuals and their organizations. People were able to share what they knew they knew and have others draw out knowledge that they may not have articulated previously in as receptive a forum as the roundtable. The study was also an opportunity to generate new knowledge about the functioning of the Laurel Creek Watershed.

The City of Waterloo, in adopting a watershed approach, as advocated in the Laurel Creek Watershed Study, has bundled its flooding concern with other water resources and land use management issues. One consequence has been the move away from tactics that narrowly "solve" one natural resource related concern in the City of Waterloo to strategies that address the multi faceted elements of ecological functioning. This is exemplified in the shift from channelizing streams as a means to reduce flooding to a multi-objective program of stream rehabilitation (McGoldrick 2002 personal communication). A more bounded example is retrofitting stormwater ponds initially designed to control water quantity to also control water quality. The flood element of a watershed approach may not be as easily distinguished as an identifiable agenda item as was flooding when there was less of an integrated approach to addressing water related concerns. It is unclear whether or not flooding information is successfully embedded in watershed policy. By successfully embedded we mean that it is influential because it has become part of the assumptions and definitions of those who hold that information (Innes 1998). Does the shared understanding of the watershed approach in the City of Waterloo, seamlessly and invisibly include flood awareness? Does it mean that individuals will have a higher tolerance for non-life threatening, economically insignificant flood events because of their awareness of the ecologically beneficial dimensions of disturbance?

Conclusion

Amending the City of Waterloo's Official Plan to incorporate recommendations from the Laurel Creek Watershed Study is a milestone in using watershed planning to underpin municipal land use planning (Trushinski 1993). It is a commitment by the City of Waterloo to recognize ecological reality and its implications in local government decision making. At the same time, employing a comprehensive approach to considering water resources has ramifications for the treatment of constituent concerns, such as flooding. For example, flood mitigation is treated as one of a number of environment related issues. "Solutions" to flooding are at best meant to enhance other watershed features, such as aquatic life, and at least not produce serious adverse consequences for other elements of ecological functioning. Watershed knowledge then becomes a synthesis of information drawn from different dimensions of watershed management. Ideally, the result of applying such knowledge is a synergistic approach to watershed management.

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Acknowledgments

The authors wish to acknowledge the assistance of Denise McGoldrick, Environmental Coordinator, Water Resources, City of Waterloo. An early draft of this paper was developed in the University of Waterloo course, Plan 474 Managing Knowledge for Environmental Stewardship.

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RISK ANALYSIS IN PLANNING: COMMUNITIES AND WATER EMERGENCIES

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Keywords: Potable water emergency, safe municipal water, protecting ground water

Abstract

Water emergencies are serious matters for municipalities and they are more than simply engineering problems. Health and business can be negatively effected and lives lost. This paper is centered on the broader risk aspects of potable municipal water supply. Selected risks associated with source of supply, bulk transmission, treatment and distribution are identified, and considerations for planners outlined. Planners can help assess risks and can take professional initiatives to manage parts of some of the risks through land use control, jurisdictional arrangements and information development.

Introduction:

There is increasing concern about the adequacy of municipal infrastructure that relates to managing water in communities. Water emergencies result from a variety of reasons and involve potable water, wastewater, storm water and flood considerations. In previous papers the author (Newkirk, 1995, 1996, 1997, 1999b, 2000) has discussed a number of planning issues related to storm water and floods. This paper centers its attention on planning issues related primarily to potable water supply and draws on the author's experience on risk assessment panels for large and small-scale municipal water supply systems. Municipalities are facing significant challenges with their potable water supply systems.

In Canada, one province (British Columbia) has at times had in excess of 100 communities under a "boil water" order at one time. Recently there have been high profile cases where break down of water treatment equipment and break down of procedure has led to significant illness in communities and loss of life. The most notable recent cases in Canada are North Battleford, Saskatchewan, and Walkerton, Ontario; in both cases large numbers of citizens fell seriously ill and in the latter case, a number of deaths occurred. This has resulted in two detailed, lengthy and costly judicial investigations: North Battleford (2001), and Walkerton, (2001).

It is a topic of another paper to delve into the detailed lessons learned through these inquiries. The reader will find extensive information available through the web sites identified in the references as well as a number of related web sites and the final reports. This paper takes a broader view of important considerations related to municipal water supplies and matters to be considered by planners.

Context:

In large part, the development and operation of municipal water systems historically has been seen as primarily an engineering matter. The focus has usually been on ensuring there is a reliable and robust water collection, treatment and distribution system. As a member of some water system risk assessment panels, the author has noted the engineering attention to reliability and safety often differs between large and smaller municipal systems. There also may be a significant difference in system operator education and training between systems of different scale. Generally, the large systems are supervised by professionals with more extensive qualifications. This can be a matter of concern since such a large number of individuals in North America live in small communities serviced by small water systems. Some of these matters are discussed in both inquieries mentioned previously. Yet, the water acquisition, treatment and distribution system is often viewed with benign neglect by citizens and their politicians alike; most attention seems to be directed to keeping water charges low.

Many components of water systems are underground and remote; consequently, they and the whole system are not usually noticed by citizens in their daily life. Systems are taken for granted. This has allowed governments to cut back on water system financing as part of on-going cost cutting exercises. For example, it is generally agreed that the Greater Boston Area water supply system was impoverished and was refused the right by local government to increase water rates to repair and improve systems until it was taken over as a State Agency. The new Massachusetts Water Resource Authority (MWRA) has made significant steps recently to reverse this situation – but only by removing the system from local control, injecting substantial funding, and undertaking major capital works.

With the exception of the serious North Battleford and Walkerton water contamination problems noted above, citizens are primarily only concerned if they are forced to conserve water due to shortage of supply. In many cases the public view of the water situation is that the engineers need to figure out how to increase the water supply yet not increase the price. There is clear evidence that there are steadily increasing problems with water source shortage. One need only consider the chronic water shortages in the American Midwest and South, the well water shortages in Southern Ontario, the reduction of stream and river flows due to climate change, and the record low levels of the Great Lakes to understand that there is a looming critical shortage of supply. Governments have been slow to protect water sources and generally have given water supply systems minimal attention.

Lack of local government attention has led to aged water facilities that are crumbling away out of sight. Water losses are very high in such poorly maintained systems; this exacerbates the supply shortage problems because a larger volume of water must be pumped and treated just to deal with losses in the transmission and distribution systems. We now explore some of the risks, risk context and planning implications related to source of supply, bulk transmission and pretreatment, treatment, and distribution. Excluded from this discussion are the very technical engineering and hydrological risks that must be managed by good engineering in system design, building, operation and maintenance.

Risk Considerations in Supply :

Water supply comes from a variety of sources that include: lakes, rivers, wells, springs, and oceans (via desalinization plants.) Risks facing the source of supply may be divided into long term and short term ones. Long term supply risks include reduction of water tables, lake levels and stream flows due to climate change, cumulative effects of long term pollution – including deposition of airborne contaminants, cumulative effects of land use in recharge areas and upper parts of watersheds, compromised aquifer recharge areas, engineering or system failures in adjacent waste water systems, and loss of jurisdictional authority over supply areas.

There are also risks associated with excessive water consumption. Demand outstripping supply clearly leads to short term supply problems that result in water use restrictions; these can go beyond inconveniencing domestic users to the extreme of shutting down industrial operations. This can lead to firms not choosing to locate in an area or moving to an alternative jurisdiction that provides a more reliable water supply. A serious concern arises when excessive demand on water sources permanently alters the nature of the source. For example, fresh water lenses used for municipal water supply lie atop salty-groundwater in Florida and Bermuda. As long as the supply aquifers can regenerate the fresh water lenses as fast or faster than consumption, a supply of fresh water will be provided. On the other hand, excessive consumption may lead to the complete loss of the fresh water lenses – leaving only brackish water unsuitable for normal potable water consumption. This problem is not limited to the two areas mentioned; there are many other geographical areas that share a similar ground water situation.

A related and very serious risk relates to the migration of contaminants in ground water aquifers that supply potable water. These contaminants may be natural, but more often are related to present or past industrial operations or garbage landfill sites. Since water flows to fill the areas where water table is drawn down by extraction to the surface, it only makes sense that the moving water may transport contaminants and pollute a previously good water source. The Region of Waterloo, Ontario, experienced this first hand in the Town of Elmira well system. The increasing water demand by this growing community drew sufficient water out of its wells to pull dangerous contaminants in ground water from the Uniroyal Chemical plant site into several potable water wells. These wells had to be permanently removed from use, emergency water arrangements made and expensive pipelines built. In large part, these migrating chemicals related to long ago industrial processes and clean-up processes still continue.

Risks of intentional (i.e., terrorist) or accidental pollution of water sources need consideration. These could result in short term removal of the supply source. For example, a transportation accident that pollutes a river used for municipal water supply. The possibility of long term or permanent loss of supply is more unlikely; engineers argue that the normal water volumes at sources makes it unlikely that sufficient quantities of pollutant could be introduced to cause long term loss. Of course, where the source of supply is small, e.g. a well, the matter is different as revealed in the Walkerton (2001) situation and the Elmira case mentioned above.

Risk Considerations in Raw Water Transmission

Many municipalities obtain their water supply from outside their own immediate area of jurisdiction. In some cases, there may be very long supply lines indeed. Some major cities in the United States and Canada rely completely on water sources hundreds if kilometers away. For example, the greater Boston area (with population in excess of 3 million) relies completely on inland lakes half way across the State of Massachusetts; the entire supply relies on transport through a gravity fed aqueduct that is over 100 years old. Risks in raw water transmission clearly relate to the integrity of the transmission system. Risks may be posed by extreme natural events (e.g., floods and earthquakes), by cross contamination from other (e.g., Petrochemical and sewerage) high-pressure pipelines due to leakage, by structural failure, by terrorism or vandalism, or by construction accidents. The extensive length of many transmission facilities implies risks due to difficulty in monitoring activity on or near the right of way and monitoring may be compromised if the water authority does not own or have full jurisdiction over the land where the facility is sited. While easements allow an authority to run its pipes through regions, they do not provide the kind of authority over land use activity on the right of way that is required. In many cases, rights of way were established long ago, and the authority is not fully knowledgeable on the legal status of its authority. This can lead to failure to enforce desirable protection of the transmission system.

Risk Considerations in Water Treatment

Most municipal water systems treat raw water to remove contaminants that can include: organics, viruses, bacteria, sediment, and chemicals. Often this is done in one or more factory-like facilities and involves the use of heavy equipment, pumps, filers, and, in many cases, dangerous chemicals. In municipalities that rely on a distributed set of wells as their source of supply, the water treatment takes place right at the wells. Water treatment facilities are large enough to be noticed but often ignored by neighbors. These facilities are normally located within built up areas; but they may be in out-of-the-way or industrial locations where there is little oversight by public and law enforcement over a full 24 hour period. Because modern equipment control and monitoring technology is now quite reliable, many of these systems operate without on-site human supervision. This exposes such systems to risks from tampering, vandalism or terrorism from intruders.

It is beyond the scope of this paper to deal with the technical aspects of treating water sufficiently to remove contaminants. Rather we consider the broader risks associated with water treatment. The following potential risks need assessment by system planners: plant failure due to very high demand and the following intentional or accidental events: loss of electrical power to the treatment equipment, equipment failure (e.g., screens, filters, pumps, biocide systems), monitoring failure, or chemical accident. Adequate monitoring of site integrity and processes is important to manage risks; in many cases there are enough dangerous chemicals stored on site at a water treatment plan to endanger nearby residents or workers.

Risk Considerations in Potable Water Distribution

Distribution of treated water to residences, commerce and industry involves a large network of trunk and local pipelines, valves, reservoirs and standpipes. High and low pressure systems are involved. Normally distribution areas are divided into zones that are supplied from several trunks. Many of these systems have been developed incrementally over long periods of time and may have a large mix of old and new technology – some in poor and some in good condition. Some parts require real-time monitoring and control, other parts operate independently and only receive attention on an exception (i.e., emergency) basis. It is beyond this paper to discuss the engineering design and operating aspects of these systems. Again, we consider here the wider set of risks – particularly those that relate to land use or activity on the land.

<u>Cross Contamination in Distribution:</u>

Water distribution systems coexist in close proximity to a wide variety of below-grade utilities. In some cases, sections of these systems are virtually "dead" areas with little or low flow. (These pose real problems in the event that a water distribution system needs to be decontaminated. The Walkerton case, it took several months to fully decontaminate the distribution system.) Proximity to the other below-grade services and the presence of some low pressure low flow water pipes exposes a risk of possible cross contamination from leakage of external materials into the water distribution system from other (dangerous to water but) legitimate utilities. There is further increase in risk if a low-pressure part of a distribution system passes through an industrial area where there are many buried pipes carrying chemicals and where the presence of heavy traffic could increase the probability of leaks. Prevention of cross contamination problems requires good cooperation from industry, accurate documentation of pipe locations contents and pressures, and an effective monitoring system.

Industry and neighboring utilities are not the only potential risk sources for cross contamination. Residential and commercial users are normally viewed as "very low pressure" systems and are therefore usually seen by systems designers only as "sinks" or consumption points. Most systems simply assume that water will only flow from the higher-pressure distribution mains into the service location; in most if not all cases, there is no equipment installed to prevent an (unexpected) reverse flow. There is a risk that a commercial or even residential service location could back-feed water or other materials into the distribution system if the pressure on the service end was raised sufficiently. This appears to be the main risk factor for water distribution system poisoning by accidental or intentional (i.e., terrorist) means. It seems remarkable to this author that it is not common practice for municipalities to install check valves for every consumer connection at the main exterior shut off (owned by the municipality) to prevent back-feed possibilities.

Distribution System Breakdown

Likely this is the most frequent water system problem seen by end users. Often system break down is due to an isolated pipe or valve rupture or a loss of electrical power to a wide area. The consequences are usually benign and repaired quickly. Construction near water distribution systems can lead to this kind of problem particularly if the actual location of piping is not well documented. Pipe failure can also result from the freeze/thaw seasonal cycle and vibration from heavy rail or road traffic. Distribution systems rely on water pressure differential maintained by electric pumps. It is remarkable that many water distribution systems do not have facilities in place to deal with major electric power outages. This was clearly evident as a problem in the Eastern Canada Ice Storm (Newkirk, 2001); yet many municipalities have not taken steps to provide power back-up systems. Situations are known to the author where the residents of whole subdivisions have been left without any water supply for several days due to a power outage. Minimizing distribution break down risk probability is very important due to safety implications related to both health and fire protection.

Water Risk Considerations for Planners

Through the previous discussion a number of land use and governance considerations were identified. This leads to recommendations that planners take an active role in identifying, quantifying and discussing the associated risks to community water systems. Further the following suggestions are made to encourage more planner contributions to the water risk discussion.

Supply Considerations:

Planners need to assist in the determination of land tenure and the jurisdictional authority over the water source(s). Once determined, planners need to develop approaches to buffer the sources from possible contamination. (This could include steps to impose strong controls on large scale livestock farms (Newkirk, 2001)) Most communities do not have adequate information on the ground water resources and flows. Planners need to require ground water studies as part of the evidence considered in review of new development proposals. The area's history of possible point sources of land-based contamination is usually poorly documented; this makes it nearly impossible to identify the potential for contamination problems of increased water harvesting. Planners need to commission historical studies to locate old landfills and industrial sites; these need to be built into a risk assessment GIS database for the community. Planners must include water demand (and wastewater treatment requirements) tied to their usual population and employment forecasts. An interpretation of this demand against the available resources and system capabilities should become part of an annual reporting of risks to government.

Raw Water Transmission:

Planners need to assist in the determination of land tenure and the jurisdictional authority over the rights of way used to transport bulk raw water to treatment plants. Once determined, planners need to map and then develop regulations to buffer the rights of way from nearby negative land use or activities. This may require acquisition of land to convert rights of way easements to ownership. Accurate GIS mapping of piping and associated physical plant should be added to the regional database. Planners should work with system engineers to ensure a basic level of redundancy in routing of bulk water transmission. This should be part of normal regional strategic planning processes to ensure adequate provision of rights of way for the future and to incrementally enhance system redundancy and robustness over the long term.

Water Treatment:

Planners need to recognize that water treatment plants contain hazardous chemicals and processes; treatment plants should be treated in the same manner as other industrial plants regarding safety set backs and site planning requirements. Planners should work with water system designers to ensure that water treatment is distributed spatially within a community to minimize the effect of an unintentional or intentional event at a treatment facility that would require it to go off-line leaving numbers of people without treated water (or possibly without water.) For example, the MWRA 's new state-of-the-art water treatment plant is designed to treat the entire water supply to the Greater Boston Area. This creates an unnecessary level of vulnerability for the whole region to one major event. To improve community overview (more eyes on the street) there may be benefit of having areas like water treatment plants and reservoirs developed as actively used parks to increase the surveillance of facilities by the public.

Distribution Systems:

To reduce the risk of contamination by consumers back-feeding contaminants into the distribution system (and reducing the potential for terrorist activity), planners should arrange revisions of water connection standards to require a check valve at the municipal shut off valve for every consumer service connection. All site plan review by planners should include evaluation of all below grade utilities in consultation for municipal engineers. Any changes to existing utilities or development of new utilities should be by permit after review of detailed location information and identification of the properties of any potential contaminants contained therein. This information should be inventoried in the planning GIS database. Planners should conduct risk assessments of the possible impacts on water systems of substantially increased road or rail traffic or new transportation developments. In cooperation with municipal engineers, planners should conduct historical surveys to assemble information on below grade utilities – especially in industrial or previously industrial areas. Such information should be considered during the review of all site plans related to brown fields redevelopment.

Conclusion:

This discussion has identified a number of possible water system risks that need investigation by planners – often in cooperation with municipal engineers. There is need to add significant information to the planning GIS database. There is also need to better understand and deal with the ownership and jurisdiction over the land used by municipal water systems. It has been argued that many water system risks are more than simply engineering problems and that planners have an important role in better understanding, and, hopefully, mitigating the risks facing those millions of people who depend upon municipal water supply systems.

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METHODOLOGY OF ORGANIZATIONAL LEARNING IN RISK MANAGEMENT

Development of a collective memory for sanitary alerts

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Keywords: Experience reflection, food-related sanitary alert, collective memory

Abstract

In France, each Veterinary Central Department (VCD) is confronted with situations of food-related sanitary alerts occurring in its territory of responsibility. Management of those alerts often creates an interesting experience, but the organization of the control is done in such a way that this experience is not shared outside this area. We present a method to capitalize and to share the experience obtained by the inspectors, based on the dynamics of the alert's management. Development of an alert is formalized as a succession of events and cycles of decisions that constitute the base of an actor's experience, which they use for management of new alerts. This set of cycles is going to constitute a support for formalization and capitalization of experience: a collective memory.

Introduction

Our society is nowadays regularly affected by food-related sanitary alerts and crises. The population expects from professionals and from the government that they reduce the risks and hazards to a minimum. For the professionals, there is a large economical importance. A food-related crisis that is rather badly managed by a company – mostly concerning the communication aspect - can cause, besides important financial damages, large damages to the image of the company. The economic consequences for a small and medium-sized enterprise (SME) in France that was at the origin of an epidemic of Listeriosis is estimated at $2 million [Cerisier 1998].

From this point of view, the management and the sharing of the knowledge obtained with an experience reflection of the food-related sanitary alerts and crises constitutes a method for progress towards the prevention and the management of those risks and hazards, and for the formation of the actors of both the profession and the services of control.

Experience reflection

Collective learning is mainly based on debriefing, or what we call an *experience reflection* (ER) process. It is a post-operational evaluation activity that is used to learn from incidents, accidents and crises to reduce their occurrence. ER is composed of four phases: collect events, analyze events, learn lessons and apply new decisions [Colardelle 2000].

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All actors that participated in accidents or in incidents have interesting experiences, and those actors are more or less willing to share that experience. All experiences are useful for sharing: the good ones and the bad ones. Indeed, it is not only the worst accident that contains the most interesting experiences.

Experience is obtained on two levels: in day to day management, and on certain occasions while managing an alert or crisis. In this paper, we are interested in the experience obtained while managing food-related alerts. Sharing of those experiences between actors needs a simple methodology and formalism, simple but adapted to their way of working and to their organization.

Experience reflection in the professional world: state of the art

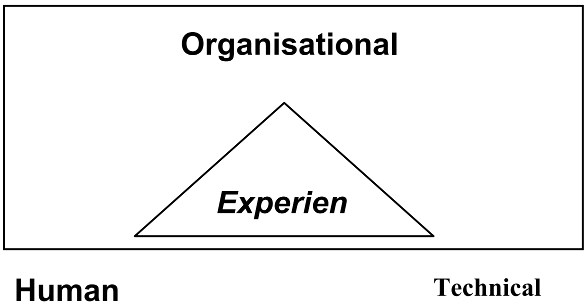
Gilbert [Gilbert 2001] has resumed very well the state of the art of debriefing or experience reflection in the professional world. His point of view is that an experience reflection generally is focused on the collecting, in a more or less automatic or standard way, of information on events that occur frequently and that can be treated within the organization. The approach is largely focused on technical problems and the goal is to constitute databases. This approach, focused on the technical aspect, is in line with the engineer's culture, a culture that rules largely in organizations that have the responsibility of hazard activities. This way of experience reflection tends to minimize the implications of the actors and the organization, to reduce the difficulties only to technical problems. The human and organizational aspects are almost not considered. This approach of experience reflection corresponds to the general approach in this domain.

Our approach tries to take into account the complexity of the systems to which it is applied, one of the reasons being that danger cannot be fully assessed in isolation.

The complexity of the system can be represented by the analysis of three subsystems:

- Human: employees of all activities
- Organizational: documents and procedures
- Technological: technical equipment and machinery

Figure 1: The three subsystems [Nicolet 1997]



Formalization of the experience

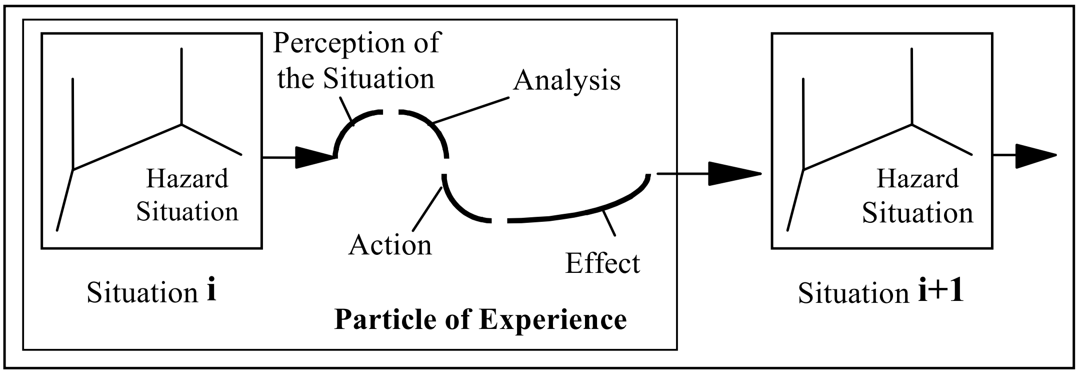
When we want to memorize the experience of accident management, the method generally used consists of formalizing each accident as an elementary entity. This approach is commonly used with databases of accidents. This way of proceeding is useful for a statistical use of the accidents. On the counterpart, there is a major inconvenience of losing a lot of important information, including the dynamics of accident development and the different steps in decision making with the argumentation.

Most of the hazard situations change with time, caused by external conditions or by a succession of events and decisions. Each one of those key events is associated with a *decision cycle*. [Therrien 1998]. Thus, for the definition of a situation's evolution between two instances, we will use a decision cycle, composed of four main aspects: *perception of the situation, analysis, action and effect*. This decision cycle represents the smallest element of experience that still holds onto its properties, that still renders information without distortion and hence preserves most of the complexity of the situation. We will name it "*particle of experience*".

A particle of experience is composed of four main aspects:

- Situation: what was happening at that particular moment in time (event and context),
- Decision: after analyzing the situation, what decisions concerning actions are taken,
- Action: what is the action taken,
- Effect: what is the effect of the action taken until the next key event.

Figure 2: The decision cycle [Wybo 2001]



The hypothesis is that the key events with their representative decision cycles constitute the basis of the actor's experience, or the experience that they reutilize for the management of new accidents.

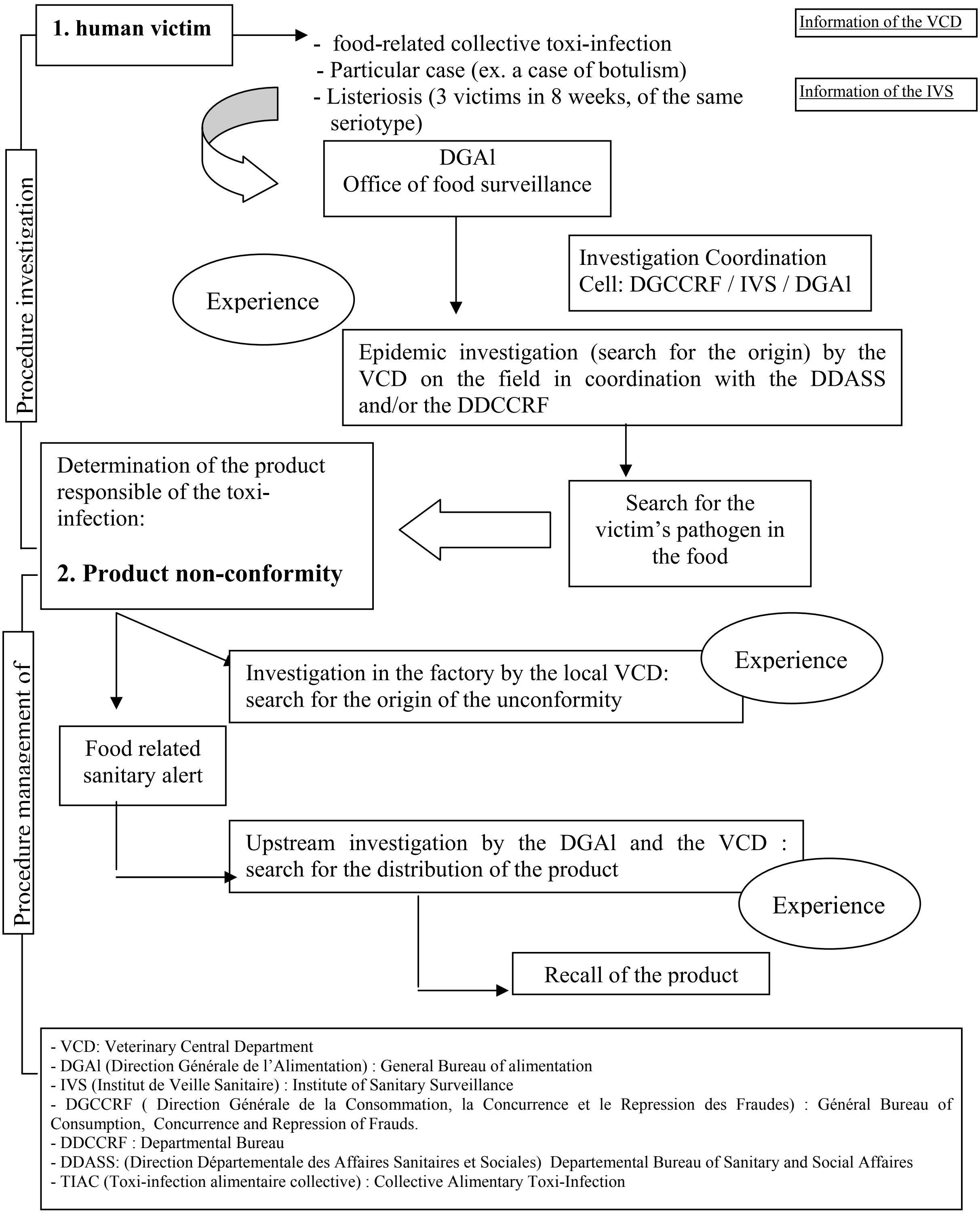
Proposing a model of the dynamics of an alert's management is only the first point; we have to define a method of collection of the experience that is accepted by the actors. Our approach is founded on the search for conditions that are the most adapted to the organization of the Veterinary Departments. In the mean time, it is important to put emphasis on the limitation of negative aspects like the fear of being reprimanded, timidity, focus on the search for the 'guilty', personal opinions, etc.

Organization of a Veterinary Central Department and the management of food-related alerts

A food-related alert is managed in a Veterinary Central Department (VCD) by relatively few people. Depending on the importance of the alert, the VCD director, the chief inspector and several inspectors are involved. Sometimes, even the secretary is briefed to take telephone calls and to inform victims. So, generally a minimum of two persons and a maximum of six to eight persons are involved depending on the importance of the alert. In this case, we'll concentrate on rather small alerts, with two to four inspectors involved.

The management of an alert results in a file. The content of such a file depends largely on the method of working in a VCD. In certain departments it is very detailed and complete, in others it is rather poor in information. The existence of different kinds of files does not help in easily sharing information and experience between the VCD. When an alert is resolved and closed, the file is archived and there is generally no debriefing or retrospective analysis due to the workload of inspectors, the lack of time, the lack of method, culture or organization of debriefing.

Figure 3: Management of an alert



Capitalization and sharing of the experience for the Veterinary Central Departments

Methodology

The starting point of our approach is the PER method, *positive experience reflection* [Colardelle 2000]. This method, that is part of the methodology for debriefing and organizational learning, is currently under development within an interest group composed of academics, companies and public bodies [REXAO]. It is applied to different kinds of hazards: natural, technological (industries and transport) and food-related.

The method illustrated in this paper is for the management of food-related hazards by different organisms of control, specifically the Veterinary Central Departments. In France there are 96 such departments and six overseas departments, which represents 102 departments in total. The inspectors of a department have no direct contact with the inspectors of other departments. There is neither communication nor sharing of experiences. The only way to have an exchange of experiences between inspectors of two different departments is during training sessions or when an inspector is transferred to another department.

Analysis of the alerts

The method of experience reflection used is composed of four steps: *collection, analysis, validation, sharing:*

- *Collection*: the starting point is the file of the Veterinary Central Department and interviews of the actors by telephone, electronic mail or in person. The extraction of the dossier's information depends largely on the quality of the file. Some Veterinary Central Departments used to keep a logbook of their actions (which is very useful for the second step, the analysis), other Veterinary Central Departments have only a written conclusion that synthesizes the management of the alert and finally some other Veterinary Central Departments have only the official letters and the official microbiological analysis documents.
- *Analysis*: In the collected information we are looking for key events and key decisions. Those key events and key decisions will constitute the particles of experience. We obtain a series of key moments and key decisions. Once each key event is identified, it is detailed into 4 phases of what we call a particle of experience: a situation, an analysis with a decision, an action and its effects. This series of particles of experience constitutes the support for formalization and capitalization of the experience and is named *the string of key events (SKE)* [Colardelle, 2000].
- *Validation*: The parties correct or complete the string of key events and the particles (electronic mail, telephone or meeting). Each person involved in the management of an alert is interviewed and he helps to complete the string of key events with his experience in the form of *hypothetical particles of experience*. The actors are asked what alternative actions they could have taken in a similar situation. There are two kinds of possibilities, positive actions and negative actions [Colardelle 2001]. The answers are the reflection of a past experience or a hypothesis of a different possible action. We noticed that the persons who have managed the alert have difficulties in finding positive hypothetical particles. Most of the time the alert is managed in a satisfying way with no damage and they think – with grounds - that they have taken the right decisions. Persons who are exterior to the service or who have not managed the alert are more likely to propose hypothetical particles of experience.
- *Sharing*: The sharing already exists inside a Veterinary Central Department. It is less common between several Veterinary Central Departments (due to geographical distance, difference in the alert files, workload). Generally, the number of actors who manage the same alert is rather small (two to four persons, exceptionally more). Those actors are holding regular meetings

with the other persons of the service/office/department and share in this way the same experience related to an alert.

Firstly, the analysis of the alerts is going to be presented to persons outside of the Veterinary Central Department, who we can qualify as ‘experts’. We will ask for their remarks and advice. With those supplementary elements we can form the hypothetical particles. Secondly, the whole of the alert’s analysis is combined on a database (the collective memory), with the goal to share the experience.

Since June 2000, corresponding with the beginning of this work, the management of eleven alerts have been analyzed with this method, collaborating with 8 Veterinary Central Departments. The analysis and the validation of those analyses by the actors have validated our approach of representation of the experience of food-related alert’s management.

Utilization by the inspectors of the VCD

Important questions have to be answered: How can this knowledge be used? Do we do the analysis in ‘real time’ situation or after the closure of the alert? Do we analyze every alert or do we choose a limited number of alerts? Do we deal differently with some alerts, some superficially, others more in detail?

We decided to analyze only a few interesting alerts a year in each department. The lack of time is the primary deciding factor to do so. Also, we suppose that some alerts and their management do not contain enough experience to justify the energy and time to analyze and capitalize. So we are aware that this database can not have a statistical goal - we choose the alerts to analyze - but this is only for pedagogical use and for sharing of relevant experience.

Definition of the collective memory: a database

As support for the collective memory we’ll use a database which will be accessible for the VCD by an Intranet connection. A first prototype of a database was developed with Access ’97 and presented to some inspectors. Those presentations were followed up by some remarks from the inspectors and those remarks were taken into account.

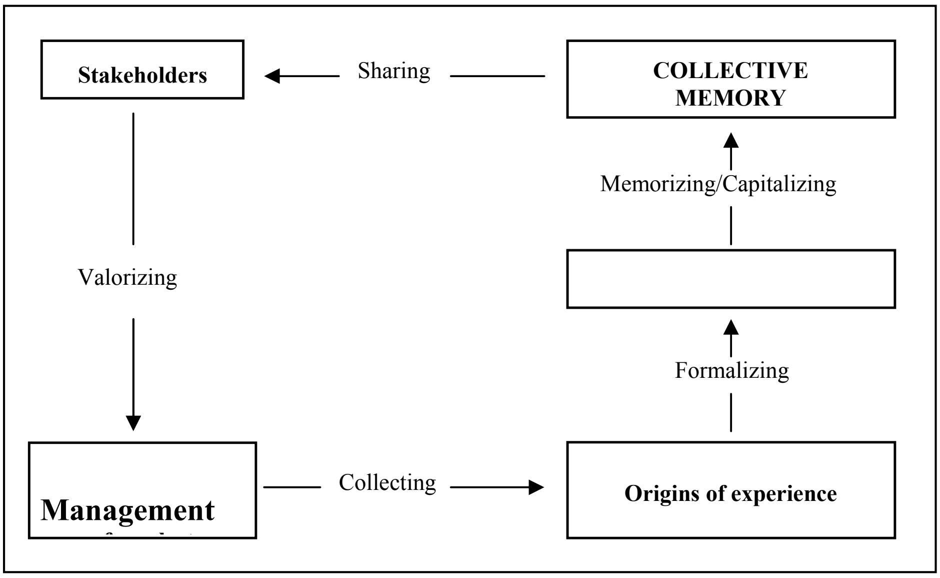
Conclusion

This work has shown the difficulties of the day-to-day management of food-related alerts, the role of the actors, the importance of the individual experiences and the potential for the sharing of those experiences. We are proposing a formalism based on the particles of experience, with the goal to compare the management of the alerts and to facilitate the sharing of the knowledge and the development of a collective memory (*Figure 4*).

The alerts that have been analyzed and capitalized in this memory will serve also for the definition of a risk assessment method. This method of hazard analysis will treat the three aspects of hazard: technical, human and organizational.

The following step in this work will be the definition of the collective memory of the alert’s management by the Veterinary Central Departments and the procedures to achieve sharing of knowledge.

Figure 4: Experience reflection return and collective memory



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Author Biographies

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SECTION 11:

RESPONSES TO TERRORISM AND BIOTERRORISM

"UCF 2001": A JOINT MILITARY-CIVILIAN WMD EXERCISE[1]

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Key Words: Weapons of Mass Destruction, Simulation, Training, Incident Command

Abstract

The very real threat of a weapons of mass destruction (WMD) attack in the US has heightened public awareness and has led to the demand for better emergency response that includes well-trained crisis teams who can respond to this type of large-scale emergency. The result has been a growing need to train emergency responder teams not only to perform their individual specialties, but also to coordinate and cooperate with multiple agencies to accomplish this training. Only a few joint military-civilian WMD field exercises have been conducted to test military-civilian coordination. This paper describes an exercise held on the University of Central Florida campus on February 10, 2001. Events were extensively recorded and analyzed. There were about 100 participants in addition to umpires/ controllers and observers: about half the participants were military personnel, including the entire 4th WMD Civil Support Team from Georgia and elements of the Florida and Louisiana teams; the other participants were personnel from local public safety agencies, principally the Orange County Fire Rescue Department (OCFRD). In addition to describing the exercise, we summarize after-action reviews conducted by the 4th WMD Civil Support Team and OCFRD and document lessons learned. This exercise proved both difficult for participants and extremely valuable in terms of improving the training value of future similar exercises.

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[1] Opinions expressed in this paper are those of the authors and do not necessarily reflect policy of the US government.

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Introduction and Background

Heightened Awareness WMD Threat

The threat of additional weapons of mass destruction (WMD) attacks, following the September 11 2002 (9/11) attack in the US, has resulted in the need for well-managed crisis teams who can respond effectively. The result has been a growing need to train emergency responder teams to coordinate and cooperate with multiple agencies. The federal government (Department of Justice) has responded with a series of grants to local public safety agencies, including several grants to the Orange County Fire Rescue Department (OCFRD). Also, WMD Civil Support Teams (special National Guard units whose function is to aid local responders to WMD incidents) have been set up across the country. Only a few joint military-civilian WMD field exercises have been conducted to test military-civilian coordination; they are being held more regularly since the 9/11 but their full training value is not being realized. This paper describes one of the most realistic joint field exercise yet conducted.

The scope of emergency response services have expanded so rapidly since 9/11 that public safety agencies have been hard-pressed to handle their increased workloads. Greater demands, in the face of financial and manpower reductions, require more creative and cost-effective use of available training resources (Crissey, et al., 2001). Emergency situations encountered by military, law enforcement, fire-rescue, and other emergency management agencies and groups require significant tactical decision making skills to achieve effective and efficient resolutions to incidents. Improper or slow decision making can significantly increase loss of life, loss of property and damage to the environment. While many techniques are available to train physical skills, there are few effective training techniques and tools to teach critical decision making skills.

There is an urgent need for training of personnel from different agencies, with different professions and standard operating procedures, to understand each other's methods and procedures in order to coordinate rescue activities most efficiently. Training people for critical and dangerous incidents requires realism in the training situation without putting the participants at risk. It is also important that the participating trainees effectively learn from their performance during training to enhance their readiness and capabilities in real situations (Kincaid, 1992). The understanding by all participants of the overall task force goal and the importance of cooperation among different agencies and between sub-units motivates trainees and enhances learning effectiveness.

Simulation Tools to Support Field Exercises

Several simulation tools have been developed to support large scale field exercises. Among the most successful of these is the MIND system developed by the Swedish military (Jenvald, 2000, Crissey, et al., 2001).

UCF 2001: The WMD Exercise

On February 10, 2001, a large field exercise was held on the campus of the University of Central Florida campus involving both military and civilian responders.

Scenario Overview

The scenario was a fairly elaborate WMD incident involving both chemical and biological agents (a nerve gas and anthrax), which originated in a university chemistry lab. Response to events was mostly not pre-determined and appeared to unfold in a natural way from the viewpoint of the participants. For example, the first three fire-rescue responders were unaware that they were entering a space with deadly nerve gas, and were wearing only standard firefighting protective clothing and breathing apparatus; since some amount of skin was exposed, they "died" due to exposure to the nerve gas. Later responders were protected by "Level A" suits which provide much greater protection. Actual precursor components of an organo-phosphate nerve gas (contained in separate containers and in low concentrations) were retrieved by military specialists and chemically analyzed to produce a realistic positive chemical analysis. Smoke generators visually depicted the "toxic agents" being carried downwind.

Participants

There were about 100 participants in addition to umpires/controllers and observers: about half the participants were military personnel, including the entire 4th WMD Civil Support Team from Georgia and elements of the Florida and Louisiana teams; the other participants were personnel from local public safety agencies, principally the Orange County Fire Rescue Department (OCFRD) as well as a few members of the UCF Police Department and other UCF safety officers. The incident commander was from the OCFRD.

Training Objectives

General Exercise Objectives

Training objectives of a general nature (for responding to known or unknown potential chemical threats and/or biological threats) included the following:

- Remove people from harm's way.
- Assess situation.
- Be cognizant of secondary devices.
- Secure the perimeter, set up operation areas, and establish hazard control zones (i.e., hot, warm and cold zone).
- Rescue, consider decontamination, triage, treat and transport victims.
- Control and identify agents involved.
- Stabilize incident.
- Avoid additional contamination.
- Secure evidence and treat as a crime scene.

Individual Agency Objectives

4TH WMD Civil Support Team

- Establish and maintain a civil-military operations center and perform all liaison tasks (integrate into existing Incident Command System)
- Conduct Chemical/Biological Survey Operations (hot zone surveillance, sample collection and packaging)
- Conduct medical operations (medical surveillance, emergency medical care, medical advise regarding suspected agents)
- Provide for hazard determination (modeling)
- Conduct decontamination operations.
- Conduct communications operations.
- Collect samples and provide agent identification through analysis of samples employing MALS operations.

Orange County Fire Rescue Department

- Incident Command system will be established with prompt identification of the Incident Commander and placement of a Command Post.
- Communications will remain effective throughout all operations from initial response to stabilization of incident.
- Special Services Unit will respond to event and attempt to isolate, contain, and stabilize incident under direction of the Incident Commander.

- Medical screening, decontamination set up and dress out with proper protective gear will occur within 32 minutes of arrival on scene.

University of Central Florida

- 911 protocol will be followed according to UCF's Emergency Management Plan 2000.
- UCF Campus Police will respond to event using appropriate caution.

Special Equipment

The exercise was supported by an elaborate array of special equipment and teams from both the military and civilian participants including: two sets of decontamination equipment; the OCFRD Hazmat (hazardous material) team and their specialized equipment; communications vans, including a military van with satellite up-link capability; a military vehicle with chemical and biological analysis equipment with a specially trained operator; and a medical aid unit staffed by paramedics and equipped with a sophisticated medical simulator.

Events of the Exercise

Major events of the exercise, which lasted about 2 ½ hours included:

1. Briefings to Civil Support Teams and local participating groups (Orange County Fire Rescue Department, UCF Police Department and other UCF units).
2. Release of toxic agent in university chemistry lab killing terrorist and several other in lab and injuring two bystanders just outside of lab.
3. 911 call by injured person.
4. UCF Police Lieutenant investigates but does not enter building because of noxious fumes.
5. OCFRD Battalion Chief arrives and assumes role of incident commander.
6. First team of responders from Station 65, OCFRD, enter lab in regular fire fighting gear and are declared "dead."
7. OCFRD sets up decontamination and communication equipment.
8. CST Team arrives with full equipment.
9. Search team recovers chemicals in lab for analysis.
10. Search team fails to identify presence of "anthrax" powder in lab's ventilation system.
11. One "victim" is treated but one is not.
12. Second (redundant) decontamination system set up by 4th WMD CST.
13. CST team takes samples of possible contamination in down wind area (marked by smoke generator).
14. Exercise concludes and After Action Reviews held.

Events of the three hour exercise were extensively recorded and analyzed. Sources of data included: video recorded by a professional team; approximately 400 digital still photographs; recordings of all voice traffic routed through the Orange County dispatch center; a series of hand-written event logs; and a series of reports of after-action reviews conducted by the 4th WMD Civil Support Team and OCFRD.

Figure 1: Terrorist's Letter Left at Crime Scene in Lab

TO WHOMSOEVER IT MAY CONCERN

Last week, I got a letter from the head of the department stating that I have to quit this job. Today, I'll not only kill myself but also my fellow students and I want this department to feel the tremors for the following years to come. This chemical is just a sample. In about 24-48 hours from now students and faculty members, in and around this building shall fall ill.

Figure 2: Orange County firefighter briefs 4th WMD CST team members.

Figure 3: WMD military specialists on the scene in the lab taking chemical samples

Figure 4: Decontamination

Results

This was one of the largest, most complex joint military-civilian WMD field exercises ever held and the results can be summed up as "mixed." The exercise produced a wealth of lessons learned, and many components of the response were well done. At the same time the exercise highlighted weaknesses in both standard operating procedures of the agencies involved and numerous issues related to interagency cooperation and communication.

Figure 5: "Victim" being treated using Human Patient Simulator at University Fire Station Simulation Lab

Table 1: Ratings of Exercise by 4th WMD CST in After Action Review

Were the Following Adequately Used/Addressed?	Yes	No	No Answer
Plans, Operating Guidelines, Resources	6	7	3
Exercise Objectives	9	3	4
Communication Systems	9	2	5
Intra- and Inter-Agency Information Exchange	3	8	5

Lessons Learned and Exercise Benefits

Comments offered during the after action reviews included the following.

Overall comments

- Lots to learn from this one.
- This was a very ambitious drill. The 4th proved to be a tremendous asset. Most objectives were addressed even if some were almost simulated.
- The shortfalls discovered during today's exercise can help you to focus on particular areas where objectives may not have been made.

Interagency Coordination

- Maybe there can be a standard developed between agencies. More pre-planning necessary, especially role definition, task assignments for team members.
- With the various different departments working together, it seemed to drag on but there was good interaction and most seemed to be learning from the exercise.
- Decon was redundant.

Communication

- More thorough commo, commo, commo!
- CST's need to ensure flow of information is complete from beginning to end.
- Very little information flow between agencies.

Scenario

- This scenario would tax most communities.
- The scenario provided an outstanding opportunity.
- Scenarios were very realistic and well developed.

Time Schedule

- Due to compressed time schedule, the following items were neglected: briefing, downwind hazard, safety briefing, and medical briefing.
- Exercise would have been excellent if time had not been so compressed.
- Time was too compressed, procedures were rushed. Would have gone much better with more time.

Conclusions

This exercises proved both difficult for participants and extremely valuable in terms of lessons learned. We are developing a multimedia depiction of important events in the exercise (which is the start of a courseware training module) as well as a summary of lessons learned and the impact of the exercise in organizing for future exercises and response to actual WMD events.

The area most in need of further attention is inter-agency collaboration and particularly communication. It is clear that more exercises involving civilian and military units are needed and that participants need to be better prepared to benefit from these expensive exercises. This means more training in preparation for the exercises and improved use of the information gathered during the exercises. The courseware package we are preparing should prove to be useful in this regard.

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Author Biography

J. Peter Kincaid is a Professor and director of the Modeling and Simulation Ph.D. program at the University of Central Florida. Much of his research and publishing for the past seven years has dealt with simulation and training techniques for disaster response. He holds a Ph.D. from Ohio State University in human factors. Major Patti Pettis is Chief Medical Officer of the 4th Weapons of Mass Destruction Civil Support Team located in Georgia. Chief Joseph Donovan is in charge of training activities for the Orange County (Florida) Fire Rescue Department (OCFRD) and is former Director of the National Fire Academy. Renea Moser is an environmental safety officer with the University of Central Florida. Lieutenant Michael Bass is a member of the OCFRD training department.

CITIZEN CORPS VOLUNTEERS TO PREPARE FOR AND RESPOND TO TERRORISM AND NATURAL DISASTERS

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Keywords: terrorism, natural disasters, preparedness, response, United States, volunteers

Abstract

In his State of the Union address to Congress on January 29, 2002, President George W. Bush announced his intention to establish the USA Freedom Corps, one purpose of which would be to improve homeland security. The President invited every American to commit at least 4,000 hours over their lifetime to volunteer service to their neighbors and the nation. The President gave the Federal Emergency Management Agency oversight responsibility for coordinating the new Citizen Corps, the homeland security part of the USA Freedom Corps.

The Citizen Corps will unify and expand new and existing volunteer programs which focus on crime prevention and natural disaster preparedness and response to add terrorist-related concerns. These programs include Community Emergency Response Teams, overseen by FEMA; Neighborhood Watch, overseen by the Department of Justice; Volunteers in Police Service, overseen by the Department of Justice; Medical Reserve Corps, overseen by the Department of Health and Human Services; Terrorism Information and Prevention System, overseen by the Department of Justice and FBI; and Citizen Corps Councils.

The Administration is requesting more than $230 million for these Citizen Corps initiatives in the Fiscal Year 2003 budget. The federal responsibilities are to provide general information, to develop training standards and materials, and to identify initiatives that support the goal of the Citizen Corps to bring together local government, the private sector and volunteers into a cohesive community resource. The role of these volunteer programs to prepare for acts of terrorism and natural disasters will be examined.

Introduction

The attacks by terrorists on the World Trade Center in New York and the Pentagon in Virginia have resulted in a number of actions in the United States to both find those responsible and to prevent such incidents in the future. President George W. Bush described his plan when he gave his State of the Union address to members of Congress on January 29, 2002 (Bush 2002a) He said that he would be sending a budget to Congress to support three goals: to win the war against terrorism; to protect our homeland; and to revive our economy. This paper will discuss his homeland approaches to protect our citizens and strengthen our nation against the threat of attacks in the future.

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The President stated that his budget would have funding for a sustained strategy of homeland security focused on bioterrorism, emergency response, airport and border security, and improved intelligence. He called for every American to become a volunteer and commit at least 4,000 hours during his or her lifetime to the service of neighbors and our nation. He invited everyone to participate in the new USA Freedom Corps, which will focus on responding in case of crisis at home' rebuilding our communities' and extending American compassion through the world. The homeland security portion of the USA Freedom Corps will be called the Citizen Corps. It will include activities such as mobilizing retired doctors and nurses to assist in major medical emergencies, enlisting volunteers to help police and fire departments, alerting transportation and utility workers to spot dangerous activities of terrorists, and expanding neighborhood watch programs and community emergency response teams.

The President also called for the USA Freedom Corps to rebuild our communities by expanding and improving the AmeriCorps efforts for young people and for funding the Senior Corps to recruit more than 200,000 new volunteers. He is also concerned with extending the compassion of our country to every part of the world. He plans to double the number of volunteers in the Peace Corps over the next five years in an effort to encourage education, development and opportunities in the Islamic world.

Citizen Corps Programs

Citizen Corps volunteers will be able to participate in various programs which match their interests, skills and ability (Citizen Corps 2002). These programs are:

- Medical Reserve Corps: Retraining of retired doctors, nurses and healthcare professionals so that they can augment the local healthcare capacity to respond to medical emergencies caused by terrorists.
- Neighborhood Watch Programs: Expanding and enhancing neighborhood watch programs by incorporating terrorism prevention into the mission.
- Volunteers in Police Service: Expanding existing Police Department citizen academies and other programs for training local volunteers to perform non-sworn duties to free police officers to perform their front-line duties in times of emergency.
- Operations TIPS (Terrorist Information and Prevention System): Operation TIPS is designed to enlist the cooperation of postal workers, public utility employees, transportation workers and other citizens to identify and report suspicious activities which might be linked to terrorism or crime.
- Community Emergency Response Teams: Expanding the number of volunteers who have been trained to help neighbors in their local community prepare for and respond to natural disasters, and to add training for preparedness and response to acts of terrorism.

Medical Reserve Corps

Community-based volunteer Medical Reserve Corps units will be created as part of local Citizen Corps Council efforts throughout the United States. These Medical Reserve Corps units will be supported by the Department of Health and Human Services and the Department of Veteran Affairs. The objective of these community-based Medical Reserve Corps will be to enlist retired healthcare professionals to augment local health care capacity during an emergency. No structured, coordinated system exists at the national level to incorporate the talent and knowledge of inactive physicians, nurses and other health professionals who may be eager to volunteer during emergencies. The Department of Health and Human Services will work with state and local jurisdictions to address issues of licensing and liability.

The Medical Reserve Corps will assist communities in the delivery of necessary public health services during a crisis by providing state and local public health officials with a corps of volunteers to help expand capacity for the delivery of care. These volunteers will remove some of the burdens placed upon physicians, nurses, and others responding to a large-scale medical emergency affecting local communities. Medical Reserve Corps volunteers could assist community emergency response teams in triaging patients in order to send the most seriously affected to emergency rooms at hospitals, while providing care directly to those victims with less serious injuries.

The Department of Health and Human Services will provide guidance on how to create the Medical Reserve Corps at the local level. The Department of Health and Human Services will provide $10 million in Fiscal Year 2003 to support this initiative. Hospitals of the Department of Veteran Affairs in local communities will provide additional support, such as training, for the Medical Reserve Corps. The Medical Reserve Corps units could also become another resource for deployment to other areas within states or regions in cases of extreme emergencies.

Neighborhood Watch Programs

Burglary rates in the United States increased during the 1960s. Law enforcement agencies considered a variety of crime prevention programs and developed a concept called "neighborhood watch" in which citizens of a neighborhood became more involved. The National Sheriffs' Association took this concept a step further and proposed a national initiative called the National Neighborhood Watch Program (NSA 2002). Funding was sought and obtained from the Law Enforcement Administration in 1972 for this program. The first few years of the program involved disseminating information on the nature and volume of burglary and providing information to individual home owners on techniques to make their homes less vulnerable to break-ins. This effort then evolved into the establishment of local neighborhood watch groups where local residents banded together with their local police or sheriff's department in an effort to reduce burglaries and other neighborhood crimes. The adoption of community policing by many local law enforcement agencies has contributed to a resurgence in Neighborhood Watch groups over the years.

The present concern about terrorism has resulted in a revised Neighborhood Watch program that will incorporate terrorism prevention into its routine mission. Neighborhood Watch will also operate as a distribution mechanism for anti-terrorism information circulated by Citizen Corps Councils and other agencies. The President's announced goal is to double the number of Neighborhood Watch programs within the next two years. Neighborhood Watch programs have already been in existence for 30 years and have played an important role in preventing crime. The National Sheriffs' Association estimate that approximately 7,500 communities representing nearly 30 million people around the country participate in grassroots crime prevention under Neighborhood Watch. As the "eyes and ears" of local communities, Neighborhood Watch is unique in bringing together local law enforcement and citizens for protection of communities.

Citizen Corps Councils will encourage the creation of Neighborhood Watch in communities that do not have them, and enhance the capacity and relevance to terrorism for those communities that do have Neighborhood Watch. The Neighborhood Watch programs will receive materials from the Department of Justice, working in conjunction with the National Sheriffs' Association, on how to incorporate the new focus on terrorism. As a matter of fact, the National Sheriffs' Association published a "Neighborhood Watch Manual" on the Internet on April 12, 2002. This manual was created to assist local communities and law enforcement organizations in understanding the new version of Neighborhood Watch, its role, and how to build a Neighborhood Watch program. The Department of Justice will provide $6 million in Fiscal Year 2003 for the expanded Neighborhood Watch Program.

In March 2002, Attorney General John Ashcroft visited Loudoun County in Northern Virginia to talk to residents about expanding the community crime prevention program to include the participation of ordinary citizens in detecting and preventing terrorism. The Loudoun County Sheriff who hosted the event felt that his county had been chosen for Ashcroft's announcement because of his emphasis on community policing and the commitment for establishing partnerships in the community. Since the announcement, the Sheriff's office has been working with residents to help them understand what it means to be on the lookout for terrorist activity. For example, the residents have been asked to report strange things, such as rental trucks parked in areas where there doesn't seem to be any driver around, or abandoned vehicles with out-of-state license plates.

Volunteers in Police Service

State and local law enforcement organizations have been given additional tasks since September 11 and many are finding it increasingly difficult to perform these tasks with the current number of sworn personnel. Recruiting additional officers is difficult and training takes months. Many Police Departments have found it desirable to establish citizen police academies to train local volunteers to perform non-sworn duties to free police officers to perform their front-line duties. I live in Pacific Grove, California, a city with a population of 17,000. The Pacific Grove Police Department has a Citizens Police Academy which offers a twelve week, 36 hour training course about twice a year. The course consists of three subjects given in each of the 12 weeks:

Week	6 pm	7 pm	8 pm
1	Department organization	Equipment/training	Station tour/ ID pictures
2	Recruitment/training	Arrests/interviews	Crime investigation
3	Defensive tactics	Field training	SWAT team
4	Traffic enforcement	Traffic Accidents	Driving under influence
5	Communications Center	Public Defender	District Attorney
6	Traffic stops	Domestic problems	Role playing
7	Horses & bicycles	Search & Seizure	DNA
8	Records	Report writing	Fire Department
9	County Coroner	County Jail tour	Juvenile Hall tour
10	Narcotics	Narcotics	Gangs
11	Less lethal agents	Firing range	Stun gun
12	Challenges	Evaluations	Graduation

Trained citizens are thus able to participate in Volunteers in Police Service programs (VIPS 2002). Some of the activities appropriate for non-sworn personnel are: doing finger printing; acting as crossing guards; assisting with crowd control and parking control at special events; participating in search and rescue missions for lost children; working with neighborhood watch groups; taking police reports; and performing other administrative tasks so that police officers can do front line police work. The Department of Justice will provide $3 million in Fiscal Year 2003 to support these Volunteers in Police Service programs.

Operation Tips: Terrorist Information And Prevention System

As part of the Citizen Corps, Operation TIPS – the Terrorist Information and Prevention System- will be a nationwide mechanism for reporting suspicious terrorist activity (TIPS 2002). It will enlist millions of American transportation workers, truckers, letter carriers, train conductors, ship captains and utility employees. Operation TIPS will establish a national reporting system that would allow these workers, who have routines and are well positioned to recognize unusual events, to report suspicious activity to appropriate authorities. Every volunteer participant in this new program will be given a Citizen Corps: Operation TIPS information sticker that could be affixed to the cab of the vehicle or placed in some other public location so that the toll free reporting number would be readily available to report any suspicious activity.

Operation TIPS builds on the success of programs such as Highway Watch, which is a crime prevention partnership among the American Trucking Association and six states which enhances the ability of mariners aboard American vessels in inland waterways and the Great Lakes to track and report potential threats. Everywhere in America a concerned worker will be able to call the 1-800 Hotline with terrorist information which will route calls immediately to law enforcement or a responder organization. It is important to recognize that this terrorist information system will not use the existing 911 emergency system but will take the stress off already busy local systems needed for emergencies. The Department of Justice will provide $2 million in Fiscal Year 2003 to establish the terrorist hotline and assist with training, and an additional $6 million for the pilot programs and outreach materials.

U.S. Coast Guard / FBI "Coast Watch" Program

In World War II, the Coast Guard deputized recreational and commercial mariners as Coast Guard Auxiliarists beginning in 1942 (Webster 2002). Sailing yachts, motor cruisers, and fishing vessels were used to look for German submarines and perform harbor surveillance duties. The prototype of a new program based on this WWII Coastal Picket mission, called Coast Watch Maine is a joint effort of the Coast Guard and the Federal Bureau of Investigation to solicit voluntary help from commercial and recreational mariners.

This community outreach program encourages those who work at sea along our coasts or who are recreational boaters to report any unusual or suspicious activity which might be associated with terrorists. The Coast Watch program has investigators available 24 hours a day, seven days a week to take reports of questionable activities. Citizens are asked to call the local Coast Guard if they see:

- Unfamiliar individuals who: Take photographs, notes or sketches near commercial or passenger vessel activities, bridges or waterside facilities; loiter near or ask specific questions about commercial or passenger vessels or waterside facilities; attempt to rent or buy fishing or recreational vessels with cash for short-term, undefined use; or attempt to gain access to waterside facilities without proper identification
- Vessels which: Circle in and around pilings, particularly near commercial traffic; or loiter offshore near commercial or passenger vessel activities
- Other items of interest/concern: Suspicious attachments to bridges and overpasses; unusual packages or unusual deliveries; or recently established vendors or roadside food stands near commercial or passenger terminals or waterside facilities

In late September, 2001, a local Connecticut fisherman reported to the Coast Guard that he had seen "unusual items" under a bridge. Five pipe bombs were found, removed and detonated by the Connecticut State Police bomb squad. In October, 2001, a Massachusetts resident noticed a fishing vessel operating very close to shore in an area not normally associated with fishing activity. The citizen reported that the fishing vessel and a car waiting shore side were communicating with flashing lights. This information was provided to the FBI for investigative follow up. In mid-October, 2001, two fishermen reported a suspicious individual inquiring about purchasing a fishing vessel, training to become a fisherman, the amount of time to get offshore, and the location of the nearest Coast Guard station. This information was turned over to the local FBI office.

The First Coast Guard district is thus actively soliciting the help of commercial fisherman and recreational boaters who know what is "normal" on the water and what are suspicious activities. The Coast Watch Maine program will be expanded to all New England states in the near future.

Community Emergency Response Teams

Fire departments in Los Angeles and San Francisco began training citizens in earthquake preparedness in the 1980s. The program was called Community Emergency Response Teams in Los Angeles and Neighborhood Emergency Response Teams in the San Francisco area (NERT 2002). I live in Pacific Grove, about 125 miles south of San Francisco. The American Red Cross gave earthquake preparedness grants to the San Francisco Fire Department to send a group of instructors to Monterey, California in three different years to put on three-day train-the-trainer courses for the local fire departments in the 12 cities in our Monterey County. The normal neighborhood emergency response team training consists of a three-hour class each week for six weeks. The subjects covered are earthquake preparedness in the home and work place, control of gas, water, and electricity utilities, disaster medicine, light search and rescue, organization of emergency response teams, and use of fire extinguishers and cribbing to rescue injured people. Exercises and refresher training to practice disaster skills and bond the volunteers into teams have been emphasized. An organization of trained volunteers in the San Francisco area has continued for years.

The Federal Emergency Management Agency has added disaster preparedness for hurricanes, floods, fires, and winter storms to the original earthquake focus of the California initiative and has an expanded student manual and instructional materials (CERT 2002). It has been estimated that communities in 28 states have initiated Community Emergency Response Team training and more than 200,00 individuals have completed the training. FEMA will provide $61 million in Fiscal Year 2003 to support expansion of Community Emergency Response Team training.

Citizen Corps Councils

The Citizen Corps will be a locally-driven initiative managed by newly created Citizens Corps Councils, supported at the state level by Governors and coordinated at the national level by the Federal Emergency Management Agency (Councils 2002). The Citizen Corps Councils are intended to include leaders and representatives from local law enforcement, fire, emergency management, businesses, schools, faith-based groups, public health, community foundations, and other organizations that represent the diversity of local communities. The Councils will be responsible for developing a community action plan, including a local assessment of infrastructure vulnerabilities and possible threats, available local resources, and how to organize and expand local efforts. The community action plan will coordinate the community-based prevention and preparedness efforts with the new emphasis on terrorism.

The Federal Emergency Management Agency will provide $144 million in matching funds in Fiscal Year 2003 to help create and maintain the efforts of the councils. Funds can be used for staff, training, equipment, program materials and other costs.

Recent Developments in the President's Support of the Citizen Corps

On April 8, 2002, President George W. Bush traveled to Knoxville, Tennessee to discuss his Citizen Corps initiative with leaders from fourteen cities and counties who have already launched Citizen Corps Councils (Bush 2002b). The President announced that he has requested $50 million for Citizen Corps in his supplemental budget request to Congress for fiscal year 2002. He has already requested $230 million for the Citizen Corps initiative in his fiscal year 2003 budget.

The local government leaders were from: Arlington Heights, Illinois; Charlotte, North Carolina; Chattanooga, Tennessee; Fort Wayne, Indiana; Knoxville, Tennessee; Laredo, Texas; Los Angeles, California; Orange County, California; Orlando, Florida; Placentia, California; Redondo Beach, California; Santa Fe County, New Mexico; Tucson, Arizona; and Washington, D.C.

America's mayors, local government leaders and governors will receive the comprehensive Citizen Corps: A Guide for Local Officials. This guide will instruct them on how to start Citizen Corps Councils in their communities to build upon their existing crime prevention, disaster preparedness, and public health response activities through volunteer service.

The Federal Emergency Management Agency and other federal agencies have begun examining ways to include Citizen Corps activities as a factor in awarding grants to local and state governments from existing and proposed emergency preparedness and response programs.

While in Knoxville, President Bush commended that city's Citizens' Police Academy to illustrate how volunteers can help their local first-responder agencies in times of emergencies. The Knoxville police academy has trained more than 600 citizens in the past seven years, each of whom volunteered for 30 hours of police and emergency training. Other examples of exemplary performance of cities and counties to develop volunteer resources include:

- Orlando, Florida: The "Mayor's Matching Grant Program" enabled seven neighborhood associations in Orlando to create Community Emergency Response Teams and purchase emergency equipment.
- Placentia, California: The call for Citizen Corps volunteers has already gone out and they have stepped up recruiting efforts for their Neighborhood Watch, Community Emergency Response Team, Volunteers in Police Service, Police Explorers, and Radio Amateur Civil Emergency Services programs.
- Tucson, Arizona: Two weeks after the terrorist attacks of September 11, 2001, the Mayor started "Operation Safe Tucson" which has now become the local Citizen Corps Council.
- Washington, D.C.: The Mayor has committed Washington, D.C.'s Commission on National and Community Service to develop its Citizen Corps Council. The Commission has already convened a meeting with local volunteer organizations and local officials to begin their planning activities, including their plans for Medical Reserve Corps and Volunteers in Police Service programs.
- Los Angeles, California: The City of Los Angeles' Citizen Corps Council will be working to expand a number of local programs, including their Community Emergency Response Team, Neighborhood Watch and SafetyNet programs. In 1985, Los Angeles developed what is now FEMA's national model for Community Emergency Response Teams as a way of providing citizens with basic training in disaster preparedness and rescue skills in the event of an earthquake. SafetyNet is the city's volunteer neighborhood emergency training program.

The Citizen Corps is up and running. More than 25,000 Americans in all 50 states and territories have signed up to volunteer in Citizen Corps activities.

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BIOTERRORISM PLANNING: SAN ANTONIO LESSONS FOR SUCCESS

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Abstract

Although planning for bioterrorism has gone on in many US communities for several years, it has been hindered by obstacles including jurisdictional isolation, inertia, lack of funds and lack of standards. The terrorist attacks of 9-11 and anthrax cases of October 2001 demonstrated the urgency of this planning despite all barriers. San Antonio, TX, succeeded in putting together an achievable plan using existing resources in less than 60 days. Its process included defined lines of authority, broad inclusiveness, triage of goals and breaking up tasks. With elements of a comprehensive plan in place, it is now possible to go back and solidify it, adding resources as funds become available. Key points of the process included gap analysis, regional approach and modularity of equipment packages for standardization and economy. The San Antonio experience outlines pitfalls and opportunities for medical leaders in communities preparing for biological emergencies.

Disclaimer

This presentation describes medical planning in a community in which a significant part of both the population and the medical infrastructure happen to be military. The principles described are community-focused and could have been derived anywhere. Military assistance to a community in a homeland emergency is a separate subject, governed by the Federal Response Plan.

Bioterrorism Planning in San Antonio

That bioterrorism is a threat to the United States is no longer in doubt after the anthrax incidents of October 2001. There is broad consensus that the medical community is not adequately prepared to deal with bioterrorism, or with any of the weapons of mass destruction that may be used by terrorists. But what does that statement mean? Is it a lack of material resources, of the right people, the right plans, the right connections or the right knowledge? The medical community of San Antonio came together in October, in a way that has attracted national attention, and asserted that the answer is "All of the above". The result: in a survey of bioterrorism preparedness in the 30 largest US cities, San Antonio rated second, after New York City, despite having some of the lowest indicators of per capita resources. One of the most significant contributors to that high rating was medical preparedness.

This presentation will give a short overview of what San Antonio did and highlight some of the features of this approach which can be applied anywhere.

Our starting position was that in the face of active terrorism, we had to have a plan that was as good as we could get without additional resources. Our experience leads us to say, "You can't buy readiness." However, thorough planning provides the basis for intelligent decisions about what gaps exist, what resources must be found to fill them, and how to spend those resources for the greatest effectiveness.

San Antonio and Bexar County have a long-standing, high-quality emergency preparedness program. San Antonio was the sixth city in the US to receive Weapons of Mass Destruction (WMD) training from the Department of Justice in 1997, and several city-wide exercises sponsored by the City, Local Emergency Planning Committee, National Disaster Medical System (NDMS) and the Texas Guard in conjunction with the City addressed chemical and biological terrorism issues in the years since then. However, as is typical of most cities, these exercises focused on first responders and did not task hospitals, physicians or other parts of the medical community. Also, South Texas has a good background in regional coordination in emergency management among governments and some agencies. For medical issues, the Regional Advisory Committees for Trauma (RACs) and regional organization of the Texas Department of Health provided some foundations for regional emergency planning, but this concept was not well developed in other aspects of health care.

There are a number of significant barriers to medical play in disaster preparedness, including lack of funds, the need to continue to provide uninterrupted real-world care, lack of a central authority or common forum under which the medical community could participate, and unwillingness to reveal proprietary information to competitors. All of these factors were operative in San Antonio as they are elsewhere.

However, thanks to the leadership of a number of dedicated individuals, we did succeed in building a core group of people who understood the need for better cooperation. Thus, on 9-11, the Greater San Antonio Area Hospital Council (GSAHC) was able to convene representatives of the key organizations for a number of meetings, first physically and then by teleconference, to coordinate resources. After the anthrax incidents of October 2001, this group organized itself as the Regional Emergency Medical Preparedness Steering Committee (REMPSC). The goal of REMPSC was to produce a workable, integrated, regional plan for bioterrorism response using existing resources before the Christmas holidays, an interval of 60 days. That plan was delivered and validated 18 December.

The REMPSC actually delivered a package of products in addition to updating the city and county medical plans. Even before this group was formally chartered, several of its members engaged in a physician education program sponsored by the Bexar County Medical Society. This education effort evolved into a Speakers' Bureau and package of educational materials for physicians as well as a collection of reference materials for the media and to be released to the public in the event of a local bio event.

A second critical achievement was the formation of a regional Medical Operations Center, or MOC, to back up the solitary medical representative at the City's Emergency Operations Center. The MOC provides a way to quickly identify resources and move them to where they are most needed, from and to anywhere in the region. It consists of upper-middle management personnel from all the hospital systems and other key agencies. They do not control their agencies resources themselves, but they have the ears of those who do. While a fully-equipped command post is in the works for the MOC, it currently meets in borrowed space and is able to assemble on short notice today.

Third, REMPSC devised one of the first comprehensive regional plans in the country for reception and distribution of the National Pharmaceutical Stockpile. This is a huge amount of materiel that arrives in 747s with a small core of advisors from the CDC. All unloading, transshipment, breakdown to individual dose packs and distribution is the responsibility of the receiving community. We identified a menu of options including primary and alternate landing sites, freight handlers, wholesale pharmacies to break down the bulk medications, storage and distribution sites, record keeping and staffing. This process engaged a number of groups that were very eager to be included but had been overlooked as resources, including retail pharmacies, dentists and churches.

Other working groups addressed hospital security issues, personnel, infection control and hospital-based patient decontamination. The latter two issues were particularly interesting because the only existing national standards are unachievable on a large scale with any realistic current or future resources. We did the best we could with what we could get our hands on, and have a common local standard that is pretty good, even if it is not ideal.

The process has been very rewarding. A network of robust new friendships and collaborations has grown out of REMPSC activities. Knowing that there is a lot we can do with what we already have has been reassuring to those to whom we are responsible and empowering to us. We have also built a fact base that can lead to a rational approach to future planning priorities and looking for additional resources.

From what we have learned, here is what we can offer to other communities:

1. Authority. Somebody needs to own the medical preparedness for the area. That responsibility is usually already assigned in the Emergency Plan, and is probably the local public health authority. However, first, public health agencies have a notorious history of being overworked and underfunded, and may not have the time or personnel to fully address this huge task. Second, medical preparedness is a complex, multidimensional problem, and includes stakeholders from government, hospitals, physician organizations, laboratories, support services, suppliers and a variety of others. Thus, the responsible authority should consider assigning operational responsibility for developing and implementing the plan to a workgroup, preferably based on existing organizational lines, with subcommittees from all interested constituencies.

2. Inclusiveness. Our workgroup had several hundred participants in multiple teams. We included City and County elected officials and Emergency Management Offices, the Alamo Area Council of Governments, local and state Health Departments, the Hospital Council and Medical Society, one civilian and two military Trauma Centers as well as about 20 other hospitals, a medical school, AirLife, San Antonio EMS and private ambulance companies, retail and wholesale pharmacies, a local grocery chain, shipping firms, churches and assorted other players. Anybody who griped about being left out was given a subcommittee to chair. The resulting community buy-in was spectacular.

3. Gap analysis. You can't know what you don't have until you know what you do have and what you might need. Right now a lot of money is being thrown around for terrorism response, but there are no data on where the needs are, what capabilities a facility should be expected to have, or what works. If the people with the responsibility do not get involved in answering these questions, people with other agendas and probably a lot less insight into critical issues will answer them.

4. Prioritization. Ours was quick and dirty—we knew what frightened us the most about our preparedness in October, and that's where we plugged deficiencies first. We were worried about education, patient decontamination at hospitals, and distribution of prophylaxis to tens or hundreds of thousands of people in a short time. Now we have those issues under control, and we are reassessing what our next priorities will be.

5. Division of labor. Nobody can do it all, and there's a lot of talent out there. We found ourselves all trying to do the same few things at first. Knowing that each issue had trustworthy people taking care of it freed each of us to concentrate on our own parts of the task.

6. Urgency. We set ourselves a brutal time line because we fully believed that it was our responsibility to ourselves and our community to have a comprehensive plan ready before the Christmas holidays. Since there have been no more anthrax cases for several months, the flame is flickering even in our community. However, the complexity of the job, as well as the length of funding cycles for supplies, training and exercises, requires a stern discipline about setting time goals. It also helps to build in some rewards along the way—internal recognition among the workgroup members, exercises designed to highlight successes, maybe even a party.

7. Civil-military integration. This falls into two categories.

> a. Communities that have embedded or nearby military installations have both an asset and a challenge. Installations are an asset in that they often have resources that can support a local community in an emergency. However, that support works best if detailed arrangement are made ahead of time and there are no unrealistic expectation. The other side of the coin is that installations may depend on the communities around them for a variety of services, including food supply, telecommunications, utilities, support personnel in base jobs, possibly even fire, police and medical services. These critical resources may find themselves double-tasked. This enmeshed relationship need not be a problem for either side, but it will require unprecedented levels of cooperation.
>
> b. All communities, with or without local installations, may expect to call for federal support in an overwhelming event, and some of that support is likely to be military. This presents opportunities for culture clashes and operational glitches. Get to know what help may be available, how to ask for it, and how to work with your uniformed colleagues. Especially, work with your state National Guard and Joint Forces Command to understand command and control issues and ensure that you can communicate over your radios.

8. Regional approach. The radiological, biological or chemical agent that will respect jurisdictional boundaries has yet to be identified. Small communities will be dependent on their larger neighbors for support, and may be able to reciprocate by offering personnel, hospital beds and other resources to hard-hit cities. Building in regional interoperability will be a challenge in the absence of umbrella organizations, but the time to start is now.

9. Modularity. We designed equipment packages that could be used in multiples—one for a small hospital, three or more for a large one—so that we could purchase, train and share regionally for efficiency and cost savings.

10. Exercises. It doesn't work until you've proved it works. These are hard to do on a grand scale. Start with "open book" discussions, tabletop exercises and tests of small pieces of the larger plan. Build components of medical response onto existing exercises with your fire and police departments or military neighbors. But don't give up on doing a big-picture functional exercise. Nothing else will test all the interrelationships. Just remember that these take a year or two to fund and plan.

What does it take to succeed? The requirements are simple in concept. First, you need the blessing of your senior Health Authority, Emergency Manager and elected officials. Second, you need a "sheepdog" to get and keep key players moving together in the right direction. Third, you need a few credible, knowledgeable champions from key participant groups to set that direction. Fourth, each key organization needs an enthusiast to drive and shape its participation. Finally, there needs to be a mentor to provide meeting space, administrative support and food. We found that good food was sometimes the only bait that brought tired, stressed people to meetings.

In summary, the medical community of San Antonio has done remarkably effective work in bioterrorism response for little cost other than the good will, energy and time of a lot of dedicated people. Much remains to be done in preparedness, both for our community and for the nation. We have outlined some of the processes that have been effective in our area and that we believe are broadly applicable, and we will be very interested in other communities' success stories. This is a job we must all make up as we go along. I would like to close with an anonymous quotation much favored by Lt Gen Paul Carlton, the visionary Surgeon General of the Air Force, who has encouraged members of the Medical Service to share with our civilian partners for mutual benefit: "The future is not some place we are going, but one we are creating. The paths are not to be found, but made, and the activity of making them changes both the maker and the destination."

SECTION 12:

BEHAVIORAL ASPECTS OF DISASTER RESPONSE

The International Emergency Management Society
9th Annual Conference Proceedings
University of Waterloo, Canada, May 14-17, 2002

ISSUES FOR TRAINING AN EVOLVING EMERGENCY MANAGEMENT WORKFORCE: A VIEW FROM THE U.S. MINING COMMUNITY

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Keywords: emergency responder; emergency management; older workers; training; mine rescue

1.0 Abstract

This paper reviews research from the U.S. mining community to define issues relevant to an evolving national and international workforce and to relate them to the emergency response population. The authors further explore and relate the key problem of an aging workforce to the resultant changes and emerging physical and psychological needs of emergency workers. Finally, the authors cite examples from the mine emergency response community and mine rescue experiences to suggest practical recommendations that include both organizational and individual formats, with an emphasis on new approaches to training this changing workforce.

2.0 Introduction

2.1 An aging world

The world population of the 21st century is changing rapidly, aging at a dramatic rate. The speed of population aging is attributed to three principal factors: First is the secular decline in fertility rates, which has the effect of gradually increasing the ratio of older to younger people in a population. Second is the decline in mortality rates attributed to advances in public health, medical technology, and standards of living. The third factor is what is usually referred to as the "baby boom," a temporary rise in post-World War II fertility rates (National Research Council 2001). As this cohort ages, it accelerates the overall aging of populations in various countries of the world. As recent articles in the print media suggest, the retirement of these so called "baby-boomers" will greatly impact various industries worldwide and nationwide (*Wall Street Journal*, January - June 2001; *Associated Press,* 2001; Cines, 2001; *Federal Employee News Digest,* 2001). The overall picture is of a world, and especially a nation, with changing, aging, and soon-to-retire workers.

This projected increase in older people provides for a number of challenges to the workforce. Usually population changes appear gradually over time and consequently policy makers can

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recognize and appreciate a certain degree of predictability. At this stage of history, however, the change is not so gradual. Recognizing the rapid aging of the present population can help to prepare for trends to come in the workforce. In the future, there will be a slower growth rate in the workforce, due to fewer workers. The declining labor force involvement of older people in many parts of the world is one of the most dramatic economic trends of the past forty years (National Research Council 2001).

The National Research Council (2001) in its "Preparing for an Aging World" report asked, "Is there a 'crisis of aging' worldwide?" (p. 17). In the year 2000, the net balance of the world's elderly population increased more than 750,000 each month. Two decades hence, the net increase likely will be on the order of 2 million per month (US Bureau of the Census, 2000).

Taking into consideration the difference between industrialized and developing nations, the point remains that most societies are aging. Given this difference, one way to look at population aging is to consider the median age of a country - the age that divides a population into numerically equal parts. While nearly all industrial countries are above the 31-year old level, developing nations have median ages under 25. Yet, in developing countries such as China, South Korea, and Thailand, where fertility rates have fallen precipitously, the median age is rising rapidly, and could exceed 40 by the year 2025.

2.2 An aging United States workforce

What is the definition of an aging worker? It is suggested that the definition is more situational than chronological, as there is considerable debate on the concept of older workers defined by age alone, whose ages may vary from 40 to 75. In the United States, the National Institute for Occupational Safety and Health reports that the number of workers aged 55 and older is expected to grow twice as fast as the total workforce for the next several years (Kisner and Pratt, 1997). Current Federal policy encourages Americans to retire at older ages than previously and makes it legally possible for all older workers to remain employed, regardless of their chronological age, for as long as they possess the ability and desire to work (Kovar and LaCroix, 1987). A substantial number of older workers return to work after retiring from one job. In fact, Castillo and Rodriguez (1997) report that from one-fourth to one-third of retirees return to the labor force.

Research has shown that injury patterns differ for older workers. Generally, older workers have lower nonfatal injury rates than younger workers, but once injured, older workers tend to have poorer outcomes than younger workers, with longer absences from work and higher fatality rates (Fotta and Bockosh, 2000; Laflamme et al. 1996, Kisner and Pratt, 1997, Layne and Landen, 1999).

Given these trends, how will changing demographics and a tendency toward differing injury patterns affect the international emergency management community? The United States mining industry provides an excellent example, in its mine rescue operations, of the issues presented by an aging emergency response community. The issues identified, questions raised, and recommendations made should provide a "heads up" for emergency management policy makers, educators, and workers world-wide.

3.0 Age and The First Responder Community

There is evidence that emergency response personnel in the United States are starting to feel the effects of an aging workforce. In the summer of 2001, The Federal Firefighters Retirement Age Fairness Act was passed which raised the retirement age from 55 to 57 for Federal firefighters. Some of the reasons the bill passed include the need for experienced firefighters on the line and in management positions, the lengthy training required for senior fire management positions, a tight federal workforce, and the fact that Americans are living longer (Fire Chief, News & Trends, August 6, 2001).

Even with this increase, however, Federal employees are retiring long before some city firefighters. In May of 2000, the Chicago City Council reinstated a mandatory retirement age of 63 for police officers and firefighters (City of Chicago Homepage, Office of the Mayor). The Council expected the change to force the retirement of approximately 45 firefighters and about 100 police officers. According to Mayor Daley, "Police officers and firefighters have physically demanding jobs. It's not fair to them - or to the people they protect - to let them continue past an age when their physical skills tend to deteriorate." He added, "We may lose some capable people, but there is no fair and legal way to require some to retire, but not others."

This same retirement issue was at the heart of a recent labor dispute between firefighters and the city of Bristol, Connecticut (BristolPress.com, January 29, 2001 and February 20, 2002). Two firefighters filed grievances after they were asked to retire because they were at or near the age of 65. "The case involving the men is the result of a grievance filed by the firefighters union, Local No. 773, on behalf of the firefighters named on the promotion list for lieutenants, who are essentially next in line for (one of the older men's) position ... The union's position is that we agreed, the union and the city, in a binding contract that 65 be the retirement date ... it's a public safety issue."

Whether or not retirement is forced, questions are being asked about the abilities of older firefighters to fulfill their duties. An article in the December 2001 issue of *Fire Chief* discusses the issue from a physiological standpoint (Steven Loy, Fire Chief, Dec. 1, 2001). The author recognizes that not all individuals age at the same rate, but points out that everyone does go through physical changes as they age. Physiologic system changes that he thinks are important for firefighters are: maximum oxygen consumption, muscle strength, and body composition. He comments, "It's apparent that we must encourage our [firefighters] to perform their cardiovascular and strength exercise programs. If we don't, there will be a decline in performance. Even if they do continue their programs, there will still be a decline but it will likely be much more gradual in nature." And while he encourages fitness programs to keep firefighters working as long as possible, he suggests "there's an absolute amount of fitness necessary for the job to be done well. It's not enough that you're in relatively good shape for a 58-year-old. Firefighting has an absolute factor."

The need for experienced emergency response professionals and for physically fit responders might not be at odds if the older experienced personnel were working with, and training, younger more physically fit responders. But the aging and shrinking labor market, and perhaps budgetary constraints, prohibit this from happening in some locations. The median age of firefighters in 2001 in the U.S. was 38.2 years (U.S. Bureau of Labor Statistics, unpublished employment data from the Current Population Survey). The same data show that approximately 62 percent of firefighters were 35 years old or older in 2001. In Canada, a similar situation exists. Job Futures 2000 reports that 45.3 percent of police officers and firefighters are 40 years old or older (http://jobfutures.ca/jobfutures/noc/626.html). It is likely that response personnel in other industrialized nations have similar demographics. "Out of the countries represented [(at a 1991 seminar)] (Germany, France, Sweden, the Netherlands), the perspectives for the development of the working population's age structure suggest that from about the year 2010 onwards, close to 40 percent of the population will be ages between 45 and 65" (Paoli, 1994, p. 5).

While it is not certain that the workforce in the emergency response professions will follow other labor force projections, it is likely that these groups of workers will experience trends in relation to age similar with the general population and other workforce categories. The median age of the U.S. population is expected to increase from 44.2 in 2000 to 44.7 in 2010. The median age of the labor force is projected to increase from 39.3 in 2000 to 40.6 in 2010 (Fullerton and Toossi, 2001, p. 36). "Over the 1998 to 2008 period, the oldest 'baby boomers' will turn from 52 to 62. After 2008, as more and more baby boomers reach retirement age, the impact of their retirements will continue to grow" (Brownfield, 2001, p. 6). The statistics suggest that the age of firefighters (and probably other response professionals) in the U.S. will increase over at least the next decade. The issues related to this aging of the population will also continue to grow in importance.

4.0 The U.S. mining industry

4.1 An aging mining workforce

The U.S. mining industry is a microcosm of this national and international aging trend. In fact, the trend is amplified in the mining industry due to a mining boom in the 1970s that necessitated the hiring of a large number of workers, most of whom were in their twenties. In the 1980s and 1990s, the mining process became increasingly capital-intensive, with downsizing and layoffs that resulted in a scarcity of younger new-hires. Thus, the cohort hired in the 1970s has remained the majority of the workforce, and they are aging. In 1998, the median age of a coal miner in the United States was 45.2 years (Fotta and Bockosh, 2000), and the median age continues to increase. Thus, the issue of aging workers, and particularly its relationship to the issue of emergency response in the mining industry, has been described as critical.

An aging workforce in a strenuous industry raises questions about an increase in fatal injury rates, longer injury-recovery times, and more time lost due to non-mining related medical concerns. Factors such as reduced stamina, flexibility, and strength need to be considered when designing equipment, planning maintenance, or setting protocol for mine safety and rescue procedures. Increases in chronic ailments such as back pain and deteriorating vision may also be important limitations.

4.2 Mine emergency response issues

Mining has a long history of disaster and organized emergency response. By U.S. law (Mine Safety and Health Act of 1977), every operator of an underground mine now must ensure the capability for emergency mine rescue and recovery. The mine operator may do this by establishing two mine rescue teams (each with five members and one alternate) that will be available when miners are underground, or the operator may enter into an arrangement for mine rescue services. Pursuant to this arrangement, the Act also provides for the establishment of mine rescue stations that have a centralized storage location for mine rescue apparatus and equipment.

It was determined, by the 1977 Act, that any mine served by a mine rescue team may not be more than two hours ground travel time from the associated mine rescue station. Small mines (those having fewer than 36 workers) or remote mines can, upon approval, establish alternate mine rescue arrangements (http://www.intminerescue.org).

While mining states may still be able to muster enough teams to comply with the law, there are currently no resources to spare. Since the early 1980s, many underground mines across the United States have closed. Most of these mines had at least one mine rescue team made up of miners who worked at the operation. Because of these closings, there has been an associated reduction in the number of miners, and subsequently, a decrease in the number of trained mine rescue members. The same process has also reduced the pool of potential members. In response to this problem, in July of 1992, a committee of Federal and Pennsylvania state personnel was formed to consider the status of mine rescue in Pennsylvania. The committee made the following assessment:

> Mine rescue coverage in Pennsylvania meets the requirements spelled out in Code of Federal Regulations, Title 30, Part 49. It does so with almost no reserve

> capacity, and a great reliance on Federally supplied, State Grants funding. Over two thirds of the mines in Pennsylvania rely on state trained and maintained teams for mine rescue coverage. If anything were to happen that would reduce the number of state teams or rescue stations, many mines would be unable to comply with CFR Title 30 requirements. It is also unlikely, as the situation currently exists, that sustained or multiple efforts at mine rescue could be made without assistance from out-of-state teams (http://www.dep.state.pa.us).

In other words, human resources are stretched thin, and backup support for any extended operation, if it could be found, would involve travel from great distances.

The Pennsylvania committee also noted specific concerns in the mine rescue infrastructure within the state, including a lack of information about rescue equipment availability and location. There are also unanswered liability and payment questions associated with mine rescue activities. Team members are insured by their employer while in their own mines, but a rescue operation by a mine team in another employer's mine may not be insured. Thus, Pennsylvania state teams are losing team members, and other privately maintained teams are also in jeopardy. Finally, the workforce and the rescue teams are aging (with an average age in the early 40s in 1992) (Bureau of Deep Mine Safety, 2002).

As a result of the above issues, a concern exists that there may not be enough adequately trained and equipped teams to meet the needs of an emergency. Basically, there are fewer and fewer mine rescue teams, and as experienced mine rescue personnel retire, the knowledge they have accumulated is going with them (Peterson et al., 2001).

5.0 Practical Suggestions

Researchers at the National Institute for Occupational Safety and Health have been examining the issue of aging miners, focusing not just on recruitment and retention but looking also at future concerns for miner safety (Kowalski et al. 2001). And, while recruitment and training new workers is important, maintaining the older worker has become an emergent issue. Organizations are experiencing an attitudinal change as the importance of training older workers is getting more attention. It has been suggested that with training to maintain, enhance, or update skills, older workers can continue to be very productive (Stein and Rocco, 2001). Older workers are viewed as assets in terms of work ethic, reliability, accuracy, and stability. Adaptation of the work environment and work practices, plus a re-examination of training methods and content can be a fiscally sound, production-oriented business decision.

5.1 Mandatory mine emergency response training

U.S. regulations (MSHA 2000) stipulate the minimum training requirements for mine rescue team members. Members must complete an initial 20 hours of instruction on the use, care, and maintenance of the type of breathing apparatus to be used by their team. They must also receive at least 40 hours of refresher training each year. This training must be given at least 4 hours each month or 8 hours every two months. The refresher training must include, among other subjects, underground training sessions at least once every six months and the wearing of breathing apparatus for at least two hours every two months.

5.2 Nature of traditional mine emergency response training

With the exception of the mandatory underground training, much of the required annual refresher training for rescue teams is conducted either in the classroom or in large open areas outdoors. The outdoor sessions, during which mine rescue teams don their breathing apparatus and other equipment, are designed to train the teams for participation in mine rescue contests. In an outdoor setting such as a soccer field, teams of six rescuers work to solve a theoretical mine rescue problem in which "trapped" miners are involved and must be rescued.

While training for mine rescue contests does provide a framework for teams to practice and improve their skills, this training falls short, because the exercises are not conducted in realistic settings. Teams ordinarily practice (and compete) under conditions of good footing, unconfined space, unlimited height, optimal lighting, and clear air. In the past, team members' formal training was enriched by their many contacts with others in the mine rescue community who had responded to numerous emergencies and had stories to tell about what to expect when rescue teams enter mines where there is mud, water, unfavorable geologic features, smoke, dangerous gases, and seam heights of 90 cm or less. With the passing of those who had real-life experience to hand down, and the increasing scarcity of both teams and events to respond to, the industry has begun to look for ways to enhance the training experience.

5.3 Real-world simulation training

Considering quality hands-on training to be crucial for the remaining mine rescue teams, a number of entities in the United States have turned to real-world simulation training conducted underground (Conti et al., 1998, 1999). During these simulation exercises, rescue team members don their self-contained breathing apparatus and then travel more than 300 m in mine passages filled with non-toxic smoke. Visibilities range from 0.3 m to 0.5 m during the simulations. A kerosene heater is typically used to simulate fire, reduce the ambient oxygen concentration, and produce increased levels of carbon monoxide. Among other activities, teams must search for victims, construct temporary ventilation devices, administer first aid, rescue injured miners, connect hose, and fight a conveyor belt fire. In several of the simulations, rescue teams have to crawl through a ventilation tube that is 6.1 m long and 81cm in diameter. This obstacle was designed to simulate low mine roof conditions and is the only way into and out of the other mine passageways. Although this type of training is both physically and emotionally demanding, it does simulate the type of real-world conditions and situations mine rescue teams encounter.

5.4 Some implications for real-world simulation training

The aging of the mine rescue team population at a time when a scarcity of teams has generated a call for more realistic training certainly has implications for emergency response. Real-world simulation training is physically demanding. Team members spend two to three hours wearing their self-contained breathing apparatus and perform difficult tasks in grueling, even if simulated, conditions. A recent discussion with a Pennsylvania Bureau of Deep Mine Safety mine rescue trainer revealed that two older members of his team are considering retiring from mine rescue in the near future because of the physical demands of the work. As the population continues to age, one can expect more mine rescue team members to exit this activity.

6.0 Discussion/Recommendations

On January 27-28, 1995, some 280 people attended a Mine Emergency Preparedness Conference held at the National Mine Safety and Health Academy in Beckley, West Virginia. The participants, who came from across the United States and several foreign countries, included personal protective equipment manufacturers, mining industry officials and labor representatives, State and Federal mining personnel, educators, and mine rescue team members. These individuals were convened in multiple working groups to offer recommendations for improving mine emergency response. Their recommendations, contained in a report issued by the Mine Safety and Health Administration, addressed seven issues related to mine rescue (http://www.msha.gov/MEDIA/PRESS/1995/NR950526.HTM): the composition of mine rescue teams; how to finance the mine rescue function;

regulatory requirements; rescue equipment; communications and counseling responsibilities; maximizing the effectiveness of mine rescue contests; and liability issues.

In essence, the Mine Emergency Preparedness Conference echoed many of the concerns raised by the Pennsylvania committee a few years before: In the face of a shrinking and aging mine rescue force, there is a need for 1) more realistic emergency simulations, 2) improved mine rescue training, and 3) creation of a counseling component for traumatic incident stress related to rescue operations. It was thought that these strategies would serve to facilitate recruitment and retention.

In dynamic, physically and cognitively demanding work environments such as mine rescue and more generally, in emergency management, there are specific implications for retention. It has been suggested that the older worker today is developing a third stage of working life, the period beyond the traditional retirement age and the final disengagement from the work role (Stein and Rocco, 2001). At this stage, the older worker is an active agent negotiating various roles within the workplace. This may include part-time or mentoring work, which may be very helpful to an emergency management community. As the response community ages, it may be less able to respond quickly to the rigorous physical and mental demands of a rescue effort, but has a wealth of knowledge and experience to offer. Therefore, it is important for employers to address the special needs of this population to ensure intervention strategies and work practices that effectively protect them and keep them on the job.

Lankard (1995) suggests that numerous changes in the workplace, including increased age of employees, require a different way of thinking with respect to training. As opposed to following the traditional model of an instructor imparting knowledge to passive learners, training must allow employees to draw on experience, link concepts to real world situations, and transfer knowledge from one situation to another.

As discussed earlier, the aging workforce issue has special consequences for the emergency response community. Based on past data, present research, and recent experience in the U.S. mining community, the following measures are suggested for international emergency management policy makers:

1. Assess the emergency response community with respect to the issue of aging and of turnover trends due to an aging workforce.
2. Develop a plan to address the issue in recruitment strategies.
3. Incorporate specific programs aimed at the aging worker such as physical conditioning, real-world simulation training, modified emergency response equipment, technologies such as thermal imaging and light sticks to enhance responder effectiveness, and enhanced personal protective equipment.
4. Develop a method to capture the experience and knowledge of the older responder before it is lost.
5. Encourage mentoring relationships either formally or informally.
6. Rethink jobs to include part-time or flexible hours for the retired emergency response expert.

Further research is needed to determine what specific interventions are effective for older emergency workers and emergency response organizations. The key point, as in any component of successful emergency management, is to adequately prepare for this predicted occurrence.

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EMERGENCY MANAGEMENT PERFORMANCE, THE IMPORTANCE OF ON-SCENE DECISION MAKING

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Keywords: Emergency management, decision making, on-scene commanding, coping with crisis, The Norwegian Rescue Service

Abstract

An effective emergency management is often connected with the goals achieved in the response activities. However, it is not clear which subsequent factors contribute to whether the emergency management should be regarded as a success or not. One factor, the on-scene commanding structure, and the on-scene commander in particular, plays an important role in fighting emerging crises. Dynamic decision making at the "sharp end" presents severe requirements to the commanders. This paper reviews research in the area of on-scene commanding, with special attention being paid to models developed to illustrate decision making under uncertainty in emergencies. The Norwegian practices on emergency response and rescue operations, at regional and local levels, are taken into account. The paper discusses the applicability of the models, this based on 20 years of experience as the commanding officer of a Norwegian fire department. Research in the area of real-time emergency management is difficult from a methodological point of view, due to sudden scenario occurrences, the vast number of variables involved, and the apparent uniqueness of each scenario. Finally, some ideas on future research designs applied to real-time emergency management are presented.

Introduction

Disasters, crises, accidents and incidents can strike at anytime and anywhere. Emergencies take many forms: a hurricane, an earthquake, a fire, a hazardous spill or a terrorist attack. They can be acts of nature or acts of man. The emergency can develop over days or weeks, or it hits suddenly, without warning. The consequences vary from purely local damages, to impacts on regional areas, through to national or even multi-national consequences. Every year, millions of people face disasters, and their terrifying consequences.

Decisions made now and in the past impact on the risk picture and can influence the occurrence of future emergencies. Figure 1 is an illustration of the different decision domains, where the horizontal axis shows the distance from the accident location, and the vertical axis shows the level of authority.

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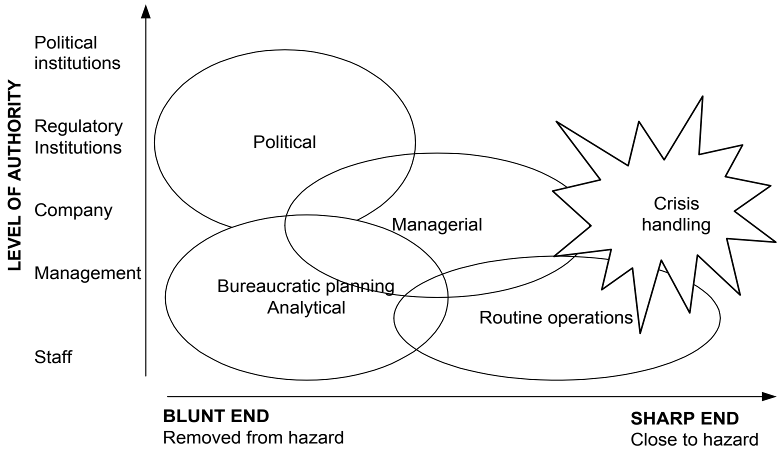
Figure 1: Typology of decision making settings, Kørte, Aven and Rosness (2002)



This paper deals with leadership at the sharp end, the crisis handling. That is the decision making in action, at the accident scene. Typical decision makers on-scene are the commanding police officer at the riverside close to the collapsing bridge, the captain on board a sinking ship and the fire chief outside the burning hotel. Decisions when a crisis is in progress are made on many different levels, but in this paper the focus is limited to the decision maker who has the overall responsibility on-scene during the crisis.

The remainder of this paper is organised with firstly, a presentation of the Norwegian model of disaster management. Secondly, a review of existing research focusing on both taxonomies and models of decision making on-scene. Thirdly, the models are discussed with reference to the Norwegian on-scene commanding structure. The paper concludes with some ideas for future action research based on my own experiences as a fire chief.

The Norwegian model

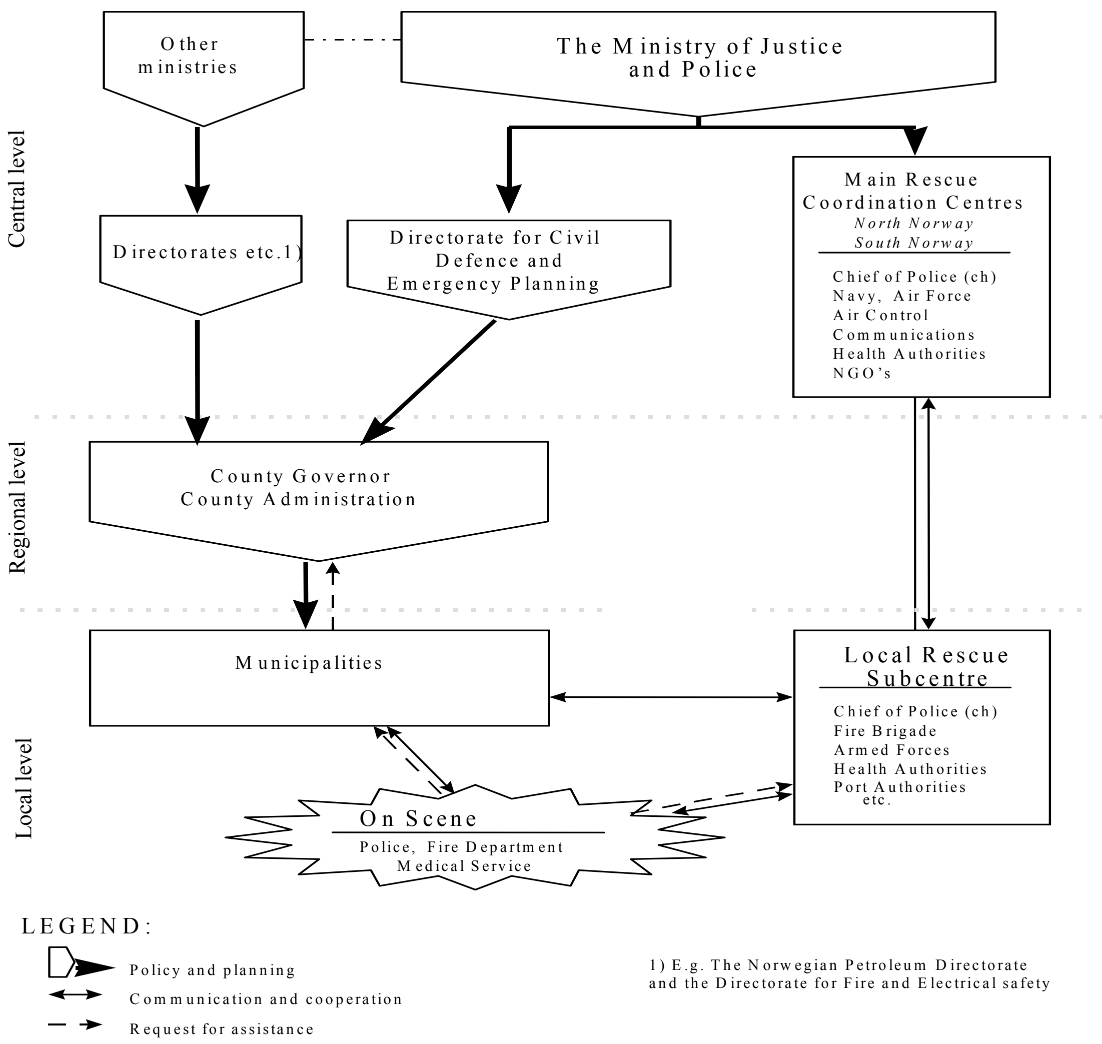
Norway measures roughly 155,000 square miles; the country is long, narrow, mountainous and is deeply intended with many fjords. Off the 25 148 km long coastline, (which is twice around the equator), 64 oilfields produce annually 181 mill. SM^3 oil and 53 bill. SM^3 gas (Norwegian Petroleum Directorate, 2002). The population of Norway, 4.5 mill., reside mostly in urban areas. Avalanches, hurricanes, floods, accidents in the petroleum activity, transport accidents (air, railway, sea and road) and fires are typical examples of Norwegian emergencies. Norway has 276 km of train tunnels and 638 km of road tunnels. The longest tunnel is the Laerdal tunnel, 24.5 km. To date, tunnel incidents have been a minor problem.

What is the Norwegian model for disaster management? Well, a general model is difficult to ascertain. Fragmented and decentralised responsibilities are the most prominent characteristics of the Norwegian model. However the Ministry of Justice and Police, cf. Figure 2, play an important role, and its responsibility will probably increase in the future national emergency management organisation. The government proposed in April 2002 to gather the public safety (security and emergency planning) in one directorate (The Ministry of Justice, 2002).

On the preparatory side of the emergency management, there has been a shift into risk based regulations. The Directorate for Civil Defence and Emergency Planning (DCDEP) has been a pioneer, by issuing guidelines (e.g. risk and vulnerability analysis, emergency planning, crisis management), by promoting emergency training and by performing surveillance of the municipalities' planning processes.

Figure 2: The Norwegian model on Disaster Management

DISASTER MANGEMENT IN NORWAY



The local and regional response and rescue service is a co-operation between the local police, the fire service and the medical service, in which the police have the co-ordinating responsibility. A typical local rescue team in an average Norwegian municipality (8.000 to 20.000 inhabitants) consist of; the local sheriff and his deputies, 16 part-time fire men and a local ambulance service. The train accident on the Røros line January 4th 2000 killed 19 persons (NOU 2000: 30). The local rescue service, as described above, stood alone fighting the crisis more than 30 minutes before additional resources of any consequence arrived. The problems with the Norwegian model are related to long distances to the neighbouring rescue services. They are expected to cope with wide range of challenges/scenarios, they have limited rescue competence (experience and knowledge), and work with limited resources. The available rescuers (firemen and paramedics) are often engaged on a part-time basis. In addition, the position of local commander is often seen as a solitary responsibility. The major problem with the fragmented responsibility model in Norway is that, in response to major accidents, it takes an unnecessarily long time to establish an on-scene emergency management team.

My responsibility as fire chief in Sandnes and 3 neighbouring municipalities, is 100 000 inhabitants, 8 fire stations and 170 employees, where 110 are part time. In a normal year we have to deal with almost 100 building fires (minor and major), 30 traffic accidents, 20 hazardous materials responses and 1500 paramedic responses. The fire chief is the on-scene commander (in fires, traffic accidents, train crashes, etc.) until the arrival of the local police.

Emergency management and on-scene decision making - taxonomy

Traditionally research has been focused on the general managerial/organisational decision making and the political decision making during emergencies (e.g. 't Hart 1998, 2001; Rosenthal et. al. 1989). Decision making under uncertainty and under time stress are general characteristics that could be related to an accident scene. The command system on-scene, surprisingly, seems to have engendered little attention amongst researchers. Some work has been done within military defence (Verzberger, 1998) and the fire and rescue service (Klein 1993). These contributions have mainly been theoretical. Applied research is almost absent. So far no scientific documentation has been found on successful on-scene management, i.e. why things went well. Of course, many inquiries/investigations have been carried out and they have given valuable knowledge about what went wrong, why the accidents occurred and whom to blame. However, in the same investigations, evaluations of the actual rescue operations in the sharp end have generally been but superficially performed.

<u>Emergency management</u>

Emergency management is the process of preparing for, mitigating, responding to and recovering (or reconstruction) from an emergency (FEMA 2002; 't Hart, 2001; Roshental et al., 1989). This seems to be a common interpretation in the research literature. But this definition also relates to terms like *risk management*, *safety management* and even *crisis management*. Are these different? Is it arbitrary which term to use or are they mutually exclusive? A massive amount of research literature on the different topics exists, and our conclusion is that the differences are more related to the research environments and traditions, than to specific physical, organisational or operational factors. Intuitively, the severity and the time constraints of the event, and the potential outcome could be used to separate the terms. No one seems to have challenged the use of terms, and what effects the uses on these terms have had.

Emergency management is a dynamic process, the work domain changes for each task. Each scenario is unique and its circumstances are often badly structured and, consequently, will only in broad general features be known to the combating actors. The teams involved are not static; they change from time to time, as the commander (Rasmussen et al. 1991) does.

<u>Crisis</u>

The Federal Emergency Management Agency (FEMA) quotes "an emergency is unplanned events that can cause death and significant injuries…". Other terms are accident, crisis, and disaster. Many describe crisis as borderless threats, creeping and acute (urgency), contending reality claims (uncertainty/surprise), ongoing process (compressed decision – making), conflictual and media roaming free ('t Hart 2001). Rosenthal et al. (1989) uses the "un-ness" to characterise the disasters; <u>un</u>pleasant, <u>un</u>expected, <u>un</u>scheduled, <u>un</u>precedented and almost <u>un</u>manageable events. The National Center for Crisis Management Research and Training of the Swedish National Defence College in Stockholm (Olsson 2000), define crisis as an event consisting of the three criteria; important values are at stake, limited time to deal with the situation, and a great deal of uncertainty involved. Thus, it can be concluded that decision making on-scene must include the terms: *severe threats*, *uncertainty* and *prompt action*.

On-scene decision making (commanding)

"We do not make decisions, we fight fires!" (Klein 1989), is a typical response from the fire chief to the inquiry about what decisions were made during a building fire. This indicates that the process leading to the different decisions is an automatic process.

Decision making in the on-scene context, has in the research literature many different names, such as decision making in action (Klein, 1993), rapid decision making (Klein, 1993), dynamic decision making (Brehmer, 1992), decision making in natural context (Rasmussen, 1991), vigilante decision making (Janis and Mann, 1977), naturalistic decision making (Klein 1993) and crisis decision making (Rosenthal et. al, 1989). Dynamic decision making may often be a compromise between a good strategy for controlling the decision task, and a strategy that enables the decision maker to exert some measure of control of the rate at which he/she has to make decisions (Brehmer 1992).

Edwards (1962) gives some characteristics of dynamic decision making. Firstly, *a series of decisions is required to reach the goal*, a successful outcome. Secondly, *the decisions are not independent*. One decision leads to a later decision. Thirdly, *the state of the decision problem changes*, both autonomously and as a consequence of the decisions already made. Brehmer (1992) adds a fourth characteristic; *the decision has to be made in real-time*, which means that the decision maker is not free to make decisions when he himself wants to. He/she cannot wait until he/she has gathered all the information, made the analysis and organised the necessary resources. The decisions must be made in accordance with the demands of the situation. The decision maker is the "owner of the problem "; no one else can make the decision. We can describe the decision process as a longitudinal time process. Time is running, and it is impossible to stop or have a time-out. In addition, the goal of a successful outcome is not straightforward in a crisis. The decision making is often incremental, in which it is difficult to relate sub goals to the ultimate one. This is emphasised by Klein, Orasanu, Calderwood and Zsambok (1993), who describe the conditions of on-scene command with ill-defined goals and ill-structured tasks. They also introduce the notion "knowledgeable people", which means that every crisis consists of a unique combination of knowledge from both the rescuers and the victims. In order to cope with the event, the on-scene commander has to perceive the real-time situation and its dynamics. Orasanu and Connoly (1993) introduce ideas of a commanding strategy on-scene, employing feed-back loops, and Brehmer (1992) adds feed-forward strategies to deal with the changing situation in real-time. The workload on the on-scene commander can be extreme, compounded by; the *critical values at stake*, *multiple players involved*, *time constraints* and *competing goals* (Orsanu and Conolly, 1993). The decisions that are made in the first minutes, and hours, are crucial to the successful mitigation and the overall conclusion of the crisis (Kowalski and Vaught, 2001). An on-scene commander is essential, especially when the crisis is novel, the consequences are unclear, different authorities are involved, many actors struggle on-scene and the media are paying particular attention.

Uncertainty is regarded as a prominent characteristic of on-scene decision making. Hansson (1996) presents interesting considerations concerning severe uncertainty, i.e. in cases where "the decision maker lacks much of the information that is taken for granted in the textbook cases". Although Hansson's ideas are not related to emergencies, important parallels effects can be discerned. The uncertainties relate to: the identity of the options not being well determined (*uncertainty of demarcation*), the consequences of at least some options are unknown (*uncertainty of consequences*), it is not clear whether information obtained from others, such as experts and informants, can be relied upon (*uncertainty of reliance*), and the values relevant for the decision are not determined with sufficient precision (*uncertainty of values*). The main common characteristic of on-scene commanding and decision making is uncertainty. Uncertainty is the on-scene commander's sword of Damocles.

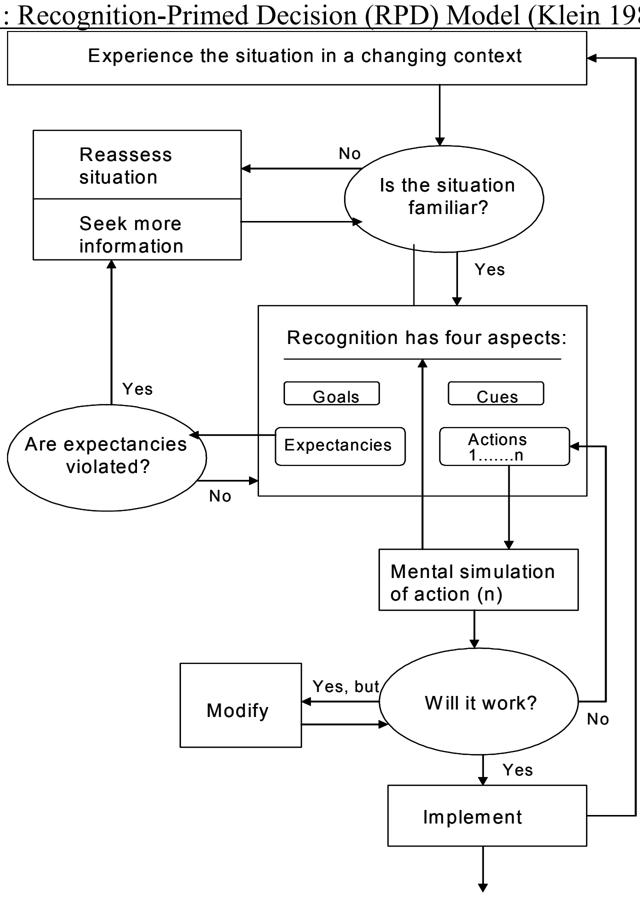
Emergency management and on-scene decision making - models

Human decision making might be thought of as a process where individuals construct certain maps to help to clarify their thoughts and subsequent actions. The map summarises the interdependence of variables, or the influence that one variable might have on another. We define the map as a model.

The following presentation is not an exhaustive overview of models employed in or developed from on-scene decision making.

Recognition-Primed Decision (RPD) Model (Klein 1989,1993) refer to Figure 3, is selected as a starting point, because intuitively it complies with my experiences as a commanding officer.

Figure 3: Recognition-Primed Decision (RPD) Model (Klein 1989,1993)

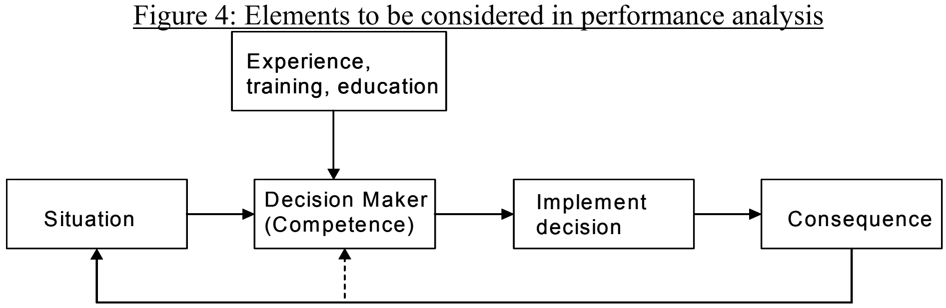


The RPD model is a process model where decision making is a sequence of activities. The process consists of three typical phases; *Situation recognition*, *Serial option evaluation*, and *Mental simulation*. Klein's conclusion is that proficient or expert decision makers rarely compare among alternatives. Instead they assess the essence of the situation, e.g. types of building fire and its demands. Then they select an action which they know will cope with the urgent situation, e.g. use a ladder and smoke divers to rescue the people trapped on the third floor of the burning house. This view on the mental reasoning of experts is also supported by Cosgrave (1996).

The RPD model describes emergency situations, minor as well as major, offshore and onshore, earthquake and landslides, and that is its forte. In addition it is easy to understand and it is holistic. The decision maker identifies critical cues (e.g. is the driver breathing after a car crash?), then one assesses the situation (the driver is not breathing), and implements action (CPR, cardiopulmonary resuscitation). Plausible goals are set (the non-breathing driver should be able to breathe on his own). The action is evaluated (is he breathing?). If the patient does not breathe, the decision maker has to start the process over again. The RPD model includes feedback loops (e.g. the effect of the actions that have been carried out) and mental simulations promote feed forward loops - a way of being proactive.

The decision problem on scene can be compared to a model from cognitive psychology where focus is placed upon the person's ability to meet emergency situations in a functional way. This implies that the decision maker needs to know in *which situations* he/she must act, the decision maker must be *familiar with* his/her tasks, the decision maker must be *able to perform* his/her tasks in an appropriate way and be able to *evaluate the consequences* of his/her own commands. Schematically it could be presented as follows:

Figure 4: Elements to be considered in performance analysis

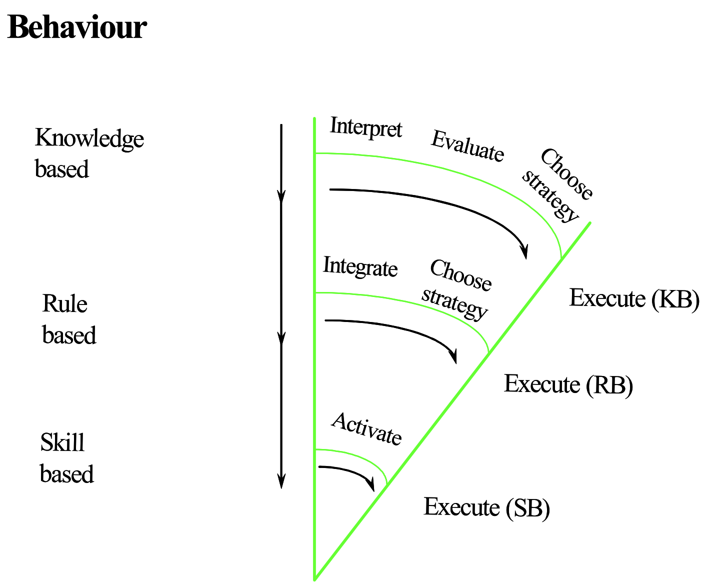


If a *situation* should occur, for instance a fire, a *Decision Maker* should - as a result of experience, training and education - be capable of evaluating the fire situation from, for example, an evaluation of the smoke plume and/or information from the personnel. He/she shall *react/implement his/her decision* in an appropriate manner, for example command smoke divers to a specific entrance. Finally he must be able to evaluate the *consequences* of his own commands, for example by checking that chosen fire fighting method has been effective. All elements are critical for the aim of achieving an effective emergency response. But what kind of competence is then needed? Rasmussen's (1982) behaviour model could be applied:

One problem with crises is that they can not be deterministic described in advance, because they have a stochastic nature. Thus it is not usually sensible to train decision makers for certain behaviour in a specific scenario and well known environment. The decision maker's competence should be balanced in a way that he/she both is able to analyse the situation (knowledge based level) and able to respond quickly and automatically (skill based level).

An offshore installation manager (OIM) will usually become the head of the rescue management in an accident situation. In these situations the OIM is responsible for the strategic decisions. The OIM must be able to analyse the situations and find/extract effective solutions. His/her behaviour is primarily knowledge based, but as a result of effective training, parts of the behaviour could be shifted to rule based and even some to skill based level. The OIM could be trained to recognise situations and connect them to established procedures for actions to be taken. Training could improve the decision making behaviour, ref. fig. 5, both the decision maker's ability to generalise (vertical arrows) and his/ her ability to discriminate (curved arrows) between events (Njaa, 1998).

Figure 5: Training impact on behaviour level and thus decision making on-scene (Njaa, 1998)



Lipshitz (1993) reviews and compares nine models of decision making, including the RPD model. Lipshitz identifies six common features; Real-world decisions are made in a variety of ways, Situation assessment is a critical element in decision making, Decision makers often use mental imagination, Understanding the context surrounding the decision process is essential, Decision making is dynamic – it does not consist of discrete isolated events or processes, Normative models of decision making must derive from an analysis of how decision makers actually function, not how they ought to function.

Lipshitz's (1993) Argument–driven model suggests that consequential choice, matching and reassessment are three generic modes of making decisions. Especially interesting is his description of consequential choice, which is framed as forward-looking choices. The expression ”think ahead” advocates a proactive management, which, in my opinion, is crucial to success.

Applicability of research achievements to a Norwegian fire and rescue service

Is research useful in the practical setting that constitutes our daily work? So far, I am not sure. The models are developed by researchers with limited experience in practical emergency management and decision making. Many of the models are abstract, incomplete and lack practical perspectives. Descriptive models clarify to some extent important features seen in emergency management, such as decision makers' challenges and attitudes. A question is, how can these models be integrated into the sharp end of decision making? Of course, the material could be used in training and theoretical education as an informative background. However, the *normative models* – the ideas of how activities and decisions *should* be made - are scarcely discussed. If we cannot say anything about what is constructively good and bad practice, the work has rather limited value.

Dreyfuss and Dreyfuss (1986) present the competence stages from *novice*, through to *advanced beginner*, to *competent performer*, to *proficient performer* and finally to the *expert*. As Klein (1993), Orsanu and Conolly (1993) and Cosgrave (1996), Dreyfuss and Dreyfuss claim that an expert generally knows what needs to be done based on mature and practised understanding. An expert's skill has become so much a part of him that he does not need to be more aware of it than he/she is of his/her own body. When things are proceeding normally, experts are not actively solving problems or making decisions, they are intuitively doing what normally works. Whilst most expert performance is ongoing and non-reflective, when time permits and outcomes are crucial, an expert will deliberate before acting. This deliberation does not require calculative problem solving, but rather involves critically reflecting on one's intuition. But, being able to describe an expert does not help. How do we develop on-scene commanders from being novices to becoming experts? Must they learn the hard way?

Decision quality is discussed by Simon (1955). Simon claims that people satisfy rather than maximise when they make decisions. To satisfy is to choose a path that satisfies your most important needs, even though the choice may not be ideal or optimal. This statement complies with the characteristics of decisions in emergency response. The reason is obvious; there is not sufficient time to optimise. One simply chooses the best option available.

Normative models, based on a comprehensive set of success factors, could be a good starting point for increasing the competence levels amongst on-scene commanders. The objective is to aid the decision maker under stress to make sufficient decisions at the right time, and to help implement the decisions. Remember, in Norway many on-scene commanders are infrequently in action, and rarely do they experience major accidents. From my experience, work to develop a set of success factors should be based on:

- A wide range of situations, e.g. from small traffic accidents to regional floods
- Mental maps for information seeking, evaluation and problem solving – recommended heuristics. Assessment of the situation and information processing
- Capacity of equipment and resources
- Inter-human relations and trust
- Level of uncertainty
- Time constraints and conditions that increase time stress in the situation
- Establish major goal and sub goals
- Ability to change courses of action

Brehmer (1992) emphasises that the proficient or successful on-scene commander often collects more information, he/she collects it more systematically, he/she establishes adequate goals, he/she evaluates the effects of his/her decisions and he/she is generally more systematic in their work. Orsanu and Conolly (1993) focus on the decision maker's ability to evaluate the situation and make cause-coherence models as being important success criteria.

To us, operation demands are well known, and often a theme in the discussion amongst the firemen after an emergency response action. To come to an understanding of the actual situation, and based on this, to arrive at directives for changes and improvements is crucial. The decision maker is context bound, embedded in ever-changing environments. Decisions in action are decision taken under a degree of uncertainty. In April this year we had a house fire at 8 o'clock in the morning. I arrived at the scene 15 minutes after the first fire engine had been called out and it was in action. A part of the house was burning. The heat was close to setting fire to the neighbouring house and an elderly man was missing. Or was he missing? Where could he be? Could he possibly survive if he was still inside? Where should we search for him? How many smoke divers could I use? The neighbour's house was in immanent danger. The uncertainty was great. One of my task as commander was systematically to reduce the uncertainty, while carrying out the most appropriate actions. A huge effort was made to search for the man, who, unknown to us, was visiting a friend in another part of the village. Could the emergency management and the decisions and actions that were carried out have been better? What is better, really?

Situations like this are difficult. Afterwards it is easy for bystanders and the media to criticise if something of value is lost.

A strategy to establish proactive decision making is proposed:

(1) *Establish a goal and sub goals*. Ask the question; what are the threats? Without a goal (or normally many minor goals), the commander on-scene doesn't know what to do or the right thing to do.
(2) *To figure out the available time before the decision must be carried out*. When time is running the losses can increase and the question is: What can be acceptable injury, damage and loss of life, environment and economy? When do we accept the provided information as sufficient for making decisions? Brehmer (1991) talk about overload of information. That is not the real problem. The main problem is to sort out the information you need right now and the information you may need later on. A strategy to sort out the urgent and non-urgent problem and related need for information, may give the decision maker valuable time during the hectic periods. Delegation to subordinates is an effective way of dealing with low quality, non-urgent problems when time stress is high.
(3) *Determine what response performance (including emergency management) that is needed,* when to reach the goal and determine the alternative actions. How can we minimise damage or loss?

Some ideas on future research design to real-time emergency management

Most studies of decision making in action have been retrospective narratives conducted after the outcomes were known. An example of such 'historical' analysis is Rosenthal and Pijnenburg's (1991) reconstructive logic through case studies. While historical analysis is necessary for examining many questions, it is generally better, if possible, to initiate studies of decision making in action as the processes unfold in the natural field setting, before the outcome of the process becomes known. The research must aim to produce new valid knowledge, not alone to validate well-known hypotheses.

To me, when research is about understanding how to manage an emergency or to make decisions on-scene, it seems necessary for the researchers to place themselves in the manager's temporal, contextual frame. The major focus of a study would entail conducting real-time observations of the events and activities in the emergency while it unfolds-without knowing a priori the outcomes of the events and activities. To understand the causes of the changes and how they interact there is a need to supplement regularly scheduled data collection, through surveys and interviews, with intermittent real–time data.

Systematic longitudinal observation is necessary to substantiate and elaborate suitable process models of emergency management and decision making. Action research may be a valuable approach for achieving valid knowledge, and is a term for "describing a spectrum of case that focuses on research and learning through intervening and observing the process of change" (Cunningham, 1997). According to Grønhaug and Olson (1999) "action research is often difficult to conduct through experiments". Randomisation seems usually to become impossible, manipulation of treatment is often difficult, and true control groups are seldom available. An accident occurs unexpectedly and at a discrete time and it thus ensures a natural randomisation. Another research challenge is that the accidental situation develops with time, dependant on the system ability to mitigate the consequences; hence the state of the system in question could be viewed as a stochastic process (Njaa 1998). Some challenges to be aware of with action research are; the ability to control treatments, to focus on co-variation between cause and effect, to focus on time order of cause and effect, access to control groups and of course randomisation (Grønhaug and Olson, 1999).

Action research design must aim to produce valid knowledge:

- about assessment of needs throughout the different phases of an operation; i.e. prevention, mitigation, response and reconstruction

- to find coherence between interactions, actions, reflections (consequences) and changing direction during the emergency management
- to describe explanatory factors constructing our perception of emergency management and decision making on-scene
- to capture longitudinal real–life problems during the emergency management on-scene (what, why and when)

An interesting research strategy is participatory action research. It means that the researcher must be a part of the rescue team and be on call with them. If not, it is impossible to observe the whole emergency operation, and observations- data of the inherent important decisions, particularly in the initial phase, are lost. During the emergency the researcher makes adequate observation, either purely as an observer, or as a working member of the rescue service. The latter is controversial, but can be efficient if the researcher has the necessary rescue competence, integrity and position in the team.

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Acknowledgement

I am grateful to associate professor Ove Njaa, Stavanger University College, for valuable comments to this paper. The author gratefully acknowledges the financial support from the Stavanger University Foundation.

Author Biography

Eivind L. Rake holds a MSc. in Civil engineering, and he has many years experience as commanding officer in a fire department. He is fire – chief in Sandnes Fire and rescue service. Rake has led projects connected to risk and vulnerability, which spans from emergency preparedness in municipalities to regional hazardous material responses. At the Stavanger

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The International Emergency Management Society
9th Annual Conference Proceedings
University of Waterloo, Canada, May 14-17, 2002

HOW TO COMMUNICATE THE PUBLIC DURING THE THREATS OF BIOTERRORISM: STRATEGIES FOR CRISIS MANAGERS

Chienchih Lin
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Keywords: Bioterrorism, Strategy, Crisis Communication

Abstract

After the worst terrorist attack in American history happened on September 11, 2001, the subsequent biological event of anthrax being sent through the U.S. mail system caused several deaths and generated public anxiety. To eliminate the fear of future biological attacks and to create credibility and trust, health system officials must communicate effectively to the public during future biological events. Under the fear of biological attack, a crisis communication plan should be prepared to respond to such biological events. **PURPOSE:** When a biological event occurs, health system officials and government leaders should make an announcement of the biological event to the public. The officials and leaders should have the capability of crisis communication for improving public perception and understanding of health and environmental risks of bioterrorism to the press. The purpose of this paper is to provide strategies of crisis communication in order to assist officials and leaders in communicating with the public during bioterrorist threats. **GENERAL APPROACH:** The issues which involve the consequences of bioterrorism attacks are providing mass prophylaxis to exposed populations, mass patient care, mass fatality management and environmental health clean-up procedures and plans. In order to provide appropriate information in response to reducing public fears and concerns about bioterrorism, crisis managers should design a crisis communication plan to address this unique challenge and to reduce the impact of bioterrorism attacks. **METHODS:** This research describes the importance of a crisis communication plan and provides strategies for officials to communicate to the public in a biological event. Reviewing past and present news shows the public fears and concerns about the bioterrorism and the performance of crisis managers during a biological event. Indeed, reviewing literature and studies present communication strategies to assist officials and leaders to communicate to the public during the threats of bioterrorism. **FINDING:** The strategies for crisis communication to communicate to the public during the threats of bioterrorism are Openness -- to adopt a policy of appropriate disclosure about biological events, Truthfulness -- to avoid assumption and never mix facts with reassurance, Responsiveness -- to present the response of government agencies to counter the threats, Transparency -- to recommend specific steps that people may take to protect themselves, and Engagement -- to help people to settle in changed state of circumstances.

Introduction

After the worst terrorist attack in American history happened on September 11, 2001, the

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subsequent biological event of anthrax being sent through the U.S. mail system caused several deaths and generated public anxiety. To eliminate the fear of biological attacks and to create credibility and trust, health system officials must communicate effectively to the public during a biological event. Under the fear of biological attack, a crisis communication plan should be prepared to respond such biological events.

In Chinese, the word "crisis" is called "Wei-Ji" which is consisted of two words, "danger" and "opportunity". This means that crisis is a turning point in the course of anything, an unstable condition toward the best or worst consequence. Indeed, Professor John Harrald, Director of the Institute of Crisis, Risk and Disaster Management at the George Washington University, explains that crisis communication differs from risk communication in the following perspective [11]:

- "Event Specific",
- "Taking place in potentially adversarial environment", and
- "A top management responsibility".

Obviously, the characteristics of biological terrorism meet these three criteria. For example, the responses required during a bioterrorist event differ from the responses that would be required in responding to traditional hazardous materials, chemical, radiological, or nuclear terrorism. Moreover, the decisions of government officials and leaders who are located at the top level in organizations affect the consequence and development of a biological event. Therefore, how to communicate the public during bioterrorism is a unique challenge of health system officials and government leaders to respond such biological events. To reduce the impact of biological attacks, officials and leaders should understand what are the fears and concerns of general public about bioterrorism, what is crisis communication in a biological event, and how to use appropriate strategies to communicate the public.

Background

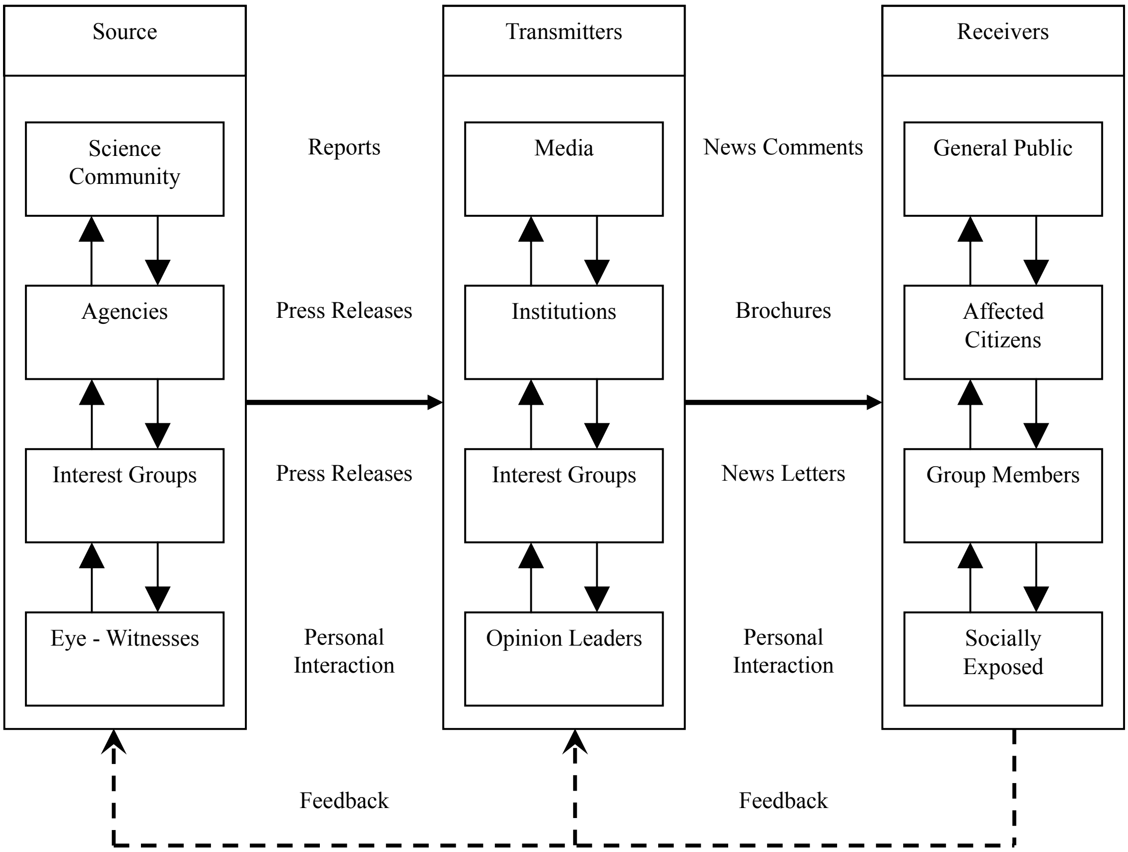
Purpose

When a biological event occurs, the health system officials and the government leaders make an announcement of the biological event to the public. Further, to eliminate the fear of biological attacks and to create credibility and trust, the officials and leaders should have the capability of crisis communication for improving public perceptions and understanding of health and environmental risks of bioterrorism. Therefore, the purpose of this paper is to provide strategies of crisis communication in order to assist officials and leaders to communicate to the public during the threats of bioterrorism.

General approach

The issues which involve the consequences of bioterrorism attacks are providing mass prophylaxis to exposed populations, mass patient care, mass fatality management and environmental health clean-up procedures and plans. Certainly, providing appropriate information can decrease public fears and concerns about bioterrorism and reduce the impact of biological attacks. Therefore, crisis managers should design a crisis communication plan to address this unique challenge.
For improving public perceptions of bioterrorism, holding a press conference is one way of communication models. Further, to implement effective communication to the pubic, Figure 1 demonstrates the organizational structure of communication to help officials and leaders to understand the communication process.

Figure 1: Organizational Structure of Communication



(Source: Renn, Ortwin. Risk Communication and the Social Amplification of Risk. Communicating Risks to the Public: International Perspectives. P287-P324.)

Objectives and methods

Objectives

This study has three objectives that are:

- Describing the public fears and concerns about the bioterrorism and the performance of crisis managers during a biological event,
- Presenting the goals, priorities, and management of crisis communication, and
- Providing recommendations for communication strategies to assist officials and leaders during bioterrorist threats.

Methods

This research describes the importance of crisis communication plan and provides strategies for officials to communicate to the public in a biological event. To conduct this study, the author uses the ABI/Inform and LEXIS/NEXIS search engines to reviewing past and present news with the keywords: “anthrax” and “crisis communication”. Past and present news show the public fears and concerns about the bioterrorism and the performance of crisis managers during a biological event. Indeed, reviewing literature and studies by searching library’s catalogues present the fundamental issues of crisis communication and provides communication strategies to assist officials and leaders to communicate the public during the threats of bioterrorism.

Discuss

The public fears and concerns

On October 5, Robert Stevens, a photo editor working for American Media Inc. in Boca Raton, Florida, became the first victim of inhalation anthrax following the September 11th attacks. [2] After this case, "seven more people . . . [were] diagnosed as contaminated in Florida, one person employed by the National Broadcasting Corporation in New York . . . contracted cutaneous anthrax, three people involved in the investigation . . .[were] contaminated, and 28 Capitol Hill workers . . . tested positive for exposure."[2][20] When the news was disclosed, a lot of people flocked to emergency departments and family doctors to request the prophylactic antibiotics to anthrax. [2] Indeed, gas masks in military-surplus stores sold out in a short time. After these cases, no one wants to take chances in such biological events. The publics seek help and attempt to protect themselves.

The performance of officials and leaders

The Florida Experience: After the first death case of anthrax disclosed, the Secretary of Health and Human Services, Tommy Thompson, announced that this case was an isolated instance and that the victim might have contracted by drinking from a stream. [2][20] However, drinking from a stream is "a very improbable explanation for the inhalational form of anthrax."[2] Of course, scientists promptly dismissed the possibility. [20] In fact, more than seven staff in the same company were contaminated by the anthrax mails in Florida. In this case, "senior government officials . . . [said] they have learned painful lessons about what and what not to say and do in the future."[20] Moreover, to reduce public confusion to fester, "the White House began staging daily briefings with its new chief of domestic security, former Gov. Tom Ridge of Pennsylvania, and top doctors and officials from a bevy of affected agencies."[20]

The New York Experience: At least 1997, New York City had been preparing for the biological or chemical attacks. The city government officials designed a drill that involved hundreds of city employees and more than 40 emergency rooms to show their preparedness against biological or chemical terrorism. However, in the case of anthrax letters, both the F.B.I. and city health technicians made serious mistakes. When the first suspicious letter was founded at NBC on September 25, the F.B.I. officials did not initially alert the city police and did not follow protocols to test the letter for anthrax spores directly. Further, when the F.B.I officials sent a second letter, which did contain anthrax for testing to the New York City Health Department laboratory**,** technicians unintentionally contaminated a special chamber in the lab and exposed themselves to miniature amounts of bacteria. Subsequently, technicians were given antibiotics as a prophylaxis and the city closed this lab. As a result, both the New York City officials and the F.B.I. acknowledged the gaps of bureaucratic rivalry in coordination, communication, and command. [20]

The Washington Experience: On Capitol Hill, 28 workers tested positive for exposure to anthrax from a letter opened in the office of the Senate majority leader, Tom Daschle. More than 20,000 people waited to get tested, including congressional staffers, messengers, lobbyists, reporters, tourists, and photographers. Initially, the response was a mistake to take 30 or 45 minutes to shut the Senate ventilation system. After that, "four senior Congressional leaders decided to shut most of the Capitol complex for testing and to end the week's session a few days early."[20] Nevertheless, "speaker J. Dennis Hastert of Illinois presented the decision to the House Republican conference as a fait accompli. Then he asserted before television cameras that the ventilation system and tunnels in the Capitol complex had been contaminated."[20] Therefore, "at week's end, bitter recriminations raged on, not between the parties but between the two chambers over which had acted more responsibly to balance symbolism and safety."[20] Consequently, "one person has died and a handful out of thousands tested have been infected and are responding to treatment with antibiotics or are cured."[20]

The goals of crisis communication

According to Mr. James E Lukaszewski, an expert in the subject of Public Relations, he defines the following goals of crisis communication [6]:

- Openness, accessibility -- availability and willingness to respond.
- Truthfulness -- unconditional honesty is the only policy.
- Responsiveness -- recognition that any constituent concern is by definition legitimate and must be addressed.
- No secrets -- behavior, attitudes, plans, even strategic discussions are unchallengeable, unassailable, and positive.

The priorities of crisis communication

In the same paper, Mr. Lukasezewski also sets the following priorities of target audiences in crisis communication [6]:

- Priority #1: Those most directly affected (victims, intended and unintended).
- Priority #2: Employees (sometimes they are victims, too).
- Priority #3: Those indirectly affected neighbors, friends, families, relatives, customers, suppliers, government, regulators, and third parties.
- Priority #4: The news media, and other channels of external communication.

The management of crisis communication

The goals of crisis communication are to create or to develop the credibility and trust between the general public and the government officials in a biological attack. To understand the management of crisis communication and to analyze the different level of contributing trust, confidence, and credibility, Table 1 presents three levels of factors to illustrate the key variables.

Table 1: Factors of Credibility for Messages, Persons, Political / Cultural Contexts

MESSAGE	
Positive:	Negative:
Timely disclosure of relevant information	Stalled or delayed reporting
Regular updating with accurate information	Inconsistent updating
Clear and concise	Full of Jargon
Unbiased	Biased
Sensitive to values, fears and concerns of public	Inconsiderate of public perception
Admits uncertainty	The absolute truth
From a legitimate reputable source	From a questionable source
Organized message	
Use of metaphors	Too literal
Explicit conclusions	Receiver derive own conclusion
Positive information recorder in early part of message	
Forceful and intense	Dull
PERSON	
Positive:	Negative:
Admits uncertainty	Cockiness
Responds to emotions of public	Indifference
Appears competent	
Similarity with receiver	Perceived as outsider
Has some personal stake in the issue	

Clear and concise	Too technical
Perceived as "expert"	
Perceived as "attractive"	
Charismatic	
Trustworthy-honest, altruistic, and objective	
POLITICAL / CULTURAL CONTEXT	
Positive:	Negative:
Faith in institutional structures	Perception of structural decline
Check and balance system functioning well	Poor leadership / incompetence
	Corruption / scandal
	Energy crisis
	Perception of unfair taxation
New and innovative ideas	
	Perception of worsening financial situation
	Social unrest
	Terrorism

(Source: Renn, Ortwin and Debra Levine. Credibility and Trust in Risk Communication. Communicating Risks to the Public: International Perspectives. P175-P217.)

"The objective of crisis communication is to control damage to an organization's reputation."[17] Moreover, crisis managers should use the occasion of media attention to advertise the organization's mission, values, and operations to the public. Understanding the fundamental rules and doctrines about crisis communication, leaders and officials will know how to manage the crisis communication and to maximize the effect of crisis communication. [6] According to Mr. Otto Lerbinger, a professor of Public Relations in the Boston University, he indicates that the following measures to manage communications during the crisis event are [17]:

- Ascertaining and facing up to the reality of a crisis.
- Activating crisis management team and alerting top management.
- Designating crisis media center.
- Conducting necessary fact-finding.
- Speaking with a single voice.
- Holding quickly news conference and making disclosures to the media openly, honestly, and accurately.
- Communicating directly with government employees, customers, stakeholders, and other key publics.
- Taking appropriate remedial action.
- Keeping a log to improve future performance.

Findings

The strategies for crisis communication

The strategies for crisis communication to the public during the threats of bioterrorism are Openness -- to adopt a policy of appropriate disclosure about biological events, Truthfulness -- to avoid assumption and never mix facts with reassurance, Responsiveness -- to present the response of government agencies to against the threats, Transparency -- to recommend specific steps that people may take to protect themselves, and Engagement -- to help people to settle in changed state of affairs. [6]

Openness: Openness means that officials and leaders should adopt a policy of appropriate disclosure about biological events. In the first case of inhalation anthrax, the government official made a mistake by announcing that this case was an isolated case. In fact, in the days following this case, several victims had been diagnosed from the same anthrax mail as Mr. Robert Stevens received. In this experience, officials and leaders did not disclose appropriate information to gain the credibility of the general public. Therefore, the fears and concerns of bioterrorism were not reducing by the government response. In contrast, the government officials and leaders fuelled the fears of biological attacks. For this reason, openness is the first important strategy for governments and organizations to respond and handle with biological attacks**.**

Truthfulness: Truthfulness means that officials and leaders should avoid assumption and never mix facts with reassurance in a biological threat. On Capital Hill, Senator Tom Daschle inaccurately described his staffs as "infected." Likewise, Mr. J. Dennis Hastert, the speaker of the House, assumed the ventilation system of the Capitol complex that had been contaminated with anthrax spores. Subsequently, experts in biological warfare and building design had been examined these assumptions and called that "extremely unlikely". [4] This shows that officials and leaders should not assume any information of biological events. Furthermore, officials and leaders should avoid mixing the facts of biological threats. As a result, truthfulness is the second strategy to build the trust and confidence between the government and the pubic in a biological event.

Responsiveness: Responsiveness means that officials and leaders should present the response of government agencies to against the threats of bioterrorism. In the days after the first anthrax case was disclosed in Florida, health and law enforcement agencies stated conflicting statements frequently. Moreover, officials hypothesized about what had happened or what might happen. [4] However, in the view of the general public, people want to know not only what is the development of bioterrorism but also what is done for them. To demonstrate a model for how crisis communication might be effectively managed, the response of the New York City's mayor, Rudolph W. Giuliani, held a daily press conferences about the city's anthrax exposures and to disclose how the city government to counter the biological attacks. [4] Therefore, responsiveness is the third strategy to reduce the fears and concerns of the general public during the threats of bioterrorism.

Transparency: Transparency means that officials and leaders should recommend specific steps that people may take to protect themselves in a biological attack. Based on the limitation of the information flow, the public will be the last one to receive the information of anthrax through the media. It seems that anthrax is an unpredictable germ capable of killing a lot of people without warning. [4] Of course, the public does not have enough knowledge to protect themselves to avoid the risks of bioterrorism as specialists in a biological warfare. To address this challenge, officials and leaders should help people hold onto a rational assessment of the threat. Indeed, recommending significant measures is an appropriate way to reduce the fears from an unpredictable threat. Therefore, transparency is the fourth strategy to assist people to protect themselves in the biological threats.

Engagement: Engagement means that officials and leaders should help people to settle in changed state of affairs during and after the threats of bioterrorism. Certainly, a biological attack will impact the daily living and operation of the general public. Thus, the consequence of the bioterrorism is not only loss of lives by microbes but also causing social/economic impacts from interrupting the routine. Moreover, encouraging people to return to the normal operation in order to reduce the impact will be an important issue for government officials and leaders to consider in the response and recovery phase of bioterrorism. For example, a cabinet minister publicly fed a hamburger to his child to demonstrate the safety of beef products after the British recovered the food market from the disease of Bovine Spongiform Encephalopathy (BSE). [4] Therefore, engagement is the last strategy to encourage people to return to the normal business after the changed circumstances from bioterrorism.

Conclusion

When a biological attack strikes, the coordination and preparedness of government agencies and the leadership of officials are tested. Certainly, using a federal grant to assist state and local health systems is a good way to reduce the impact of bioterrorism. However, how to unify the effort of countering biological threats is the most important issue for officials and leaders to address. Using appropriate strategies in crisis communication can achieve and maximize the effectiveness of government's response. Therefore, officials and leaders should develop a crisis communication plan that incorporates openness, truthfulness, responsiveness, transparency, and engagement to most effectively counter the effects of bioterrorism.

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Acknowledgments

The author wants to thank Prof. Joseph Barbera, MD and Ms. Deana Byard in the George Washington University.

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SECTION 13:

TRANSPORTATION ACCIDENT INVESTIGATION

HARMONY IN DIVERSITY
Methodological issues in independent accident investigation

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Keywords: Methodology, accident investigation, safety board

Abstract
Performing an accident investigation requires specific skills and a distinct investigative methodology. Such an investigation should be separated from allocating blame and should be based on a systems approach. Such skills and methodologies are not identical with academic methods and procedures and prove to vary across the 5 principal processes. An encompassing and structured case-based fact finding strategy is required to establish an eventual causal chain of events. Such fact finding has to be put in a systems perspective and should eventually lead to acceptable and implementable systems changes. Academic research, in contrast, focuses on experimental verification of assumptions, derived from a theoretical framework with implicit scientific paradigms involved. Although scientific proof may well be required throughout the five investigation processes, this methodological distinction should be recognized. Until recently, this investigative methodology has not been made explicit to researchers outside the safety board community. A methodological evolution of TSB's is discussed and options are explored for co-operation with academic disciplines, as well as possible priorities for global harmonisation with respect to its methodology.

Introduction
Three schools of thought

Safety in modern transportation systems has been an issue for about 150 years. It evolved as a discipline from several different domains and disciplines and has a strong practical bias. Consequently, various 'schools of thought' have been merging, of which the most important can be categorized as 'Tort Law School', 'Reliability Engineering School' and 'System Safety Engineering School' (McIntyre 2000).

Each of these schools represent a different pattern of thinking and can be considered as consecutive, representing the societal and scientific safety concepts of their times. These schools are supported by extensive literature covering a wide variety of domains and scientific disciplines.

The 'Tort Law School' as defined by McIntyre, has a long history and roots in the U.S. railway industry since the end of the 19th century. It goes back to the introduction of safety engineering design in the railway industry to cope with the carnage among railway workers. Lorenzo Coffin is stated to be the first railroad safety advocate and champion of safety legislation in the USA. He was the first in line of a series of safety advocates, followed by people such as Ralph Nader in the

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automobile industry or Mary Schiavo in the aviation sector. He had a pioneering voice for the merging of two streams of safety technology and government policy control. Out of this development, an engineering design approach emerged, focusing on certification and standardization of technical designs and products. This development found its counterpart in 'forensic engineering'. This discipline focuses on technical failure and factfinding for the benefit of tort and litigation in liability issues concerning accident investigation, mechanical and structural failure of buildings, constructions and products (Carper 1989). Driven by a number of catastrophic events from the sixties to the eighties of the previous century, legislative efforts expanded safety litigation to almost every area from occupational and environmental to product safety, all modes of transportation and other major hazard activities. Moreover, the concept of failure is central to understand engineering, for engineering design has as its first and foremost objective the obviation of failure (Petroski 1992). Lessons learned from disasters can do more to advance engineering knowledge than succesful machines or technical designs. Such learning does not only refer to enhancing the safety of design products, but refers to enhancement of the design process as well (Stoop 1990).

Reliability Engineering became a new engineering school based on the problems of maintenance, repairs and field failures during the second World War. In communication and transportation, the rapid growth in complexity and automation fueled the development of sophisticated techniques in probabilistic risk assessment (PRA). The drive to understand the likelyhood of hardware malfunctions and errors led to the adoption of PRA in many high-risk industries, including the process industry and energy supply sector (McIntyre 2000)

After laying a basis for the design of man-machine interfacing in the Second World War in the military sector, the ergonomics area rapidly expanded to these industrial domains. It was only a natural development that the focus of mechanical reliability engineering expanded to the area of the human factor, predicting human reliability. Cognitive aspects of human error came to maturity by the work of James Reason, defining and operationalizing the concept of human failure. Most recently, the reliability concept has expanded from the technical aspects into organisational aspects of systems. The concept of High Reliability Organisations by Laporte and Normal Accidents by Perrow examined the complex relation between organizational culture and safety.

The modern Systems Engineering school developed with the dawn of space transportation. This approach focused on accident prevention and was heavily supported by the development of safety standards, specifications and operating instructions. The Systems Safety concept calls for a systems life cycle safety analysis and hazard control actions from the conceptual phase of a system on into the design, development, manufacturing, construction, operation until modification and finally demolition.

However, this quantifcation of risk standards raised questions about the acceptability of such risk levels and the application of scientific methods in assessing design consequences. The terrifying accidents in aviation with the El-Al 747 freighter crash in Amsterdam, the Valuejet crash and TWA-800 underscored the need to draw a distinction between regulatory compliance for 'certification' and 'safety' when communicating risk to the public (McIntyre 2000). Based on the analysis of a series of disasters, the sociologist Turner defined disaster not by its physical impact, but by its social impact: a significant disruption of existing cultural beliefs and norms about hazards and their impacts. He introduced the systems concept to sociological analysis of accidents and expanded the technical systems approach into socio-technical systems. An even further expansion of the systems scope of a disaster redefined disaster as 'crisis': unique events, embedded in the social context in which they occur, irrespective of their origin and causation, deprived from their specific (technological) characteristics. The focus shifts from sectoral and technical-analytical towards social-managerial, in which 'crisis' is a 'battlefield of subjective constructions, definitions and feelings, where objective risk analysis and expert based norms do not work any longer'

(Rosenthal 1999). As a consequence, causes of accidents may remain obscured or even become irrelevant. The complexity and dynamics is assumed to be so overwhelming, that a shift in focus to administrative responsibilities of national and local authorities is legitimate. This concept implicitely restores the notion of blame.

As a consequence of expanding scopes, attention should also be paid to higher order systems levels and post-event consequences dealing with rescue, emergency and crisis management or administrative responsibilities, institutional constraints and policy decision making and policy management issues. Demarcation lines between investigating major accidents and Parliamentary Inquiries become thin. After a major accident or disaster a Parliamentary or Public Inquiry may be installed to find out what happened, focusing on administrative and policy management responsibilities at a national administrative level. Such inquiries however are not functionally independent due to limitations in investigative potential, legal powers and political involvement at a national level in defining their mission statement. Consequently they cannot serve as a substitute for independent investigation agencies.

<u>A fourth school of thought</u>

In addition to these three ‘schools of thought’ a fourth school has emerged during the last decade. Based on the operational experience of Transportation Safety Boards throughout the world, a school of ‘safety deficiency and system change’ is developing. Essentially, this school elaborates on the systems engineering approach and transforms notions from accident investigation experiences into a theoretical framework. In this school the concept of independence is crucial, separating the investigative mission and efforts from allocation of blame and vested interests of major stakeholders. This school also separates the investigations from scientific preferences or biases of a technical, behavioral, organisational or cultural nature. A fundamental issue is how to achieve a neutral and objective analytic result as a basis for safety enhancements. Consequently, this school does not focus on ‘deviation’ from a normative performance, but refers to ‘system deficiencies’. It emphasizes the need to implement sustainable safety changes in the system rather than issuing recommendations without monitoring their lasting effects. (De Kroes and Stoop 1992, Hengst, Smit and Stoop 1998, Kahan 1998, Johnson 1999). A ‘layered’ model of the complexity and dynamics of socio-technical systems is being developed (Evers et al 1994). The focus is on safety critical characteristics in its structure, culture, contents and context with respect to safety critical performance throughout the life cycle of the systems (Stoop 1990). These characteristics can be identified and analysed along the lines of:

- an analysis of the primary processes and relevant actors during design and operation including their safety critical strategic decision making isues. However, such a preventive encompassing analysis is not always feasible in practice due to the complexity and dynamic nature of transportation systems.

Therefore, a second reactive approach is indispensable:

- an in-depth and independent investigation into systemic incidents, accidents and disasters. Such independent investigations may provide a temporary transparency as a starting point for removing inherent deficiencies in such systems.

There is a growing consensus that such investigations may require separate institutions with formal and functional independence such as Transportation Safety Boards with their own, specific methodology (van Vollenhoven 2001, Stoop 2002). The concept of independent accident investigation has a generic potential, expanding its application to other sectors outside transportation, such as defence, other high-risk industry, natural disasters, threats to health and environment, and major events such as explosions, major fires or the collapse of buildings and structures (IDAIP 2001). The concept deals with an integral safety notion: a multidisciplinary investigation into all causes, before, during and after the event.

Independent investigation agencies consequently may evolve into public safety assessors and have a function as gatherers of information across stakeholders and actors. After the TWA 800 and Swissair 111 aviation crashes the American and Canadian Safety Boards took a role as clearinghouses for informing the public and victim's relatives after the disasters. In the near future, they may be seen as safety ombudsmen, the principle advocate for transportation safety and appropriate care of accident victims. Independent investigations are considered a right of every citizen and a duty of society and may as such be of great significance to a democracy to function properly. Such rights should be anchored in law (Van Vollenhoven 2001). The new Safety Investigation Board in the Netherlands will have the form of an Independent Administrative Authority (ZBO), guaranteeing its independence, and precluding any influence by commercial interests (IDAIP 2001).

It should be acknowledged however, that the objective of learning may serve two goals: on one hand the goal is to conduct an analytical and objective diagnosis on deficient performance of a system, while on the other hand such investigations should serve to help the victims and their relatives to come to terms with their suffering and to put an end to any public concern that may have arisen in the aftermath (Van Vollenhoven 2001). The definition of 'disaster' as 'battlefield of subjective constructions, definitions and feelings, where objective risk analysis and expert based norms do not work any longer' may get in conflict with mission, credibility and reputation of TSB's in their working environments.

In conclusion, accident investigation may have two major objectives.
Either to

- allocate blame and liability to stakeholders and involved actors as a part of the judicial framework, to support the collection of evidence in court and to take disciplinary, criminal or civil law actions

or to

- learn from accidents and incidents in order to improve the safety performance of a system and to prevent reoccurrence of the events.

These objectives ask for two different methods of investigation, as well as different legal frameworks for the conduct of these investigations.

Diversity

<u>Different notions and rationalities</u>

It should be realized however that actors involved in accident investigation also may have fundamentally different notions of risk and may apply completely different rationalities (Stoop 1996).

During the conceptual design phase, projects and products are defined by a systemic rationality derived from physics, mechanics, engineering design and construction. This phase is linear and confined to specialists. The results of these design decisions are firstly and only exposed to an outsider view and judgement after the detailing phase during testing or operation. Risk perception of operators and users is based on a political and societal rationality. Such rationality is defined by interactions with other actors, negotiating and defining social reality in which operators have to cope with the complex and dynamic operational environment. Decisions made by commissioners and designers have led to a product which can be perceived by its physical appearances without revealing the inherent decisions of the earlier phases. Its operational performance can only be reconstructed by its physical appearance and behavior as exposed to operators and users. The technology which is applied is therefore 'to be discovered' to actors during the operational phase, taking the earlier design decisions as incontestable facts. Characteristics of the design may manifest themselves during the operational phase by incidents, accidents or disaster. Transparency of safety aspects in both rationalities is a crucial issue since safety may be outbalanced and obscured by other interests of a higher order. Such interests may manifest themselves only after an independent investigation into major accidents (Van Vollenhoven 2001).

Rationality of a designer and engineer focuses on realisation and is reasoning from goal and concept towards function and form. It follows a synthesizing and decision oriented line of reasoning. Rationality of an operator and user focuses on perception and knowledge. It follows a line of reasoning from observation, perception, towards structure, function and goal. It is analytic and conclusion oriented. Both lines are therefore contradictory in their development. To understand risks and safety issues two different lines of reasoning are available:

- an 'inside-out' vision of commissioners, designers, engineers and other actors which have an oversight of structure and contents of complex systems during their design, development and manufacturing. They are capable of defining complex interactions, couplings and causal relations within the system, risk management, mitigation and control included. They are less capable of dealing with the actual behavior of the system in its dynamic social environment in terms of risk perception and risk acceptance issues.
- An 'outside-in' vision of operators, users, risk bearers, regulators, administrators and other stakeholders which have to cope with the system characteristics in its operational environment. They are capable of dealing with global risk notions and and causal relations at an aggregated level, but lack a profound insight into the functioning of complex systems. They may concentrate on perception and acceptance rather than controlling risks.

An 'inside-out' vision is likely to define risk in terms of a program of requirements and standards, as a consensus document for the actual design and manufacturing. An 'ouside-in' vision is likely to define risk in terms of a defined reality among actors, negotiating risk as a 'social construct' to achieve consensus on perception and acceptance between stakeholders. If such a consensus is lacking during events with a high social impact such as disasters, a 'battleground' situation may occur.

A number of questions can be raised in which finding facts and communicating risk become critical succes factors in system deficiency identification and system change:

- can these subjective risk perceptions and differences in acceptance levels be taken into account in establishing transparency and objectivity concerning the occurrence?
- can we avoid such a battlefield and lack of expert based opinions and decision making during the formulation of recommendations for change?

Differences in context and expertise

Differences in context exist among the working environments of Transportation Safety Boards:

- there are differences per country, modality and sector. In aviation, there is an international standard (ICAO Annex 13), in other modes and sectors there are no or hardly any arrangements available.
- there are differences in world regions. In the North-American region the influence of 11th Sept is present, in Europe oncoming draft EU Directives are important and in the Asian and South American region the issue of new-entrants and low-resource agencies plays an important role.

With respect to the various knowledge domains a substantive diversity is present and scientific disciplines vary widely in their phase of development:

- regarding a technical-analytical approach a fair harmonization of methods and techniques has been achieved and a practical working relationship with judicial forensic investigations has been established. There is little development in the technical-analytical area. Principles from the aviation sector are more and more often applied in other modalities such as data recorders, reconstruction, metallurgic research, etc

- in the area of human factors and organizations, theoretical development is almost completed. The 'James Reason' school has become dominant. A translation and implementation from theory into practice is taking place. Many investigators however do still lack practical skills and a uniform interpretation of the human factor during their investigations.
- factors concerning management, administration and policy are not yet fully developed. Scientific theoretical developments are ongoing and a variety of preferences for multiple theories exist (such as learning organizations, safety culture, change management or participative decision-making in network configurations). Practical applicable methods and techniques are not generally available or are only founded on a single theory or experiences within a single domain. Theoretical models and normative notions seem to be dominant in the investigation of facts, establishing findings and drawing up of recommendations.

Acknowledging the differences in rationalities, visions, context and expertise, methodological questions arise, such as; how do we achieve transparency; how can we reconstruct major events, what kind of expertise and experience is required and; are TSB's suitable instruments for such an effort?

<u>Do TSB's suit the purpose?</u>

Maritime accident investigation courts were established by the second half of the 19th century in most of the sea-going trade nations. A judicial approach enabled disciplinary action against the misconduct of a captain and officers endangering vessels, cargo and passengers. Such an approach required an investigation into the naval disaster which had occurred, the responsibilities of the officers on board and their involvement in the event. Most of the present maritime accident investigation boards evolved from these earlier maritime courts, adding a learning aspect to their mission.

The role of the government was explicite and exclusive: the findings of the boards were addressed to the ministry which held jurisdiction over the issue. In most cases this was the ministry of transportation. The investigative efforts were conducted by the inspectorates of the ministries which also issued the reports on which boards could base their decisions. The investigative authority therefore was not functionally indepedent from administrative powers, although it could take a formal independent position, such as in the British administration. Similar administrative investigation agencies were established in the railways in many countries, although the disciplinary aspect was less prominent or even abandoned for the sake of learning.

Developments in aviation were slightly different from the maritime and railway sector. Accident investigation into major air crashes was established mandatory as an international obligation of a state by ICAO under Annex 13 in 1951. Initially, the investigation of accidents had the objective to mitigate the international juridical and administrative consequences of an air crash. Any state of operation, manufacturer and company should reduce the annoyance to the state of occurrence by establishing the causes of the accident, publish a report on the findings and issue recommendations to prevent the accident from happening again. The focus was on the technical reliability of the aircraft, the performance of the pilot and compliance with regulations.

In the sixties of the previous century, independent and permanent investigation boards appeared with the mission to investigate major aviation accidents. The concept was adopted in other modes of transportation as well, leading to the establishment of multi-modal transportation safety boards throughout the world (De Kroes and Stoop 1992, Hengst, Smit and Stoop 1998). This concept is now expanding to other sectors of industry. Draft Directives are prepared in the European Union to establish mandatory safety agencies and modality specific independent accident investigation agencies.

The mission of present independent safety board covers four principal purposes:

- determine preventable or mitigable causes of major accidents, disasters and catastrophes in transportation as well as other sectors
- identify precursors to potential major events
- increase safety by making acceptable and implementable recommendations
- assure public confidence in safety on a national or sectoral basis.

The strength of a board for its mission comes from its independence, credibility and ability to address recommendations to any relevant party. Their responses to the board are not only based on a legal mandate of the board to demand timely responses to recommendations but also on the evidence that emerges from its investigations.

Harmony

To guarantee a successful mission, five primary working processes of boards have been identified in an international survey of best practices of multi-modal boards in the USA, Canada, Sweden and Finland and a number of single mode boards in the Netherlands. These five processes of a safety board move the board from the decision to undertake an investigation of one or more accidents or incidents through the analysis of the events into formulations of recommendations to prevent or mitigate future accidents and finally to assessing the effects of those recommendations. Accompanying these actions are ongoing communications with the involved parties (Kahan 1998).

These five processes are:
1. an *initiation process* to decide whether to take action. A board obtains information about specific transportation accidents and incidents, as well as summary statistical information on transportation conditions and events and the results of research relevant to transportation safety. In the case of specific events, the board has a mechanism that helps it decide which events merit an intensive investigation.
2. A *fact-finding process* to assemble all relevant data bearing on an event and to determine findings about the main factors contributing to the event or general situation. There are three forms that the fact-finding may take: a reactive *event investigation* of an accident or incident constituting the majority of most boards' efforts, a *retrospective safety study* to attempt to determine the factors associated with and preceding events or a *pro-active safety study* in which the board plans a research study that includes primary data collection of events as they occur.
3. A *safety deficiency identification process* that takes the facts at hand derived from single events or from safety studies, and determines systematic threats to transport safety. The safety deficiency identification process can use modern scientific tools such as pattern recognition, multivariate regression, modelling or can be based on operational experience or a combination of these two.
4. A *recommendation process* that formulates effective steps to prevent or mitigate the harms of accidents and incidents. These steps should also be economically and politically acceptable. The recommendation process may include considerations of how proposed actions might be implemented.
5. A *feedback process* that maintains contact between the work of the board and the external public world. A central feature of this feedback process is a systematic monitoring of the recommendations of the board, both in terms of the actions taken in response to the recommendations and the effects of these actions on transportation safety.

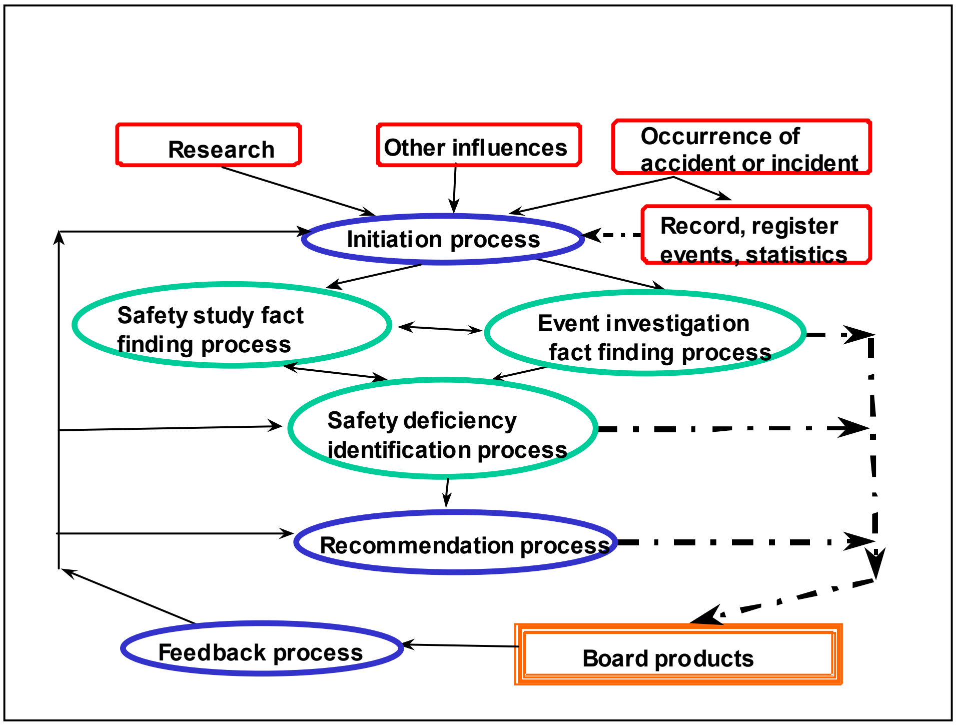
In practice, a wide variety of knowledge needs to exist. Together, they cover many aspects and can be allocated to the primary phases of the accident investigation process.

They can be categorized and allocated in particular to fact-finding, analysis and recommendations.

a. fact-finding focuses on collection of facts and other 'volatile' information. This phase provides information to answer questions about the WHAT and HOW of the accident. This phase concentrates on the sequence of events during the occurrence and provides information on the accident itself.
b. the analysis phase is focused on WHY the accident could occur and supplies additional post-scene investigative information. Collection of background information takes place and in-depth specific analyses are performed. This phase focuses on arriving at a satisfactory explanation of the occurrence and identification of systemic deficiencies.
c. recommendations focus on lessons to be learned and WHAT can be done by WHOM to prevent repetition of similar occurrences. This phase leads to a final report and drawing up of recommendations. All three phases are closely connected and require cooperation between all actors involved in the investigation process.

The processes can be characterised in a conceptual model as a benchmark for understanding the evolution of safety boards. The generic model identifies and links the five processes (see fig):

Figure 1: Five processes define work of a board



During the fact-finding phase a basic operational background knowledge is required to assess the need for specialist expertise for the interest of the investigations and to assess which information might be relevant to proceed with the investigations. In view of this operational focus, it is crucial to be aware of methodological pitfalls and shortcomings in accident investigation methods.

During analysis, data collected in the fact-finding phase are analyzed and additional information is collected by specific investigations and research in various disciplines. The investigator controls and manages the investigation process and assesses the methodological aspects.

During reporting and recommendations a translation is required into general learning aspects and a transition from explanatory factors into control variables, aiming at change in the system and acceptance of recommendations by all stakeholders.

Discussion and conclusions

A fundamental reason to introduce independent accident investigation was that parties involved began to realize that criminal law inquiries focus on allocating blame. To learn lessons for the future and to take steps to prevent similar accidents, it was essential to identify the causes of these accidents. Another type of investigation was thus needed. From a judicial point of view however, investigation methodology is restricted to inductive logic as the more useful tool for criminal intelligence analysis. It has strong ties with conventional 'forensic engineering' methodologies applied to determine liability for structural failure in engineering design. In the English language a clear distinction is made between inductive and deductive logic, by applying the notion of 'investigation' versus 'research'. Deductive methodologies have been considered less useful for investigations, since their inference does not go beyond the premises of their scientific discipline, not arriving at any new causes, conclusions or recommendations. In addition, the scope of criminal inquiries was restricted to discovering the direct cause of an accident and to identify an unacceptable deviation from a normative standard, not the underlying causes. This was aggravated by the fact that suspects were permitted to withhold information not to incriminate themselves. Conventional accident investigation methodologies therefore tended to focus on cause and not on prevention.

It may be concluded that independent TSB's represent a distinct school of thought in accident investigation. Historically, they have strong relations with engineering design and identifying failure in technical systems. Transportation Safety Boards however are evolving towards a socio-technical systems approach. Several methodological issues are yet to be resolved to guarantee their independence, credibility and reputation as a qualified agency. Historically, the role of fact-finding and accident reconstruction has firmly been established in relation to engineering design and operations in transportation. New sectors and scientific disciplines have emerged. TSB's need to develop their own methodology to comply with the need to link the processes of fact-finding and establishing system deficiencies to the process of drawing up recommendations and advocating systemic changes. It may be necessary to combine both processes in an appropriate form, despite the fact that fundamental differences exist between risk notions and rationalities across actors and stakeholders. It also clarifies the need for the TSB community to participate in an information infrastructure because TSB's will not be able to cover all required expertise on an in-house basis. It may be stated that in addition to a formal and functional independence, TSB's may also need to develop and maintain methodological independence.

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[1]DISASTERS IN TRANSPORT – THE USE OF ACCIDENT INVESTIGATION COMMISSIONS AS A PROACTIVE APPROACH

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Keywords: Accident investigation, safety board, disaster, transport, accident investigation commission

Abstract

Transport disasters and accidents with tragic consequences in aviation, maritime, rail and road traffic during the last few years have raised the issue of the safety of public transport in many countries. In addition, explosions, fires, and other large accidents and near misses in urban areas have contributed to a general feeling of fear and frustration among the public. Such disasters have been reported in detail by the mass media, politicians have called for stronger safety regulations, and police authorities have made investigations to determine if laws have been broken. Moreover, accident investigation commissions have often been asked to identify causes and propose new preventative measures.

Although accident investigation commissions exist in many countries, they do not constitute a homogeneous group. Some common international trends in establishing and organising such commissions at a national level are described and discussed, with emphasis on certain associated characteristics. The general difference between national accident investigation commissions and the safety boards in the transport sector is highlighted.

The preventative role of safety boards has been questioned. In conclusion, some of these critical questions are discussed, and certain prerequisites for a more successful preventative function are summarised.

Introduction

Some transport disasters and several major transport accidents have been widely reported in detail by the mass media in western countries during the last 2-3 years. Both the media and independent accident investigators have questioned the quality of safety management systems in transport enterprises, and the safety effectiveness of specific preventative measures. Despite the general reduction of injury risk associated with the use of public transport within the last decade, many passengers and potential users remain worried and, in general, feel that there are insufficient levels of safety within aviation, maritime and rail transport. Indeed, many people who rely on daily transport for work or leisure choose a private car as a safer means of transport! Public opinion, contrary to all the available evidence, is that the private car is safer than plane, ship or train.

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Norwegian accident statistics indicate that 90% of all fatal accidents in the transport sector in Norway were connected to road traffic (ECON Report 46/2000). This gap between individually perceived risks as opposed to the actuality of the statistically calculated risks represents a dilemma for those seeking to promote public transport.

The use of accident investigation commissions, in some form, is common in connection with public transport accidents. However, they are seldom used for car accidents where the police usually combine the functions of investigating the causes, identifying the guilty person(s) and recommending possible legal prosecution. The paradox is that despite both lower accident risk in public transport and a structured investigation procedure in the case of accidents, many people still doubt the safety of public transport and favour private cars.

Public transport, accidents and public confidence

The radical change in transport patterns in developed countries

Looking retrospectively over a long period, the overall pattern of transport of passengers in developed countries has changed radically according to the availability and use of the prevailing transport mode. Historically, over many centuries, transport overland was on foot or by horse, and at sea by ship. In the last century, the tragic sea disasters are exemplified by the Titanic in 1912 (over 1500 dead) and the Estonia in 1994 (852 dead). But most shipping accidents are connected to merchant vessels and fishing boats (excluding the two world wars) and have resulted in considerable loss of life. Technological progress in the 19th century led to the introduction of railways as a new and rapid means of transport without a high-risk profile. However, single train accidents resulting in many fatal injuries have highlighted the high-risk potential. Technological development in the 20th century led to two other transport means, with different risk profiles: motor vehicles (cars, buses and lorries) and airplanes. Road traffic was characterised by many accidents, on a small scale, but with a growing number of injuries. Conversely, the aviation sector was characterised by few accidents, but on a large scale. Today, most passenger and goods traffic in Western Europe is by road. Road traffic accounted for 79% of all passenger traffic in the 15 EU countries in 1998 (measured by billion passenger km), and 44% of all goods traffic (billion ton km). (See EU White paper 2001, page 24).

Today, the injury pattern reflects the distribution and use of the transport modes, and is partly influenced by systematic safety promotion.

Transport fatalities statistics for Sweden during the 1990's illustrates both the pattern of risk between different transport modes, and the potential for risk reduction (fig. 1). (Aarsbok 2000/2001: Transporter och kommunikationer, Svensk institut för kommunikationsanalys)

Similar patterns can be found in several countries whereby high-risk transport modes are the use of private boats and cars, whilst public transport means have a relatively low risk for fatal accidents. However, for a clearer overall picture of development, a more detailed analysis is required including the number of entities, work transportation trends and other varying factors.

The introduction of the zero vision (no fatalities/ no major injuries) in the different transport modes in many countries has highlighted the necessity of a continuous, holistic safety approach.

Fig.1 Fatalities in selected transport areas in Sweden, 1990 – 1999. Total number.

Year	Leisure boat	Rail*	Aviation	Road
1990	73	2	21	772
1991	80	0	11	745
1992	55	0	17	759
1993	50	0	8	632
1994	46	0	7	589
1995	47	0	14	572
1996	33	0	4	537
1997	38	0	9	541
1998	42	1	4	531
1999	28	1	12	580

Remark: *Rail fatalities: Source: Swedish National Rail Administration/Swedish Railway Inspection/ NSB BA. Aviation: 75 % of the fatalities in the period 1990-99 occurred in connection with private airplanes, only 25 % with other airplanes.

The risk in transport

Research has shown that, "people have a higher risk valuation when travelling by collective modes of transport like railway than when going by car". Professional transport companies operate collective modes of transport, and all employees are specifically educated and trained to do their jobs. Serious companies have adopted safety management systems, procedures and routines to ensure safety of operation. Public responsibility and liability should encourage a high level of safety. The risk of injuries varies according to the type of transport mode, and for several reasons. Laws and regulations, certification, auditing regimes etc, in addition, comprehensively regulate the transport areas. The key question is, if the different acceptances of risks as seen by society, politicians, inspectors and passengers, are concurrent or not? The tolerance of hazards will vary along different dimensions, but as a common phenomena the societal threshold has been lower from decade to decade, with the exception of the high sensation seekers, for whom individual acceptance and practice of high risk activities seems to be tolerated by societies. In the transport field, however, one conclusion could be that there is a need for more defined differentiated risk values, which in turn may raise several ethical and political questions.

Higher personal risk is not only accepted on an individual level when driving a car. Similar acceptance has been found with other activities. For example, leisure time, at home, during sport, on vacation etc. The risk acceptance gap between the collective sphere and private life can be explained by several reasons.

The present level of risk in the transport field is challenged by professor A. R. Hale (EU Proceedings 2001). His point of departure is that "most transport systems have inadequate system models for carrying out effective risk assessment and management". In his view, "the transport industries lag a decade behind the nuclear and process industries in making such explicit models of safety and risk control, including explicit and auditable safety management systems." He also argues that "transport systems such as aviation and railways have become ultra-safe without having such explicit models of how they achieve this. They are very vulnerable to the sorts of organisational and technical changes that are flooding over them at present. Without a clear model of who does what and which measures control which scenarios, outsourcing, downsizing, privatisation and decentralisation can remove vital safety functions in the system without us realising it." (Page 143).

Public confidence

A company's reputation is vital for success in the market place. The destiny of the worldwide enterprise Arthur Anderson is a good example of the thin edge between success and failure. All high-risk companies, and this includes all public transport companies, rely on public confidence for survival, and this is derived from subjective passenger evaluation of perceived risks. There are several examples from transport during the last 10-15 years of the considerable effect resulting from just one single accident. Many companies have used millions of dollars in trying to rebuild customers' confidence. The possible environmental disaster arising from the oil spill from the Exxon Valdez (1989) in Alaska and all the following counter measures is but one example.

Another example is the Aasta train accident in Norway on 4 January 2000 in which 19 people were killed. The train operator, NSB BA, carried out a public survey in the spring of 2000, and some of the results were clear:

- A majority held the opinion that it was safer to use private car than train
- Only 21% believed that NSB BA were strictly attentive to safety
- Only 51% believed that air companies were strictly attentive to safety

The survey showed that a majority of people thought car transport by road as far safer than transportation by a professional train operator, indicating a remarkable lack of confidence in the safety commitment of the rail company. Moreover, the survey also indicated distrust in the aviation companies' prioritisation of safety. The train company, NSB BA, needed several months to regain their customers. Similar examples can be found in other transports arenas and with other transport operators.

Accident investigation has a special function in this connection. This role is stated clearly in the Rand Report (1999): "The NTSB's unique role in transportation safety is …. to assure public confidence in the safety of our national transportation systems." (Page 1-2). To fulfil this role, the NTSB must of course meet special prerequisites, and such a function place also a heavy burden on NTSB. Similar multi-modal safety boards, however, characterised by independence, competence and authority, will have the same functions in their countries. The challenge to the Accident Investigation Commissions or Safety Boards is to preserve their integrity and independence in such a situation.

The role of accident investigation commissions

<u>Some major trends</u>

One major trend is to organise independent accident investigation bodies outside of the traditional organisational structures such as the transport directorate or inspectorate, and within the framework of public authorities. Usually, the responsibility of the investigating body is limited to a special transport mode, such as aviation, maritime or rail accidents.

This trend is further advanced by the European Commission's transport initiatives. In an ambitious programme, "European transport policy for 2010: time to decide" (EU White Paper 2001), several potential proactive measures are identified as intending to reduce the risk of accident in all transport modes. Two examples, of many: (a) the EU will, by 2010, reduce by half the number of 41,000 people currently killed in fatal road accidents on European roads. (b) A EU proposal to create a separate European Maritime Safety Agency. The issue of investigation commissions is dealt with under the safety directives for each transport mode. As one example, the European Commission will propose a new Directive on the regulation of safety and investigation of accidents and incidents on the Community's railways in 2002 (Draft proposal, December 2001). The draft Directive details several proposals, including an obligation on each Member State to create a permanent investigative body that shall be independent, sufficiently resourced, and capable of covering both accidents and incidents. The main aim is to improve railway safety and prevent future accidents and incidents.

On a national level, the tendency is two-sided. This involves both the creation of a sectorial accident investigation commission for each transport mode (if not already in operation), and the building up of institutional bodies and dedicating personnel with the necessary competence to fulfil such functions within major transport companies.

Parallel to this particular sector approach, there is another trend with growing importance in some European countries, the creation of independent multi-modal investigation bodies. One of the conclusions from the 1st Annual European Energy and transport conference in Barcelona (October 18 – 19, 2001 – Theme: Prevention the key to transport safety) was that "there is much benefit in the creation of a multi-modal accident investigation authority in each Member State. The multi-modal approach was seen as a positive step to widening knowledge. In particular in the field of the human element – often at the root of the accident – a multi-modal approach offers scope for cross-fertilisation" (Proceedings, page 61). A recent example of such organisational innovation is the new Safety Investigation Board in the Netherlands.

Two models of safety boards are currently in use. Firstly, there is the traditional approach of a multi-model accident investigation commission for transport as used by the US National Transportation Safety Board (1967), the Transportation Safety Board of Canada (1989), the New Zealand Transport Accident Investigation Commission (1990), and the Netherlands Transport Safety Board (1999). However, the second model is a total, or holistic safety board, covering all major types of accidents, as utilised by the Swedish Board of Accident Investigation (1990) and the Accident Investigation Board of Finland (1990). (see also John A. Stoop 2001)

<u>Characteristics by AIC</u>

Modern transport safety boards have developed through different stages and processes. In the paper, "Safety Board Methodology" by Kahan and others, fact-finding investigations are divided into three categories:

1. A reactive event investigation of an accident or incident.
2. A retrospective safety study to attempt to determine the common factors in a series of events.
3. A proactive safety study, in which a board plans a research study that includes primary data collection of events as they occur.

In addition, they summarize the evolution of safety boards by identifying several dimensions, which are dependent of historical conditions and needs:

- Independence
- No fault
- Multi-modality
- A systemic perspective
- Safety studies

Only a few of the present safety boards incorporate all of these elements**.** The authors also look into the future and advocate new evolutionary steps.

Supporting collateral for these evolutionary viewpoints comes from two of the conclusions emanating from the 1st Annual European Energy and Transport conference in Barcelona. Namely, that there "are big differences between transport modes" and, "also in the field of accident investigation it was considered that the oldest transport modes can learn from the practices established in the youngest mode (aviation)". (Proceedings, page 61).

<u>Accident investigation commissions or safety boards?</u>

Historically, there is no straight line. The first, and indeed most important commission was the US National Transportation Safety Board. This safety board was mentioned in 1938 by Adgar S. Gorell, who was president of the Air Transport Association, in connection with the adaptation of the Civil Aeronautics Act of 1938. In a later phase, the concept of accident investigation commissions was widely used in several countries. However, during the last 10 years the focus has again been on safety promotion, and therefore also on safety boards. These two concepts have been used in different historical contexts and have different associations and meanings. While the term commission is used for numerous different purposes, there are common elements: the historical perspective, the fact-finding mission, and the necessity of a conclusion. The safety board concept is associated with a positive approach, is more future oriented, and has the promotion of real safety as a key element.

Safety boards as proactive tools

Some critical questions

Most of the activity in present safety boards around the world is concentrated on investigating actual disasters, accidents or incidents. Using the US NTSB as an example, the Rand Report (1999) focuses on the inherent dilemma that all accident investigation commissions are facing: "The NTSB's mission is primarily *proactive* – the prevention of transportation accidents – yet the agency accomplishes this mission by being *reactive* in responding to catastrophic events." (Study overview, page 5). This problem is of crucial importance. However, one argument could be to underline the potential effect in-depth studies and safety recommendations can have on similar risks within the same transport mode or on corresponding risks in the transport system as a whole. The validity of the argument will depend of the real effect of the recommendations i.e. if they are adequate and implemented. Another argument could be to stress the importance of investigating incidents. A critical view would be to examine the extent of incident investigations and the follow-up of such investigations.

Another question concerns the resources, priorities and competence of safety boards. Do they currently have the necessary resources available, including personnel with the necessary competence, to allocate activities connected to proactive tasks? In an organisation with limited resources, a heavy workload, widespread mass media attention, and impatience from politicians and victims to investigate specific accidents, the all-encompassing independent role is more idealistic than the actual reality.

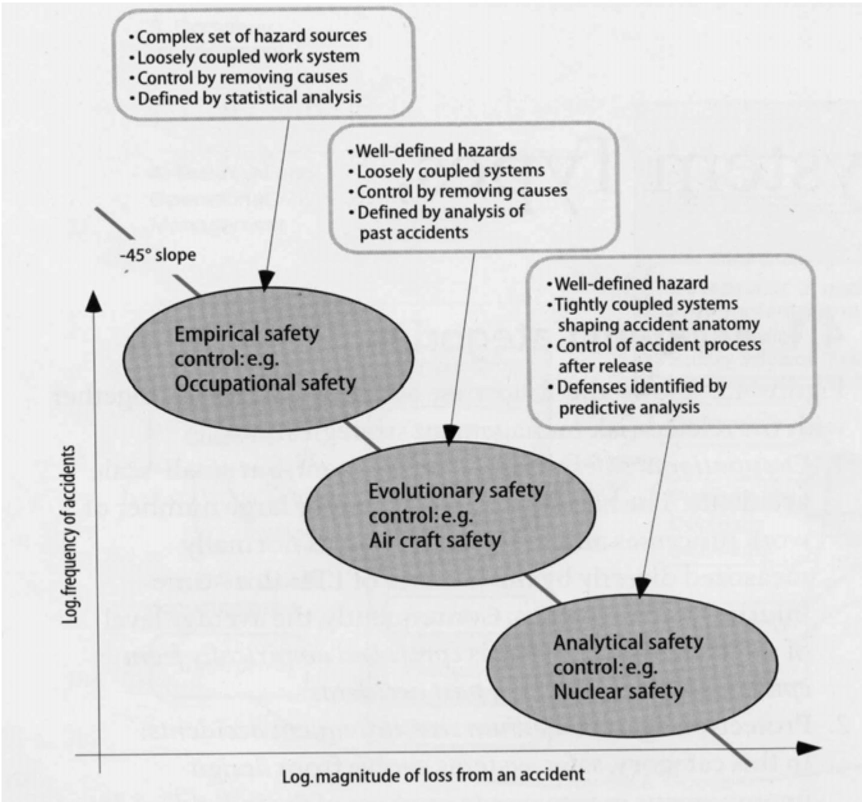
Improving the proactive function

One very important task for future safety boards must be to more clearly define the mission. This will then shape the strategic decisions concerning organisational structure and position, resources, suitably qualified personnel, methods, equipment etc.

Such a policy process should ideally focus on both objectives and limitations. This might lead to the conclusion that accident investigation commissions are not the most appropriate method to use in respect of all kind of accidents. It will be essential to identify a set of criteria to define which types of accidents are applicable for proactive aims. Danish researcher Jens Rasmussen has illustrated this point (fig. 2). He combines the frequency of accidents with the magnitude of loss from an accident, leading to the basic features of different hazard categories and the related hazard sources. Different risk management strategies are necessary to deal with these accident categories (Rasmussen/Svedung 2000, page 28). The same will occur with accident investigation commissions; their mission must be defined in more proactive terms to stimulate the development of real safety boards with proactive functions.

Independent investigations should be anchored in law, as proposed by Pieter van Vollenhoven, in 2001 (van Vollenhoven 2001). He argues that every citizen has a right to independent investigations after accidents, and society has a duty to perform them.

Fig. 2. Jens Rasmussen's figure of different hazard categories and hazard sources



Wider and improved application of conclusions, recommendations and proposals should be encouraged, both within the specific transport mode and the relevant transport sector as a whole, both nationally and internationally. Such distribution of knowledge and firm proposals could be the task of an international body, preferably a UN organisation. The usefulness of such a knowledge database will increase over time, since it is reasonable to assume that similarities at the system level, both within the same transport mode and between different transport modes worldwide, will develop towards closer uniformity e.g. human factors, technology, safety management systems etc.

There is a considerable potential for accident research to produce more scientific based knowledge about risks, accidents, prevention and emergency management. Today, the resources used on such research in different countries are remarkably small. Safety boards should be adequately financed to enable the initiation and support of research in areas where more knowledge is needed.

Concluding remarks

There is an urgent need for improved organisational and methodological approaches when using accident investigation as a method to enhance proactive measures against the threat of future disasters and accidents.

1. The establishment of safety boards should be encouraged, especially in the developing countries, with the help of financial support, systematic use of investigative and preventative competence and experience feedbacks.

2. Safety boards should, at the very least, be multi-modal and independent, cover the whole spectrum of transport modes, or be national safety boards covering all types of major accidents.
3. Safety boards should be designated the necessary resources to recruit key personnel, develop new skills and competence, and initiate research programmes and projects.
4. As a long term aim, to enhance safety promotion, a UN database is needed to incorporate worldwide information on accident and incident statistics, accident investigations, injury causes, exposure statistics, in-depth injury studies, recommendations, research results.

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Sverre Roed-Larsen, educated as a sociologist, is a project manager and has more than twenty years experience of consumer and product safety work for the Norwegian public authorities, in addition to railway safety management for the Norwegian State Railways. He is currently a researcher at the Norwegian Work Research Institute, where he is working on a Ph D dissertation on the use of accident investigation commissions following transport disasters in some European countries during the 1990s, particularly aviation, maritime and railway accidents. He has broad experience from international work, including that with UIC, OECD, EFTA, ECOSA, PROSAFE, and ESReDA.

ISSUES AND JUDGEMENTS IN ACCIDENT INVESTIGATION

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Keywords: Accident investigation, narrative, risk analysis, uncertainty, power

Abstract

Everyone seems to agree upon the fact that accident investigation is necessary and important. There are several reasons for this view, but the most prominent ones are the learning aspects and the societal need to know what really happened. The TIEMS 2001 conference put accident investigation on the agenda, and some delegates concluded then, that a national accident investigation commission, working on a continuous basis, is the right pathway. In Norway, we have had three major accidents, which all occurred close to the entrance of the new millennium. Commissions nominated by the national authorities investigated all three accidents, and the investigations were published as public study reports.

This paper questions accident investigation as a narrative art. One commission carried out two investigations during 2001, the Åsta accident (train collision, 19 fatalities) and the Lillestrøm accident (train accident caused propane gas leak and fire, which threatened parts of the town). These investigations, with emphasis on the Åsta investigation, are selected to pinpoint the power in the hands of the investigators. The power is not necessarily utilised to support the ideal and public informed goals of the investigations. Hidden agendas and poorly supported conclusions are examples of factors that undermine the independent narrative. Our conclusion is that accident investigation is important, but accident investigation processes and methodologies should be reconsidered, at least the Norwegian state of the art. There is a need to develop proper requirements in order to assure that accident investigation serves its intended function.

Introduction

Norway has recently had three major accidents, the two train accidents (Lillestrøm and Åsta) and one at the sea – the loss of the catamaran Sleipner outside the coast of Haugesund (16 fatalities). The Lillestrøm accident had a ”happy ending”, despite the fact that the local community was paralysed for several days. Commissions appointed by the national authorities investigated all three accidents (NOU 2000: 30, NOU 2000: 31 and NOU 2001: 9).

The TIEMS 2001 conference in Oslo put accident investigation on the agenda. The trend seems to be in favour of establishing national and international joint accident investigation commissions. Sverre Røed Larsen (2001) presented some experiences from, benefits of and dilemmas in accident investigations. Røed Larsen's work is normative, and it is highly influenced of his beliefs that an increased accident investigation effort is the right pathway to improve the national safety management performance. Ove Skovdahl (2001) presents the Norwegian National Railway

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Administration (NNRA) internal investigation of the Åsta-accident, and he describes some of the lessons learned.

In this paper the focus is on specific issues and judgements to be made in accident investigation, and particularly the investigators' power as the narrators of the "true" stories. In an accident inquiry the starting point is, of course, to reveal the truth about what really occurred and why the accident took place. But to reveal the "truth", i.e. all facts of the accident, is practically impossible. Ellinor Ochs (1997) describes narrative as; "It is our cares about the present and especially about the future that organize our narrative recollection of past events". Within this perspective, how shall we understand the investigations being carried out?

The remainder of this paper deals with specific issues in accident investigation. The issues relate to the *narrators*, the *mandate*, *accident modelling*, *methodological requirement*s and interpretation of *underlying organisational and operational factors*. The paper ends with a discussion of some effects of accident investigation.

Who is asked to tell their story?

Before anyone is asked to investigate an accident, there must be an event recognised by someone and the event must enforce an action. It is a "blink and wink"-situation, where the blink represents the events occurring in society. While the blinks continue to occur, the winks are the sudden considerations – "what happened" – and the time is stopped. One initial question is thus: *When does a blink become a wink?* Which criteria should govern the winks? Often media plays an important role in the decision process, but a general view is that the outcome of the accident must be severe (fatalities). The Lillestrøm accident had potential for a severe outcome, but in that case it could be questioned whether that wink was enforced by the Åsta-accident and the fact that the commission was already in place. The loss of the Sleipner A (Gravity Base Structure) in Gandsfjorden in 1991 was not investigated by a national appointed commission. This accident also had a fatal potential (approx. 15 persons on board) and the material losses (approx. NOK 3 bill.- 1991) was much larger than in the Lillestrøm-case.

As the wink is established a commission is needed. In Norway, a guideline (G-18-75, 1975) describes governing rules for accident investigation commissions. This guideline recommends a lawyer as the chairman for commissions due to their knowledge in judgements of responsibilities and legal process rules. The Åsta and Lillestrøm commission comply with this recommendation. The members of the Åsta and Lillestrøm commission were limited to one lawyer (chair), four engineers and one sociologist. In addition, two associate lawyers were employed as secretariate.

The challenge is: *What kind of competence is needed in the accident investigation*? Is safety violation a matter of law and technology? No, it is not, safety is multidisciplinary, and the judgement relates how to balance the commission between legal, technological, sociological, psychological, cultural, and other disciplines. Balance in background experience and competence is critical for the narrative and public confidence.

The importance of the members being independent is often emphasised. What does this really mean? Sometimes the question is connected with legal qualification. But, can we say, the work will be independent, as long as the members are legally qualified?

The challenge is: *How to justify independence*? Dependency can be interpreted in many ways, from sharing values involved in the accident to sharing the same educational background with the involved parties. However, dependency is needed. We need commission members who, for example understand the railway activities, who are confident with research methodologies, who can review emergency response and who are able to scrutinize human factors. The question of dependency could be replaced by confidence. The clients need to be confident that the group of investigators can develop the best possible narrative.

How to delimit the task?

What is the purpose of accident investigation? Usually the learning effects are emphasised, but in that case, how to answer the questions; what happened, why did it happen and how could it have been prevented? Investigators make a sharp distinction between investigation of causes and investigations of blame.

The challenge is: *How to select objectives of the investigation, and how to delimit the mandate to serve the objectives*? Accident investigations are a combination of observation of facts and judgements that are based on more or less consensus amongst involved parties. Blame and guilt are also placed in "independent" investigations, even though the blame is not necessarily related to the specific laws offended.

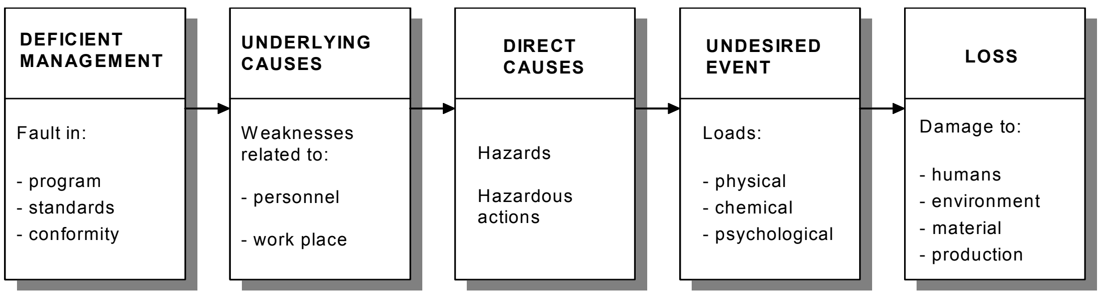
The Åsta-commission's mandate was: "to examine the facts of the accident in order to establish its cause" – that was the story as it really happened. However the commission was given total flexibility in their work, because their mandate was extended to "besides examine other conditions related to the accident". This means that the story expected from the commission change perspective from the narrow "why did the accident occur" to the wide "what could have prevented the occurrence of the accident".

Which accident model is relevant?

Accident investigators need to model the cause and effect coherences of the accident. It is simply impossible to completely reproduce the accident and its underlying circumstances (for example organisational factors). The investigators make their judgements about which models to apply. Models are simplifications of the real world, and they do have their weaknesses. The models are inaccurate, they are based on assumptions, and the models must be limited to specific issues or phenomena.

The availability of data is also critical for the narrative. The investigators collect evidence and data, they structure and analyse the information in their interpretive contexts. But despite the mass of information collected, there will always be lot of information lacking, for example due to vital actors may have died in the accident, evidence could have been deliberately or through negligence removed, or information could be lacking due to limitations of the frame conditions (economy, time, etc.) of the inquiry.

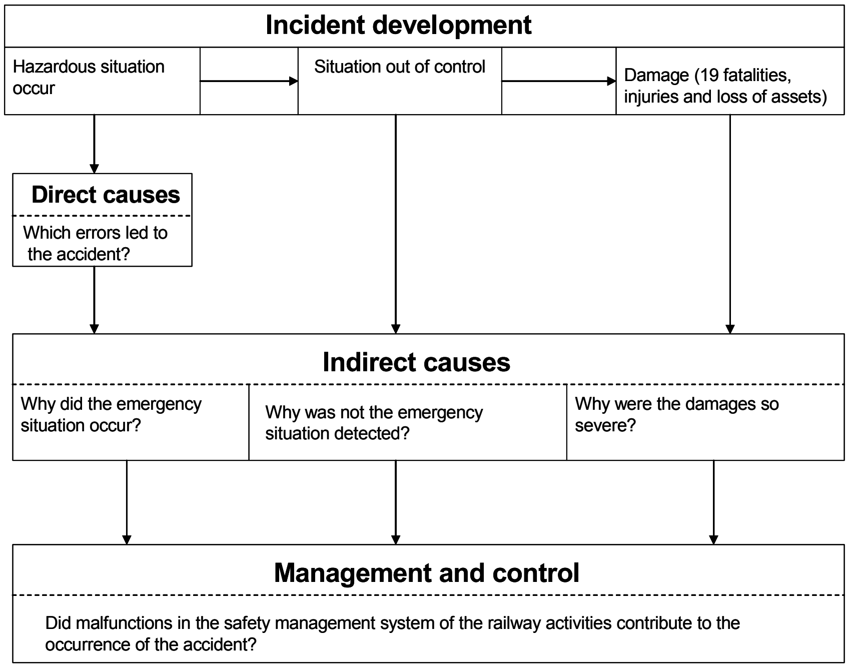
Figure 1: Loss Causation Model



The *Loss Causation Model*, see Figure 1, is a frequently used model, and it has its origin from Heinrichs domino theory. The Loss Causation Model is used by Bird and Germain (1986) to explain causes that leads to accidents, in order to develop adequate measures of loss prevention.

There exists no evidence that proves the coherence between underlying causes and losses, but Bird and Germain claims that the model is in line with recognised practice amongst safety experts and leaders throughout the world. See for example Sandve and Ringstad (1999) for a discussion of the Loss Causation Model, and for an overview of other models applied in accident and near miss reporting. The Åsta commission has also applied principles of the Loss Causation Model in their investigation, cf. Figure 2.

Figure 2: The commission's working model (NOU 2001: 30)



Models used in accident investigations have much in common with risk analysis models. They are event as well as phenomena oriented. However, the differences are firstly, that risk analyses focuses on multiple accidents, and accident investigation on the single accident. Secondly, the accident investigation is retrospective, while the risk analysis contains visions of the future. The modelling work in accident investigation relates to submodels of the overall Loss Causation Model, in order to better understand the occurrence of the accident. Such models could be *quantity-oriented* (physical or chemical) or the models could be *event-oriented (logical)*. Examples of quantity-oriented models are fracture mechanics to scrutinise the deformation of structures, and heat mechanics to understand the heat loads involved. The point source model is a quantity-oriented model. It is applied for calculation of radiation from distant fires, for example in order to determine the radiation acting on passengers being trapped in wrecked cars. The point source model reads:

$$I = \frac{fQ}{4\pi r^2},$$

where, f, is the fraction of combustion heat emitted as radiation, Q, the total amount of heat released in the flame, and, r, the distance from the flame.

While quantity oriented models describe the factors that determines the numeric value of a quantity, event-oriented models describe the conditions of the occurred event. A fault tree model is an example of an event-oriented model, describing events on a lower level leading to the accident.

Malfunction in the signalling system at Rudstad station is an example of a sub-event that could lead to a train collision at Åsta.

Independent of type of models used in the accident investigation there is uncertainty involved. With respect to the point source model, it is uncertain whether the model represents the real world. It is based on the assumption that all emission relates to a single point, which in most cases is not fulfilled. Uncertainty is also related to the quantities f, Q and r. In general, the uncertainty increases when the models are extended to include underlying causes and deficient management factors.

The challenge is: *What models to use and how shall we represent and deal with uncertainty*? If we depart from the ideal goal to reveal the truth, to investigate weaknesses in organisational and management factors, the issue could become minimised. Aven (2000) shows how uncertainties can be expressed by probabilities. This view could be useful also in accident investigation. The narrative is subjective, yes, but it is based on empirical evidence, which is open for assessments.

What methodological requirements should govern the investigations?

Is there any difference between accident investigation and scientific research? Accident investigation seems to be carried out with little regards to requirements. The report is a narrative where conclusions and recommendations are more or less related to evidences found in the investigation. Critical discussions with respect to models, investigation methodology and evidence collection (interview techniques, technical observations, expert judgements, etc.) are often minor or totally absent. It is a paradox that the theoretical basis of accident investigation methodology is so weak, when we consider the inherit power in the narrative. The Norwegian National Railway Administration (NNRA) was blamed and given a penalty of $US 1 million. The accident investigation report has also just recently been used by an insurance company to raise a recourse claim against the NNRA of $US 5.5 millions.

The challenge is: *What methodological requirements should govern the investigations*? The problem formulations are usually connected to "how" and "why" questions. Case study methodology, see for example Yin (1994) and Kaarbo and Beasley (1999), could very easily become employed as the investigation perspective. The Finnish anthropologist Pertti Alasuutari (1995) emphasises the importance of ”Without an explicitly defined method, without clear rules which tells what conclusions one is allowed to draw from different kinds of observations, research easily turns into an activity where you try to prove your prejudices right". The judgement also relates to how the accident investigation can be used, for example to put forward legal charges.

Johnson (2000, 2001) has developed a scheme, the Conclusion, Analysis and Evidence diagram (CAE), in order to identify ambiguities and to determine which items of evidence are critical to particular lines of argument. Johnson's work is interesting, but could be problematic because the schemes could also introduce new uncertainty and further complicate the investigation. It becomes an analysis of the analysis.

How to deal with organisational and operational factors?

Organisational and operational factors are widely discussed in the research literature, for example Jacob and Habers (1994), Reason (1997), Øien and Sklet (1999), Rasmussen (1990), and Sandve and Ringstad (1999). No common view exists, neither about the terms and contents, nor the factors' influence on safety. Examples of typical factors are; work coordination, work procedures and degree of formalism, communication (external and internal), roles and responsibilities, organisational culture, safety culture, ownership, time pressure, resource allocation, competence (technical, organisational) and priority of goals.

The challenge is: *What organisational and operational factors to be selected for further scrutiny*? The investigators need to make judgements on what factors they will place weight and the single factors' importance or relation to the occurrence of the accident. This is not an easy task. The Åsta-commission has made their choice, which is discussed below.

The Åsta case. The NNRA is appointed as the scapegoat with respect to the Åsta-accident, and perhaps well-founded, if we put weight on the NNRA's own comments to the public report. Why blame NNRA? The NNRA had not absorbed, in accordance with the commission, NNRA were almost reluctant to, the concept "modern safety management". Modern safety management is risk based, and in accordance with the commission modern thinking requires that risk analyses shall govern all phases and areas of the railway activities. The Norwegian State railways (NSB BA), the train transport operator, is spared for criticism because they had carried out some risk analyses. The quality of those analyses was never questioned.

At best, the commission's presentation is based on their prejudiced attitude towards "correct" (modern) safety management. At worst, we suspect the members of the commission to "feather their own nests". The Norwegian safety and emergency management consultancy business, which offers risk and vulnerability analyses, has through a Royal Decree been given a perfect document that ensures intervention with the onshore activities in a way that no publicity campaign could achieve.

Modern safety management, as described by the commission, has an inherent interpretation of risk being an objective property of the activity or system being studied, and it is heavily based on historical numbers. This implies a sharp distinction between what is the true risk and what is perceived risk. This is a very invidious approach to risk. Particularly, due to the fact that many "experts" claim to know the truth and the experts' attitude is that lay people and others are driven by feelings and irrational behaviour. This is an old and positivistic perspective, which unfortunately is widespread amongst many environments working with safety and emergency management, including the members of the Åsta and Lillestrøm accident investigation commission. The explanation is simple. This perspective maintains a pattern of power with an utter authority to the experts. Nobody wants to give up their authority and position, the aim is merely to create a stronger dependence to or demands for the experts' services.

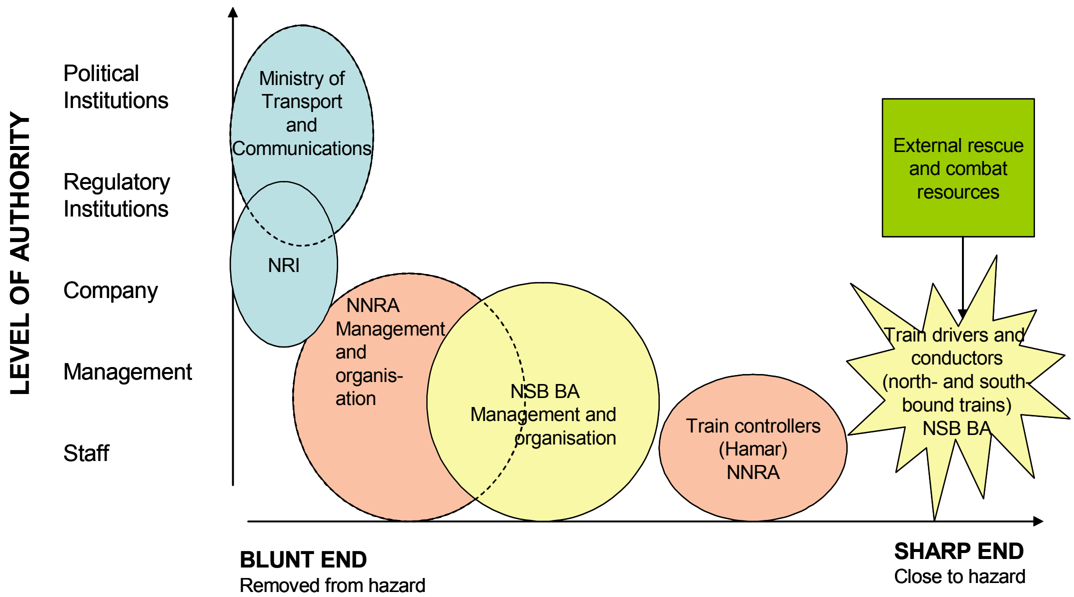
The commission do not stop here. They recommend that risk analyses shall frequently become updated in order to contribute to the daily operations of the railway activities. The updating, they say, should be performed as often as every third year. Who is able to understand this? Of course it means more projects to the consultancy business. However, we perceive these recommendations as unfair to an activity that is remarkably weakened and vulnerable to criticism after the accidents. And remember, the existing risk analysis tools do not capture organisational and operational factors that can give decision makers vital support in operations. Risk is not something that can easily become measured in operation, like for example reading a pressure level of a manometer. Risk is an evaluation of uncertainty related to the alternative outcomes of the future. The analysis tools are inappropriate for managing the daily operations, this is a fact that is widely agreed upon.

When we also know that the risk analysis consultancies, as the commission, are dominated by engineers, we find reasons for concern. Safety and emergency management is highly cross-disciplinary, to which competence in the areas of psychology, sociology, anthropology, medicine, etc. are often more important than technological competence. Risk based approaches to safety management thus need to involve every layer of the activity, in this case the railway transport activity. People simply need to understand the fundamental issues of the risk based safety management. The United Kingdom Offshore Operators Association (UKOOA), an association of the oil company managements in the UK commented modern safety management (UKOOA, 1999): "A change from – *tell me what to do* – to – *show me how to do it* – to – *involve me in it* – has taken place". The risk analysis is a debate over safety, and disagreement amongst the disciplines might prevail. Some want to place emphasis onto the technological factors, others claim that the organisational factors are most important, some highlight the operational conditions, while other will claim that human factors and heuristics plays an important role, and culture and genetic conditions etc. are all causal factors that might be applied to explaining negative outcomes or the occurrence of undesired events. When risk analysis is used by other disciplines than the engineers, remarkable progress can be expected.

Risk and vulnerability analyses are powerful tools, but only as an integral part of a safety management process, i.e. we emphasise the use of the analysis tools. There is a substantial amount of costly analyses carried out by experts, which has and have had little or no effect at all. In the oil and gas industry there are a lot of such examples. Our experience is that the oil and gas companies in the Norwegian sector highlight the benefit of analyses in which they have been heavily involved, in the sense that confidence in the analysis tools is created and the risk reducing measures stemming from the analysis are based on a common understanding. Such analyses are an integral part of the planning process of an activity. Analyses performed in order to satisfy authorities contribute to undermine the respect of the safety and emergency management discipline. Up to date, very little, if any, research exists on evaluating the effect of risk analysis and modern safety management.

By all means, the Åsta accident investigation has revealed lacking and insufficient barriers and other critical conditions at the Røros line. The NNRA internal accident investigation (Skovdahl, 2001) also supports this view. The differences between the two investigations are related to what has been regarded as acceptable solutions, acceptable risk, whom to blame, and which parties to be investigated. Figure 3 is an illustration of the parties investigated in the Åsta accident, where the horizontal axis shows the distance from the accident location, and the vertical axis shows the level of authority. The frame is based on Kőrte, Aven and Rosness (2002).

Figure 3: The investigated parties in the Åsta-accident



The Åsta commission selected their model, which placed focus on the NNRA's safety management system. The NNRA management and organisation was blamed. The train driver of the northbound train and the train controllers (NNRA) located in Hamar were also criticised. The Ministry of

Transport and Communications, the National Railway Inspectorate (NRI) and the Norwegian State railways (NSB BA) were very moderately criticised. The rescue and combat resources were not exposed to criticism at all, and the investigation of their activities was very superficially performed. The power of the commission's model is remarkable. Every party shown in Figure 3, and other parties, could have been criticised in a way that would have totally changed the ever standing conclusions.

For example, over 90 % of the municipalities in Norway have carried out risk analyses, and there is a widely accepted practice to design the local fire brigades – fire prevention arrangements - by the use of risk analyses. However, there are reasons to believe that the risk analysis processes have not been very good. Along the Røros line, on which the Åsta-accident occurred, there are ten municipalities and ten fire prevention arrangements. The NSB BA and others traffic the line, and above them are different authorities responsible for surveillance, safety and emergency management (NRI, the Ministry of Transport and Communications, inspectorates, ministries, etc). We have not registered that any of them, before the Åsta-accident, reacted against the risk level at the Røros line, a risk level that the commission has found alarming and totally unacceptable. It is not only within the NNRA that modern safety management is lacking. The power of accident investigation and the inherent methodology is enormous. Weick (1991) has investigated the Tenerife accident (583 people killed) by using Normal Accident theory (Perrow, 1984). In order to reveal the power of accident investigation we propose a similar analysis for the Åsta-accident.

Summary and discussion

What is the truth about accident investigations? Are they really efficient tools in the overall public safety management work? There are many consultants and researchers who support this view, but their evidences are weak. The major argument is related to preventing the accident from reoccurring. Of course, a similar accident will never occur, thus the argument may stand indisputable with or without accident investigation. As far as we know, there has been little research questioning or evaluating the effects of accident investigation. The discussion has been based on prejudices about the goodness of such inquiries, without critical objections. Before any conclusions with respect to formal set ups of, for example, joint accident investigation commission, more research is needed. The area is complex, and we think that, so far, the evidences supporting the benefits are evenly distributed with evidence supporting more dubious effects, such as:

- The main objective of accident investigation is to put the public opinion to rest.
- Accident investigation is a tool for the national or local authorities to maintain or restore confidence and avoid damaging conflicts.
- Since there exist few or no criteria for when and how to investigate accidents, these issues are political. Strong parties involved in accidents can manipulate the choices.
- Accident investigation as a narrative art contains numerous weaknesses.
- "Weak" parties are harshly criticised in the accident investigation conclusions and recommendations than "strong" parties.
- Even though there is a conscious attitude to avoid blame in the investigations, placing guilt affects the investigators. The investigators are prone to cognitive (judgemental) bias – no tradition exists to avoid cognitive biases in accident investigation.
- Being a national appointed investigator is connected with strong prestige, especially in controversial cases (for example the Åsta-accident). The clients (media, authorities, relatives, etc.) expect dramatic and clear results from the inquiry, and these expectations influences the work of the investigators.
- First line actors (the sharp end) become more criticized than second and third line actors (the blunt end).
- The contents of the investigations are strongly influenced by the competence (formal and experiences) of the commission, and their prejudices.

- The causal relationships presented in the investigations are strongly influenced by the accident outcome, i.e. the consequences of the accident. The investigation of the Åsta accident, for example, had a stronger focus on blame than the Lillestrøm accident.
- The learning perspective of accident investigation is poorly founded. The learning effects are minor, especially for actors not directly involved in the accident.
- Accident investigation results are often fronted in political populist cases, which usually "fall to the ground" without long term results.
- The performance of the rescue and combat resources are seldom evaluated in accident investigations, and thus there is no tradition for criticism of the external (often public) emergency management.

Accident investigation is a difficult area, but important. If we maintain our beliefs that accident investigation is an important tool in societal and organisational learning, financial and human resources must be paid. Some of the conclusions and recommendations drawn in the Åsta and Lillestrøm accident reports are not very well supported. We struggle to find an adequate research design and frame conditions for accident investigations, and, strange to say, Norwegian authorities seem to maintain an indifferent attitude.

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GLOBALIZATION AND HARMONIZATION: THE ESSENCE OF THE PROCESSES, THEIR INTERCONNECTIONS AND GLOBAL SIGNIFICANCE[1]

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Keywords: globalization, harmonization, progress, phenomenon, classification.

Abstract

In the paper the attention shall be accentuated on the complex and interrelated character of the two processes, which at present are acquiring global significance - globalization and harmonization - and reveal organic connections between them. In the authors' opinion, their significance will be growing, affecting the future paths of the society's development.

It should be noted that the globalization process deals mainly with the socio-economic aspects not only on the international, but on the national economic scenes as well. The harmonization, in particular on a global scale ("global harmonization"), is directed at the solution of "technical" issues, which inevitably accompany the scientific and social progress. The term "harmonization" was first mentioned in the "Agenda for the XXI century" of the UN conference in 1992 in Rio. It was defined there as the modernization of the systems classifications and labeling (of the chemical products, in particular) designated to secure the material safety of the users. The term had not been duly elaborated then and remains so since that time, leaving the task of the interpretation of its contents, evidently, to the specialists. It was only stressed then that the conference considered the process of the harmonization as one of the six main directions of the activities for the next century.

Introduction

The purpose of the presentation is double sided:

- to accentuate the attention on two processes of global essence - globalization and harmonization - which at present are acquiring world significance and seem to define to a significant degree the future development of the postindustrial society;
- to reveal organic connections between them and also complex character of their interrelations.

It should be noted that there is a difference between these processes: the globalization, at least ostensibly, deals mainly with the socio-economic aspects not only on the international, but on the national economic scenes as well. Whereas the harmonization processes, in particular on a global

[1] The research of this paper was carried out under support of the Russian Humanitarian Scientific Foundation (Grant N 01-03-00114).

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level ("global harmonization"), as the discussions at the TIEMS conference in Oslo showed, are directed at the solution of "technical" issues, which inevitably accompany the scientific and social progress of the modern society.

An important aspect of globalization, as a process of building up and strengthening (on all the azimuths) of general societal interdependency, particularly in its economic dimension, could be manifestly observed during last several decades. The term "harmonization", according to the "Agenda for the XXI century", accepted by the UNCED conference in Rio, was defined as the creation of the classifications system and labeling (of the chemical products. in particular) designated to secure general material safety. It was only stressed then that the harmonization should be considered as one of the main directions of the international activities for the next century.

As in the case of globalization, the term "harmonization" might be leading to some disagreements, even contradictions, among the members of scientific or business communities, or political establishments, as its contents have not still been refined to a sufficient degree and the interpretations may vary and well result in unexpected and diverse conclusions.

Generally, the harmonization process may be considered from two angles: first, as narrowly "technical" process, with limited tasks, referring mainly to the sphere of hazardous materials or goods; and, second, more general, as a process of a wider societal significance, securing societal and technological safety and/or defending certain (and significant) economic interests.

Thus, the harmonization process is directed at the creation of the classification and labelling system on a global scale, formulation of more or less strictly defined aims and methods of the realization, whether, they refer to hazardous materials or products, elimination (or minimization) of negative health and environmental effects, uniformity in labelling of dangerous chemicals, or their safe transportation or supply/use.

It should be stressed in the beginning that the processes to be interpreted here are extremely complex, the effects of which have just started to be felt in many countries of the world, whether highly developed or only at the initial phase of their economic and political development. For the presentation's purposes it is important to elucidate the interconnections between them and with other societal, technological and other processes, specific of the society at the present stage of its evolution. Due to complexities of the societal, economic and other phenomena, touched upon in the narrative, only a simplified version of the results of the processes analysis and developments considered here could be suggested, hoping that the general ideas would be worth of presenting here.

The authors of the paper find it expedient:

- To accentuate attention on the globalization and harmonization, because at present the have been acquiring exceptional significance, and defining to a significant degree the direction and substance of trends in the postindustrial society;
- To examine these processes and trends from the point of view of their importance, which, undoubtedly, will be growing at least in the foreseeable future, affecting the paths of our society's progress, and also to appraise the interrelations between them and their possible impacts on socio-economic, technological and other developments.

The processes to be analyzed here seem to be particularly promising from purely scientific, as well as applied, specifically political, points of view. It should be noted that the globalization, at least ostensibly and at least temporarily, expresses itself not only on the international level, mainly in the socio-economic sphere (international finance and trade, especially), but on the national level as well. Whereas, the harmonization processes, in particular on a global scale ("global harmonization"), as the discussions at the last year's TIEMS conference in Oslo artfully demonstrated, are directed at the solution of "technical" issues, which inevitably and manifestly accompany the scientific and social progress of the modern society.

So, the need now arises, first, to present both these processes tied together into a super complex phenomenon and influencing still more strongly all the main spheres of human activities – societal, in particular economic, technological, environmental, and political. Second, to thoroughly examine the phenomenon from its probable perspective, to define its place in the current economic, particularly international trade and finance, and industrial, activities, and forecast its possible impacts on future developments in various fields of human endeavors.

Globalization

The term "globalization", when used, is often presented or understood, as an abstract and general idea, not, at least directly, connected with any existing practices, objects or events, devoid of any "material" essence, thus, loosing any real meaning or sense. In the result, this, now notorious, term might become, not only a platitude or an empty slogan, but also an illusory notion, precluding a realistic research or analysis and, in the end, disarming a researcher, a politician or any interested person or international or national organization or movement facing some genuinely complex processes and/or threats, connected with real and serious problems, for example, global dissemination of information, activities of international financial markets, capital investments flows, political upheavals of interstate character, or possibilities of deployment of new kinds of most destructive weapons. All these events or threats became fully manifest in the last two-three decades of the previous century. Consequently, these real developments of obligatory character, taking place in different parts of the world, make it double necessary to separate them from the globalization as an ideology, which, being also a reality, though of a different nature, should be left outside this presentation.

The globalization process should be approached as a reality specific of a modern "society" (in traditional sense, as a basic entity) closely connected with the events and developments surpassing the bounds of national institutions and acquiring genuine global essence and significance. Activities of influential international organizations, WTO in particular, aimed at the propagation of the globalization process, make it more manifest and also to better observe the connections between the schemes or ideas of globalization, on the one hand, and practices of globalization, especially in such key branches of world economy, as international financial markets or trade, investments or assistance, on the other. At the same time, it is evident that sheer increase in numbers of objects (subjects) of the international processes, and/or members of the UNO and other international organizations cannot be interpreted as an expression of the globalization process or serve a justification for the destruction or disorganization of the existing national societal entities the ***nation states*** system - as one of the fundamental principles of the international law and order, established as far back as the XVII century. Or extenuate the idea of national sovereignty and non-interference, as if it is in the interests of speeding up "globalization". Moreover, to ignore the reality of a rapid increase in the numbers of TNC or international financial institutions with their increasing and practically unopposed influence on global, and more and more often on national economic activities of many countries, of the Third world particularly [5,7].

A definition of the term "globalization" may be suggested (in the frames of this paper), as a process of aggregation and incorporation of various basic components of the human civilization into an unprecedented and extremely complex phenomenon, which could emerge only at a particular period of the society's evolution; in its essence contradictory to the process of societal, in particular political, diversification.

Therefore, the globalization, in the context of the human society's evolution, should include not only its physical elements, but also consciousness, that is, many non-material components, the products of the human anthropo-socio genesis and its cultural evolution. An important aspect of globalization, as a process of building up and strengthening (on all the azimuths) of general societal interdependency, particularly in its economic dimension, could be manifestly observed during last several decades. Incidentally, that became a reason (to some specialists) to connect the process of globalization with Kondratiev's cycles (the so called "long waves") in the economic activities. As a result of this approach an idea has been put forward that the present globalization oscillation, if tied with this cycle, has already been passing a half of it, with the final conclusion that the globalization should have to exhaust itself with the cycle's end. In other words, the eclipse of the globalization is "inevitable" and would take place in the 20s of this century, creating a new, "post-globalization", period. This point of view, unfortunately, is based, on only one (though, of course, important) aspect of this whole intricate process – namely, economic – ignoring a necessity of a holistic approach to globalization, especially its long term, extremely complicated, and in many respects contradictory, essence [4].

Summarizing the above points, it is possible to denote several important specific features of the globalization process:

- As to the general impact of the globalization on the human society it should be stated, that, whether it would be strengthening the trend to the homogeneity or, on the contrary, to the heterogeneity of the society, the perspective seems to suggest that both these trends do not automatically lead to the alleged disintegration of the society's entity, in various forms. Evidently, the general principles and mechanisms of the societal "defense", worked out during its long evolution, would prevent its disintegration or radical changes with possible general negative effects [11].
- The possibility of the reversion of the globalization process seems at present unlikely. In some respects this possibility could be admitted, only if it would refer to separate aspects or parameters, and not to the phenomenon taken as a whole. Or accept the possibility that the globalization could take a *pulsating* character;
- As to the issue of the predetermined nature of the globalization, the position (of the authors, at least) may be reduced to that on the basis of the growing interconnections of main global processes, as constituent parts of the self-organizing evolution of the human society, the globalization at present is gradually acquiring an *imperative* character;
- Specifics of the globalization may give the reason to think that the process could be, generally speaking, managed, but not so much in the sense of taking decisions concerning its particular dimensions or contexts, as rather *directing or organizing* it mainly through the international organizations or institutions with particular tasks or functions [10].
- It is possible, with a degree of certainty, to assert that the globalization could not in foreseeable future eliminate the *national state,* of any existing kind, or, for that matter, *national economy* as such. Rather, it would most probably lead to the reconstruction of the sovereign "territorial" type of a state, which would mean the preservation (or creation) of "big" state organizations (unions?), their modernization on the federal or confederate basis, or the development of the interstate, or regional institutions of supranational, though limited functions; the economy would preserve its strength in large state formations, probably loosing it in smaller ones, with their place to be replaced by prospective and new national economic organizations, which could easier adapt themselves to new global realities;
- The hegemony of separate leading sovereign states in the international sphere would in the foreseeable future be preserved (if not growing) with diminishing roles of other less developed countries, in resolution of international, particularly economic, problems. But simultaneously the leading states should become more flexible, if their *status* ("big eight"?) preserved. Moreover, their hegemony might, by necessity, become limited, especially having in view the possibility of the formation of new global societal, economic in

particular, unions, systems or various other components (NGO, public movements, etc.) [6].

It should be stressed that political positions in respect to globalization, as announced in 1990s by alternative forms of thought and public movements, though still not heterogeneous or extremely strong, have a propensity to take the distinctly opposing direction and to a separation from the thought mainstream. In their opinion, globalization is **not**: inevitable or fatally predetermined; universal or eliminating all the differences or contradictions– from economic to cultural; eliminating the trends to the "westernization" (or, rather, americanization"); without alternatives to this process; effacing societal differences and inequalities. Instead, eliminating sovereign "territorial" states. In fact, in the existing world *modus vivendi,* the elimination of the national states may well be transformed into a system, where a corporate (TNC) capitalism would predominate [9]. This position, incidentally, to some extent also applies to Russian political scene [3,9].

Harmonization

The term "harmonization" was first used in the "Agenda for the XXI century" (item 19), adopted by the UNCED conference in 1992 in Rio. It was defined then as the system of the classifications and labeling (to be created by stages) and designated to secure the safety, in the sphere of, specifically, the production and trade of chemical products. At that time the term had not been elaborated and has remained so since, leaving the task of the interpretation of its contents and search of the realization methods, evidently, to the specialists of later times [14]. It was stressed only that the process of harmonization, should be considered as one of the six main directions of the international activities for the next century.

As in the case of globalization, the term "harmonization" might be leading to some disagreements, even contradictions, among the members of scientific or business communities, or political establishments, as its contents have not still been refined to a sufficient degree and the interpretations may vary and well result in unexpected and diverse conclusions.

Generally, the harmonization process may be considered from two angles: first, as narrowly "technical" process, with limited tasks, referring mainly to the sphere of hazardous materials or goods; and, second, more general, as a process of a wider societal significance, securing societal and technological safety and/or defending certain (and significant) economic interests [1,2].

It is not necessary here to indulge into technicalities of the harmonization process, so far as the purpose of this presentation is to establish close, probably organic, connections between the globalization and harmonization processes, and to show that they both strive (intentionally, or not) to fulfil, at least in the final count, the tasks apparent in the case of the globalization. It should be stressed, and appreciated, that the main specific features (up to minute details) of the harmonization were artfully analysed by the participants of the last year's TIEMS conference in Oslo at the session meetings devoted to the harmonization problems. It is desirable here to list and characterize only several particular points connected with the harmonization.

Manifestly, the harmonization process is directed at the creation of the classification and labelling systems, formulation of more or less strictly defined aims and methods of their realization, whether, they refer to hazardous materials or products, exclusion (or minimization) of negative health and environmental effects, uniformity in labelling of dangerous chemicals, or their safe transportation or supply/use. It has been stated that all these systems should finally acquire either international or global significance ("global harmonization"). It is worth mentioning that several classification and labelling systems have already been in existence, the main among them are the International system for Transport of Dangerous Goods, and appropriate classification systems in the USA, Canada and the EU.

The OECD countries through several co-ordinating groups (dealing with chemical, transport, storage and other classification systems) have endorsed the idea to apply appropriate criteria, developed and used by them, into the Globally Harmonised System (GHS) to be created at a later stage.

Among influential international organizations that are engaged in the harmonization activities should be mentioned such as: OECD, International Labour Organisation (ILO), UN Committee of Experts of Transport of Dangerous Goods (UNCETDG), UNEP, WHO, FAO, UNITAR. This fact alone shows the importance of and the attention to the problems of the harmonization on the part of the international community, and also its general significance. By the way, the mandate for the harmonisation of classification and labelling was defined by UNCED as "a globally (stressed by the authors) harmonised hazard classification and compatible labelling system including material safety data sheets and easily understandable symbols'.

The general goals of the GHS are to enhance protection of the society and the environment by:

- Provision of an internationally comprehensible system for hazard communication and a recognized framework for the countries without respective existing systems;
- Facilitation and security of international trade, particularly in chemicals, and products, whose hazards have been properly assessed and identified on an international basis and standards;
- Reduction of the need for testing and evaluation of dangerous materials [12].

The global system would use a building block approach in which application may vary according to the circumstances, type of product, and stage of life cycle, allowing selection of the elements appropriate to the needs of the various end users (transport, consumers, workers, emergency responders).

There are three main specific features of the GHS:

– First, the classification of hazardous and other substances and mixtures, to be carried out under the auspices of OECD and various UN organizations, such as the Committee of Experts on the Transport of Dangerous Goods, (CETDG), for physicochemical hazards.
– Second, harmonization of hazard communication processes and methods (e.g. usage of labels, safety data sheets, etc.), carried out under the auspices of the International Labor Office.
– Third, the criteria will be incorporated with other harmonised elements into an International Recommendation for GHS, which will be adopted by the UNESCO in 2003. The GHS will employ a building by stages approach in which application may vary according to the circumstances, type of products, stage of life cycles, etc., allowing selection of the elements appropriate to the needs of the various end users.

The very nature of the harmonization of various and (probably) sometimes competing regulations implies that certain essential changes might be made in the existing systems and procedures in order to comply with the unified procedures and rules to be adopted by the appropriate international agencies. As beneficial as these regulatory changes promise to be, it is clear that much effort in time or resources will be needed on the part of governments and private organizations to implement necessary adjustments. They could include updating data and appropriate information, materials properties, formulating data sheets, samples of product labels, transportation classifications, software packages, and etc [13].

As the first stage of these activities would proceed, the emphasis must by necessity shift from *what* the criteria and regulations of the system should be to *how* the worked out rules and separate existing systems could be transformed by various national and international agencies, and manufacturers into a comprehensive global system, securing import, trade transportation and distribution of hazardous and other appropriate products.

But the main aspect that could show where the **real interests** should be sought is the economic significance of the branches of the economy that propagate the introduction of the internationally recognized and harmonized systems, global in final count. The figures given here will speak for themselves.

As Dr. L. Séguin from Canada showed at the TIEMS conference last year (on the basis of the report of the American Chemistry Council), the US chemical industry represented in only one year (2000) sales of 435 billion USD, or 10% of the global export market and also the most important sector for investment in R&D!. The report also mentioned that in the second quarter of 2000 (after-tax) profits reached 3 billions USD, an increase of 24% over the same period of 1999. The overall chemical industry for the year 2000 was expected to come up with after-tax profits of 45 billions dollars!

Knowing that two of the main partners of the US in chemical trading are Western Europe and Japan, it is possible to see where the interests in the "harmonizing" the classification of chemicals and the documents systems concentrate.

It should be noted that back in 1992 the American National Standard Institute (ANSI) came up with a standardized format for the safety sheets (MSDS). This change induced investments of several billions of dollars from the US chemical industry alone, and the modification was affecting the format of only one document, mainly in North America. Dr. Seguin concludes that it is possible to expect a much more important worldwide impact from the coming GHS. In the software market there is also a considerable and increasing interest in the development of the GHS.

Several large chemical companies, just for an example, have decided to invest millions of dollars to develop their own IT system in order to create, manage and distribute their samples of the appropriate documentations needed by the "harmonized" systems. Since the advent of the Internet, they very often had to reinvest because they realized that posting documents on their Web sites introduced an important return on investment (ROI) for the years to come.

Attempts should be made to highlight what global harmonization would mean to small, medium and large organizations. In this respect smaller players on the markets must, more then the big ones, plan in advance to spread the investment over at least several years to minimize the impact, which seems to be inevitable with the coming of GHS.

Conclusion

The problems of globalization, widely discussed nowadays, have become, on the one hand, scientifically and socially all permeating, and, on the other (simultaneously with the first position) to a large degree dissipated and vague which could impede the understanding of the whole subject and obscure its general socio-political essence and significance.

In order to come to some definite conclusions on the basis of the suggestions, submitted here, it is necessary to indicate basic similarities between the processes touched upon in the text above:

- Both processes concern the globalization factors which are specific of the modern society at the present stage of the development;
- The main purposes and aims of the processes in question, as manifestly stated in the appropriate documents, referred to earlier, practically coincide – to support and ease the globalization trends already evident in all the most important spheres of human activities – economic, technological, environmental and others;
- Of course, there are differences between these processes: whereas the process of globalization (in the narrow sense of the term) concerns mainly socio-economic, environmental, and some others developments, with the emphasis on the societal, political in particular, essence of them, the harmonization process deals, at least at present, with

more “technical” problems, namely with the creation of the classification and labeling systems and their internationalization, at a later stage their transformation into the global harmonized system of much wider societal significance and, it should be added, impacts;

- From the point of view of the perspectives of their development and resulting consequences it is possible only to make a guess that the society, armed with the most advanced scientific methods of analyses shall be able to prevent negative consequences.

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SECTION 14:

INFRASTRUCTURE SAFETY & WARNINGS

AGENT BASED ARCHITECTURES TO IMPROVE SURVIVABILITY OF LARGE COMPLEX CRITICAL INFRASTRUCTURES

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ENEA[1]

Keywords: survivable systems, layered systems, agents architectures, network security

Abstract

Large Complex Critical Infrastructure (LCCI) are worldwide ever more dependent on information systems. The first generation of supervisory and control systems execute their functions inside a monopoly market. The new incoming free market, as well as the need to create more flexibilities and interdependencies between different infrastructures, requires more complex data transmission and control networks, sometimes partially open and interconnected to the public telecommunication networks, such as the Internet. This situation generates new types of risks and vulnerabilities of the whole supervisory and control system. Intruders, hackers and malicious operations could have in the future more and more possibilities to attack LCCI. The roadmaps, under definitions at European Union, aimed to cope with this type of problem are described in the paper. New approaches for modelling LCCIs and analysing their survivability mechanisms are analysed. The electrical power grid control network is illustrated as a special type of LCCI. Considering this type of LCCI, a multi-layers architecture of a society of agents is proposed as a *safeguard layer* aimed to improve the whole electrical grid survivability.

Introduction

During the last years, and especially after the terrorist attack of Sep/11, the importance of protecting complex critical infrastructures has increased and a deeper analysis of their dependability and interdependencies has became a more and more urgent task for all technological and industrial countries.

The term *Large Complex Critical Infrastructure* (LCCI) defines a distributed network of independent, mostly privately-owned, man-made systems and processes working collaboratively and synergistically to produce and distribute a continuous flow of essential goods and services [1].

Electrical power systems network is certainly one of the most important infrastructures of the high industrialised countries. Many other infrastructures are also very critical and interdependent with this one: telecommunication system, natural gas and oil transportation system, water supply system, banking and finance system, auto-route transport system, airways and railways system etc. Generally infrastructures depend on other infrastructure as, for example, the electrical infrastructure depends on oil/gas transportation network to acquire the primary energy sources and telecommunications network for data communication and control [2].

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Role of European Union in Critical Infrastructures Protection

The economy and security of Europe are increasingly dependent on a spectrum of critical infrastructures, which can be broadly grouped in the following five domains:

- Information and Communications
- Energy (Electrical Power and Oil and Natural Gas Production and Storage)
- Transportation
- Banking and Finance
- Vital Human Services (Emergency Services, Government Services, and Water Supply Systems)

The above five categories of critical infrastructures are highly interdependent, both physically and in their greater reliance on the information infrastructure. This trend has been accelerating in recent years with the explosive growth of information technology and shows no sign of abating. Potential threats to the normal functioning of these infrastructures are both natural and man-made. Individual outages can be serious enough, but this growing degree of interconnectedness can make possible a whole new scale of synergistic, non-linear consequences.

Information societies and, in particular, e-economies are evolving on a trans-national scale. It is thus a genuine task for the EU Commission to support a comprehensive and long-term approach for critical infrastructure protection. As the European economy becomes even more tightly connected through telecommunications, electronic signalling systems, power generation and distribution, information lines, financial networks, transportation systems (road, rail, air, water), and other connections involving critical infrastructures, possible disruptions have far greater potential than ever before to ripple throughout the economy. This unprecedented degree of infrastructure interconnectedness develops into an increasingly enmeshed European economy. In this situation, outage "ripples" in one infrastructure cause cascades of economic malfunction, as individual outages lead to outages in other infrastructures, which in turn intensify the first outages in a firestorm-type of phenomenon. This negative synergy could create havoc in an economy that does not have mechanisms in place to cope with these effects.

At the same time that the information technology revolution has led to substantially more interconnected infrastructures with generally greater centralised control, the advent of "just-in-time" business practices has reduced margins for tolerable error in infrastructures. Any one of these trends would be a cause for uneasiness. The convergence at the same time has no precedent in western economic history. While important steps have been taken on individual infrastructures, the issue of interdependent and cascading effects among infrastructures has received much less attention. This situation calls for concerted efforts of prevention and for building shock absorbers of both a physical and policy nature into our economy in order to protect against major infrastructure breakdown. Yet little is known about what these effects are or how they propagate. Future work on enhancing Critical Infrastructures Protection within the EU will need to be cognisant of all of these problem areas [3].

This finding has been reinforced by the Organisation for Economic & Development (OECD) which warns that: "globalisation, climate change, the transition to a more technology-intensive economy, demographic and societal change, growing interdependencies, to name but a few significant trends, look set to increase the vulnerabilities of major systems during the 21st century. The provision of health services, transport, energy, food and water supplies, information and telecommunications, safety and security are all examples of vital systems which can be severely damaged by a single catastrophic event, a chain of events, or the disastrous interaction of complex systems. There is growing concern that extensive disruption to, or collapse of, these systems could significantly impair future economic and social development"[4].

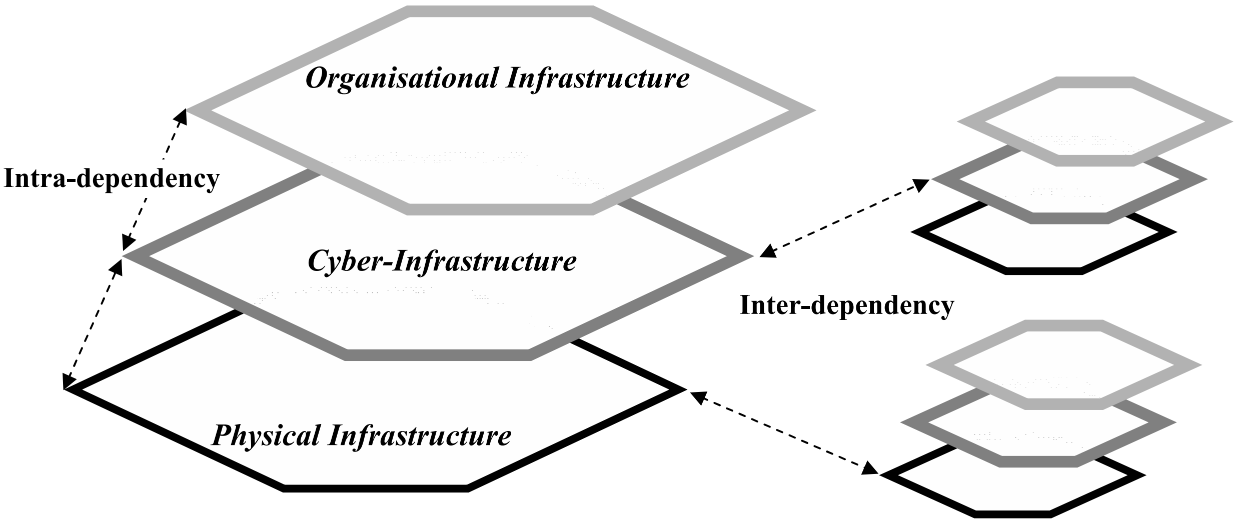
From several years EU has launched a dependability initiative inside the Information Society Technologies (IST) Programme, named the DEPPY initiative (http://deppy.jrc.it). Many recent developments and announcements provide evidence of the great need to define and plan a broader and more fully-integrated set of dependability-related activities, including the growing problem of Critical Infrastructures Protection, for the Framework Programme 6 of the Information Society Technologies (IST FWP6). For such a reason, recently has been issued by the EU a Call for Proposals for strategic roadmaps for applied research, which should provide inputs for the specific subject to IST FWP6.

Layered infrastructures

Software based infrastructures, born from the pervasive computerisation and automation of the physical infrastructures over the last decades, are generally called *cyber-infrastructures*. The Internet data exchanging software protocols establishing network connections between client and server nodes are the most evident examples of the new generation of critical infrastructures. The interdependency between physical and software based infrastructures is called *cyber-interdependency* [5]. The new SCADA-MMS systems are examples of new cyber-infrastructures controlling electric power grids. In this case the vulnerability of the electrical power system doesn't depend only by faults generated inside the electrical network components, but also by attacks against the new types of software systems, sometimes distributed and implemented inside public and not well protected information networks.

Organisational infrastructures are composed by human agents controlling, managing or utilising the functionalities the other types of infrastructures. Organisational infrastructures and cyber-infrastructures have in general a high level of interdependency, some time may be also in competition each other. When a disaster occurs inside a physical infrastructure, is not always clear if the fault was generated by the cyber-infrastructure or by the human operators belonging to the organisational infrastructure.

Figure 1: Inter and Intra dependency of LCCIs



Organisational infrastructure has the lowest degree of formalisation; it changes and is modified along the time, and frequently need to be trained about the correct utilisation of the other infrastructures.

The two types of infrastructures, described above, can be considered interconnected with physical infrastructures to form *layered infrastructures* as shown in fig 1. They are composed by:

- Physical infrastructures (made by hardware components).
- Cyber-infrastructures (made by software components).
- Organisational infrastructures (made by human operators).

As visualised in the figure each infrastructure (physical, software and organisational) could be modelled as a set of components contained in different layers. The layers are dependent on each other by a sort of *intra-dependency*. In the electrical power distribution infrastructures intra-dependency corresponds to the relationships between the physical electrical components and the supervisory/control systems based on EMS/SCADA systems. Intra-dependency realises a *strong dependency* link between infrastructures: generally the first infrastructure could not perform its mission (surviving) if it is not continuously supported by the second one.

The infrastructure physical layer is often connected to the physical layer of other infrastructures. Also in this case we could have dependency (*inter-dependency*) between infrastructures, but in this case it is a *week dependency* link: the first infrastructure could continue to perform its mission alone, at least for a certain time. This is the case, for example, of unavailability in oil/gasoline pipeline network. It could generate consequences on the electrical network only when oil reservoirs of power generation plants will get exhausted.

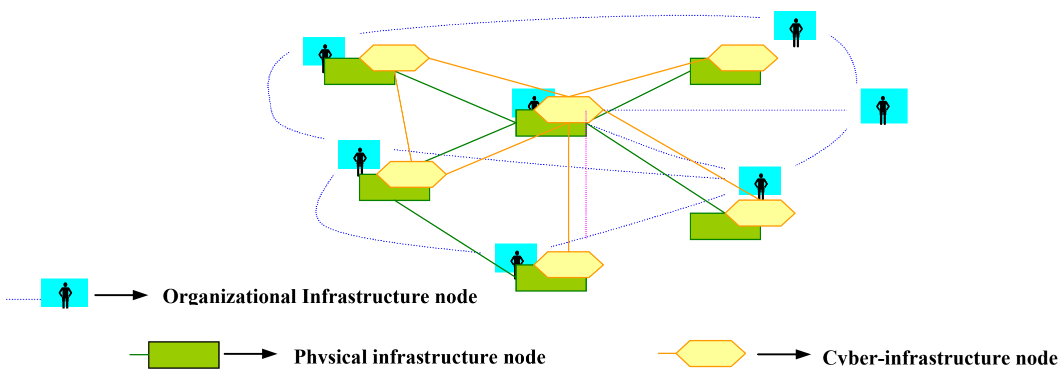
In the last years the cyber-infrastructure layers more and more frequently were interconnected with the cyber layers of other infrastructures. This is due to the increasing of services offered on Internet, new open market opportunities, and the needs of the societies to exchange data and to share software tools.

Infrastructure survivability

Survivability is the ability of a computer-communication system-based application to satisfy and to continue to satisfy certain critical requirements (e.g., specific requirements for security, reliability, real-time responsiveness, and correctness) in the face of adverse conditions [6].

Using multi-layer modelling of infrastructures, it is possible to consider the *multi-layer survivability* concept. In an oversimplified formulation of multi-layer survivability policy, no system or network entity is allowed to depend on an entity that has been assigned a lower survivability level; otherwise faults could easily propagate from less critical toward more critical

Figure 2:Modelling infrastructure as a population of agents



layers. Following the above assumption, in the schema of fig 1, the survivability level of the upper infrastructure layers may be greater that the lower ones, because generally faults and loss of functions could propagate only from upper toward lower layers.

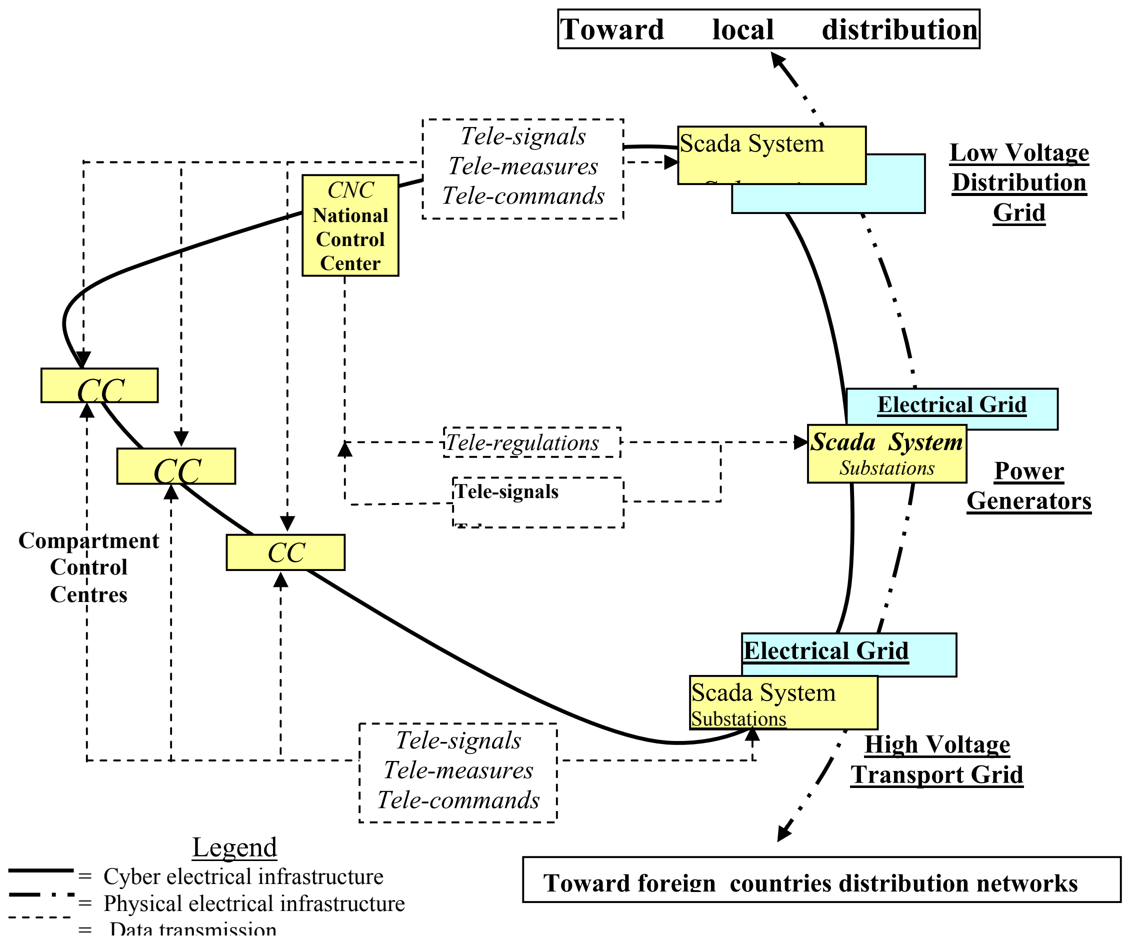
Unfortunately in the last years the survivability of cyber-infrastructures decreased especially for the increasing possibility of electronic attacks following the same patters seen in attacks on Internet e-commerce sites. As interconnections and interdependencies increases, cyber-infrastructures seem to become the most vulnerable part of all traditional infrastructures.

Infrastructures modelling

One effective way to investigate the infrastructure behaviour and criticalities is to view them as an architecture composed by a population of interacting agents. The diagram in fig. 2 shows the concept behind this type of architecture. Here the rectangles represent the components of the physical infrastructure layer, the hexagons the components of the cyber-infrastructure layer (e.g. EMS/SCADA system substations in electricity transmission and distribution domain) and the human figures the organisational infrastructure nodes.

Developing a Safeguard Infrastructure

Figure 3: Layout of electrical network control infrastructure



SAFEGUARD (www.ist-safeguard.org) is an EU project aimed to enhance the dependability and survivability of Large Complex Critical Infrastructures, such as distributed electric and fixed and mobile telecommunication networks.

Regarding the electrical network infrastructure, the introduction of competition in the electric power industry, combined with increased public demand of power, has resulted in greater reliance by power utilities on information systems and networks. Efforts to allow easier access to operational, customer, and supplier information, combined with the expansion of corporate IT boundaries, vastly increases the vulnerabilities of power company networks.

Actually, due to the fact that electrical companies represent a key component of one of the nation's critical infrastructures, these companies are likely targets of coordinated attacks by "cyber-terrorists", as opposed to disorganized "hatchers". Such attackers are highly motivated, well-funded, and may very well have "insider" knowledge.

The main objectives are to develop conceptual and software tools (integrated methodologies, models, methods and middleware) that enhance the dependability, survivability and security of LCCIs, especially focused on the cyber and organisational infrastructures.

Electrical Infrastructure Layout

The National high voltage electrical network supervisory and control system is managed by a National Control Center (CNC) connected with more Regional Control Centers (CC). The control centers exchange data through the telecommunication network with remotely controlled substations working as SCADA/EMS systems (see fig.3).

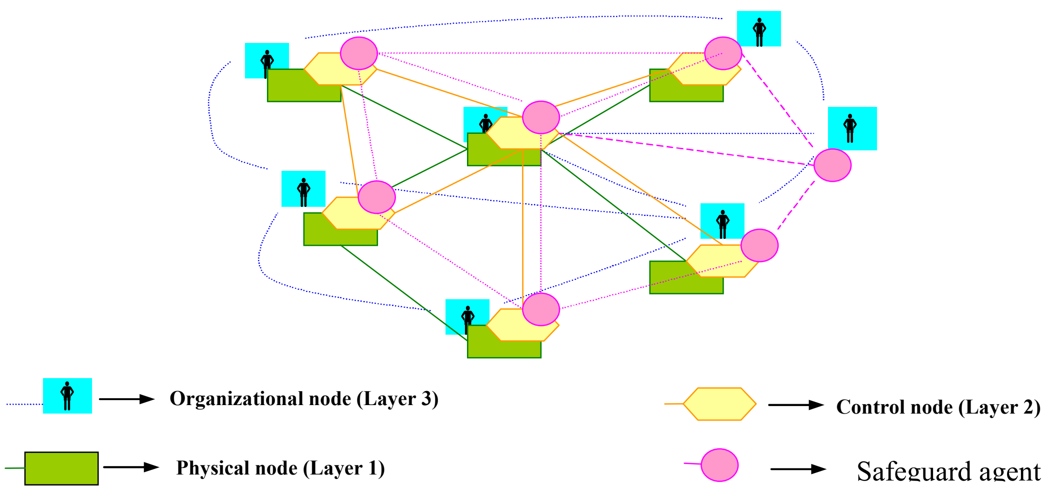
This system represents the middle layer infrastructure of fig. 1, the so-called cyber-infrastructure of the national electricity transport infrastructure. It controls the electrical power company core operations, allows companies to maintain centralized monitoring of their energy management systems (EMS) and transfer power from generation to the end user.

Safeguard agents

As it was shown in fig 2, also the electrical infrastructure could be modeled by as population of agents distributed on three different infrastructure layer:

- Layer 1 represents the physical electrical components of electrical grid;
- Layer 2 represents the control/automation components;
- Layer 3 represent the organizational/supervisory (human) components;

Figure 4: Safeguard agent layer



Electrical infrastructure safeguards could be also modeled, as in fig 4, by a *fourth layer* containing a population of safeguard agents interacting with layer 2 and 3.

The circles represent the SAFEGUARD agents, managing survivability and integrity of the whole infrastructures. One of the aims is to investigate autonomous agents architectures [7] able to manage the survivability of the infrastructure through localised communication, without appeal to a global co-ordinator, or to excessive inter node communication.

The main objective of Safeguard agents is to establish mechanisms able to discover and manage fault conditions arising from layer 2 and/or from the communication protocols working between layer 2 and 3.

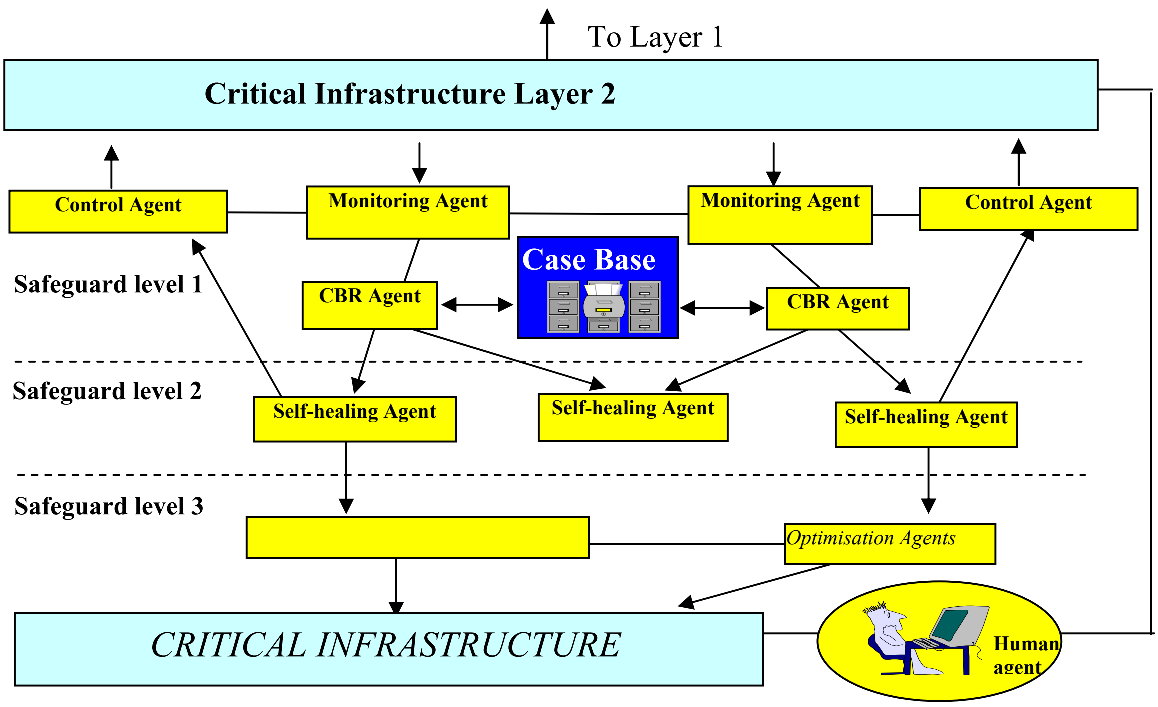
Proposed multi-agents architecture

The Safeguard Agents (SA) are implemented as a society of agents distributed inside three different levels of competences/roles:

- At level 1: predict and indicate if a certain component works in a fault condition or if an attack is in progress;
- At level 2: a self-healing mechanism tries to substitute/repair the functions executed by the fault components;
- At level 3: if self-healing fails, the fault components are isolated and LCCI reconfiguration strategies are suggested.

SA implements a mechanism able to *increment survivability* of layer 2 and 3 components: it will not be sufficient for a simple component malfunction to produce degradation of the whole system. The agents must be able to monitor, substitute, repair or isolate a fault component during a certain time of operations.

Figure 5: SAFEGUARD Multi-agent architecture



To execute functions at level 1 some SA are specialized to monitor (through the network) the behaviour of certain classes of components. Monitoring results are passed to CBR agents (Case Base Reasoning agents) [8], specialised in the fault/attack discovering. They compare the specific component behaviour with a list of *behavioural Cases*: a Case is a collection of indicators of a certain component working condition. They have a memory to store the *normal functioning condition* of the component as Cases inside a Case Base and are able to retrieve a set of faults Cases indicating characteristic statuses in presence of certain faults. The Case Base is initially constructed off-line and periodically updated on-line by some *learning activities* of the agents.

To execute functions at level 2 self-healing agents must actuate the recovery/reconstruction actions inside the infrastructure layer 2. They have the capacity to re-initialise software and procedures inside the damaged layer and substitute/repair the function performed by the fault component.

To execute function at level 3 the agents have some *scheduling/optimisation capacity*. Optimisation algorithms inside dynamic domains could to be adopted [9]. In some case may be sufficient only a *partial and not a complete substitution* of the functions executed by the fault component. In this case the choice of the parts to be substitute could be optimised respect to the objectives that the plant operators could adopt.

Conclusion and future developments

Safeguarding LCCIs seems an important and strategic task for high technological and industrial countries, to avoid unexpected disasters involving the security of the citizens. United States have just experienced some security lacks and vulnerabilities inside their national electrical grid control and supervisory systems. European Union is analysing new roadmaps and methodologies aimed to preventing and managing the principal types of attack scenarios inside the most important LCCIs. SAFEGUARD project is one of the first initiatives in this direction. We hope, in th future, in parallel with the growth and the increasing interconnection of LCCIs, their security and survivability issues will be considered further and taken into account by the public authorities.

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Author Biography

Claudio Balducelli is a senior scientist working at ENEA since 1983 in the field of AI technologies applied to operator decision support systems during the emergency industrial events. His interests include operator models, knowledge formalisation, planning, computerised procedures, plant diagnosis, case based reasoning, learning and fuzzy algorithms. Actually he is has in charge the technical management of European Projects in the field of controlling and safeguarding Large Complex Critical Infrastructure.

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The International Emergency Management Society
9th Annual Conference Proceedings
University of Waterloo, Canada, May 14-17, 2002

TELECOMMUNICATION SUPPORT SYSTEMS IN COMPLEX HUMANITARIAN EMERGENCY SITUATIONS

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Keywords: Disaster Management, Emergency Telecommunications, GIS

Abstract

Based on the suggestions of the Tampera Conference, all countries have to ensure telecommunication support during all kinds of emergency situations, catastrophes and other disasters caused by human actions or natural forces. This obligation refers to the state and its organizational levels as well as to corporations and organizations that perform, or are the part of, telecommunication services of the country. Furthermore, obligation relates to the planning, preparedness, acting, and quick relief of telecommunication systems in emergency situations, at the same time having the objective of coordination, introduction and acceptation of regulations and protocols, as well as legal regulations. Convention suggestion emphasized usage of public mobile telecommunication networks for early alert and informing in emergency situations, as well as defining the operative procedures of telecommunication support.

This paper describes the model entitled "Telecommunication Support Systems (TSS) in Complex Humanitarian Emergency Situations" that is applied in one of the Croatian counties as an example of the Urban Emergency Planning and Response concept. The system contains several subsystems which perform their function via a mobile phone network: sending SMS (Short Messages Services) to the mobile phone of the users located in the area exposed to the danger, locating lost or endangered persons by their mobile phone, etc. All these TSS functions are connected to the local emergency centre and, in interaction with GIS support, the number of inhabitants integrated in the system can be determined. As has been previously described, such a system is based on a mobile phone network and its development, thus facing the Realities of the Third Millennium.

Introduction

Recent tragic events in the United States end elsewhere, accompanied with an apparent increase in frequency and scope of natural and technological disasters, clearly illustrate the need for high quality telecommunication services. Telecommunication support to civil defence and other emergency services essentially contributes to lowering the risk to human lives and property, and, at the same time, covers the public information and communication needs in such situations.

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Important activities connected with public safety, with special emphasis on civil defence and emergency relief, are currently being undertaken within several national, regional and international organisations. Croatia undertook the procedure for laying down the “Law of protection and rescue”, which introduces implementation of regional “Centres 112” as PSAB service (Public Safety Answering Points). The implementation of the law would affiliate Croatia to the European system of unique telephone aid numbers. Establishment of Centres 112 demands very complex intervention within information and telecommunication systems in order to achieve high technological services levels, increase efficiency of first aid and, generally, interventions in diverse emergencies and catastrophes. Experiences of the United States and European countries will surely help the process of system conceptualisation in Croatia. Even though the progress in information and telecommunication technology in Croatia is not so fast, all countries have the same challenge of how to utilize all possibilities of technological progress. Furthermore, almost all countries face the problem that part or all of the telecommunication system belongs to the private sector, therefore the jurisdictional and other frameworks and principles of telecommunication services costs have to be worked out as the general public interest. However, privacy is a very sensitive matter and demands further research in differentiating public safety from private interests. The problem of standardisation of the different technologies and setting up the interfaces between users’ systems can be solved in the same context. In Europe, a number of projects, such as LOCUS (1), ROSETTA and CGALIES (2), have been launched, with the same objective: to identify some of the technological standards as well as cost estimation of the introduction of different technologies for emergency services telecommunication support. At the end of February 2002, ETSI (3) organised its first workshop with "Emergency Telecommunications (ET)" as a topic, where experts could get insight into European and American projects that go toward standardised interoperable telecommunications functions and services, as well as the concept of incorporating mobile phones in Emergency Services System due to their wide use and huge technical capabilities. One of the reports (2) shows the number of emergency calls from mobile phones within the European Union (EU), that, for the last year was 40 million calls, which represents 50 - 70% of total emergency calls. Furthermore, the report emphasises that in 3,5 million calls from both fixed and mobile phone networks, people were not able to give their precise location, which caused delay in the intervention. During traffic emergency intervention it was pointed out that in 20 – 40% of serious injuries, survival of injured people depended on professional medical help within two hour intervals, thus indicating the importance of the possibility to precisely locate the emergency site and optimally guide the emergency brigade. Jean-Luc Wybo and H. Lonk (4) pointed out the paradox of relatively low integration of information and communication technology (ICT) in Emergency Management (EM), even though ICT has great potential to "improve the resilience of organisations during the management of emergencies, by providing the right information in due time to anticipate evolution and take appropriate decisions".

Problem description, and approach to the telecommunication support system conceptualisation

In order to successfully integrate the telecommunication system into the concept of “Emergency Management” of a certain country such as Croatia, it is necessary to undertake a series of activities with the objective to enable the telecommunication system to survive, provide quick relief and give support during emergencies, with sufficient capacity to enable the functioning of various Emergency Services. In principle, the telecommunication system that offers support during emergencies consists of two parts:

1. telecommunication infrastructure,
2. operative procedures and software for different functions during emergencies.

While the aforementioned classification is rather rough, it does point out the need for a different approach to the each segment.

Telecommunication infrastructure

Telecommunication infrastructure can be very vulnerable, especially the part related to PSTN (Public Switched Telecommunications Network), namely, the fibre-optic network as the largest component of the system.

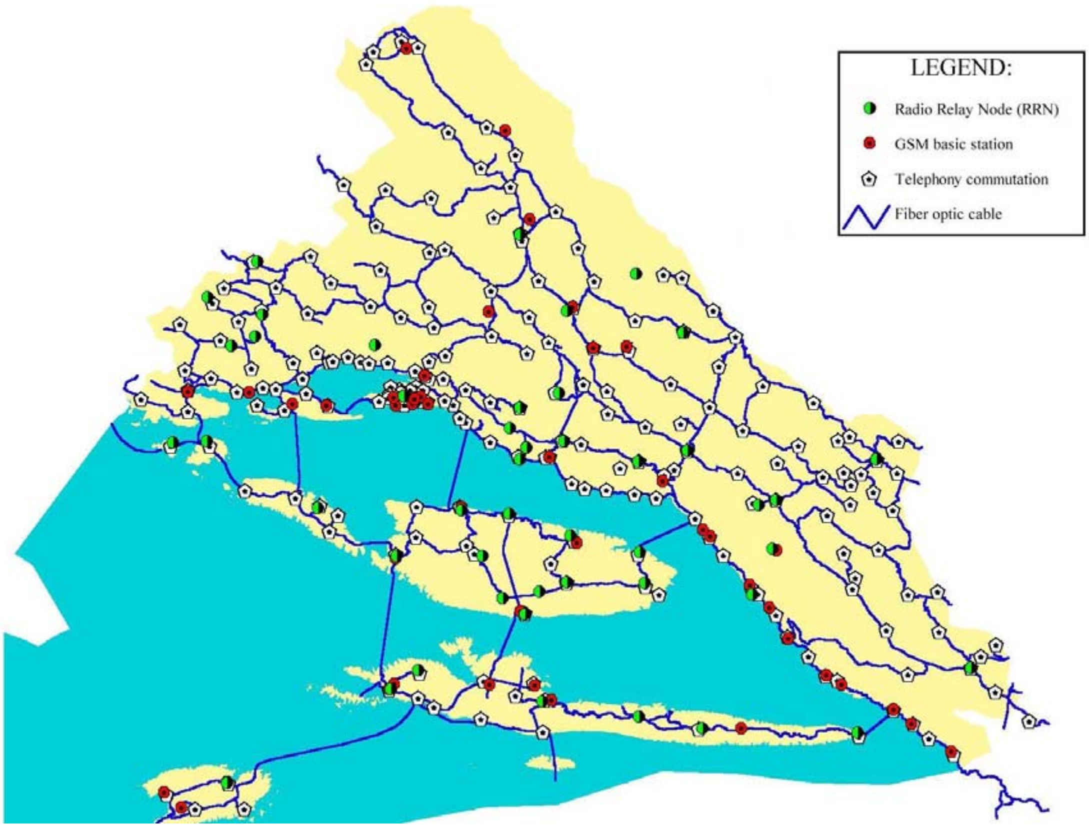
Implementation of “Telecommunication Support System” (TSS) is shown on Split-Dalmatia County, which is one of the biggest counties in Croatia, situated on the Mediterranean coast. The telecommunication system of Split-Dalmatia County is used as a pilot project for vulnerability analysis assessment using GIS tools.

Previous analysis and comparisons with other countries’ experiences pointed out the most frequent causes of system malfunctioning (5) which, generally, can be divided into two groups:

- causes generated by various natural factors,
- causes generated by human activities (directly, such as terrorist attacks, or indirectly).

Earthquakes, floods, fires, atmospheric hazards, landslides, etc, belong to the group of natural factors, while different technological accidents, or insufficient data about an installation location are included in the group of the most frequent malfunctioning of the system caused by human activities. With regard to the fact that the fibre-optic cable network is the basic telecommunication infrastructure of Split - Dalmatia County, a lot of "physical threats" to its functioning have been analysed.

Figure 1: Telecommunication system of Split - Dalmatia County



The aforementioned thematic maps are basic and provide source data about the system to be analysed. Looking at Figure 1 it can be seen that there is good coverage of the County with fixed and mobile networks, and importantly, a huge number of commutation nodes that enable alternative (by-passed) connections of different parts of the region in the case of direct connection interruption. Also, interruptions of the fibre-optic network can be substituted with radio relay connections, so important County centres, where various emergency services are situated, are covered with connections from a number of directions. Almost the whole network is built in the digital technology enabling ISDN (Integrated Services Digital Network) and partly ADSL (Asymmetric Digital Subscriber Line) connections. The fixed network, mostly containing fibre-optic installations, is often endangered by lightening coming through the energy supply system, floods, torrents, and partly by forest fires. In Dalmatia, torrents can cause serious damage to the infrastructure, due to its high power caused by terrain slope. By performing more detailed analysis of hydrological data, it is possible to estimate the probability of high water or torrents occurrences, thus the vulnerability of fibre-optic installation. Using GIS, 16 critical areas with points of close contact with the high-voltage network, torrents and the fibre-optic network were identified, thus multiplying probability for network interruption, as well as indicating potential system vulnerability. Possible terrain movements endanger fibre-optic infrastructure as well, because most of the County belongs to the earthquake zones 8 and 9 indicating high earthquake risk. However, by grouping of fire damaged areas, it is easy to notice zones extremely exposed to forest fires. These zones are in correlation with standard fire risk indicators, such as forest fire risk index, moisture index, land dryness index, vegetation index, etc. By using GIS tools (6) it is possible to group fire zones and get new homogenous zones with fire risk degree.

Table 1 displays the summary outlook of risk degree of the telecommunication system of Split - Dalmatia County, based on four criteria. As a result, it is possible to establish attributive valuation of the telecommunication system vulnerability within a scale of five possible ranks: from 1 (very high) to 5 (not significant). In Table 1, magistral fibre-optic routes are noted, because their interruptions can cause significantly more damages in the whole telecommunication system. Point (area) 6 has the highest vulnerability rank (very high vulnerability). Area 6, situated near commutation node "Sinj" is in the possession of RR station, so special attention about possible establishment of telecommunication routes via this station has to be paid.

Table 1- Summary outlook of the County telecommunication system

No. of the critical point (area)	Earthquake zone	Fire risk degree	Vulnerability rank	Comment
1	6	high risk	moderate (3)	magistral route
2	6	moderate risk	not significant (5)	
3	7	high risk	high (2)	
4	8	moderate risk	high (2)	magistral route
5	9	moderate risk	high (2)	magistral route
6	9	high risk	very high (1)	
7	8	moderate risk	high (2)	
8	7	high risk	high (2)	
9	7	moderate risk	less significant(4)	
10	7	high risk	high (2)	
11	8	low risk	moderate (3)	
12	8	moderate risk	high (2)	
13	9	low risk	moderate (3)	magistral route
14	9	low risk	moderate (3)	magistral route
15	9	low risk	moderate (3)	magistral route

16	8	moderate risk	high (2)	

Based on the data about risk degree of routes, alternative routes or use of RR connections are being planned. Due to the increasing number of public mobile telecommunication network users (PLMN – Public Land Mobile Network) in Croatia, that is 1,7 million on a little more than 4 million inhabitants, it is important to include PLMN infrastructure into "Telecommunication Support System (TSS) in Complex Humanitarian Emergency Situations". Report of CGALIES (2) project states that by 2003, two thirds of all Europeans will have a mobile phone. A primary characteristic of Split – Dalmatia County is a huge number of tourists during summer months, therefore, it is necessary to enable the use of their mobile phones on Croatian territory for any kind of emergency calls, thus making them safe. Moreover, development of the MEI (Minimum Essential Infrastructure) concept by applying multicriteria analysis defines foundation of the system that takes over telecommunication support in emergencies for the whole County. One of the crucial problems of telecommunication system functioning in emergencies is stability of the Electric Power System that supplies all devices. With regard to the fact that a part of the telecommunication system can work autonomously using its own aggregates and most of the users have cell phones, mobile telecommunication can be used as a basic tool for communication in emergencies, as well as in situations when the Electric Power System is out of order. By applying multicriteria analysis, among 120 existing GSM base stations, seven "GSM - Emergency Stations" are chosen according to the following criteria: possession of electrical power aggregates, covering the areas with high residence density, covering the most endangered areas, having the most alternative routes to other nodes, etc. These GSM base stations cover the most densely populated territories of the County, all important tourist places and the most frequented roads. Estimating the general stability of telecommunication infrastructure, as well as its vulnerability, it can be concluded that thanks to the fact that the fibre-optic network placed in the cable distribution duct is the basis of the fixed network of the telecommunication system, low vulnerability related to fires, torrents, earthquakes and other hazards is recognised. Large numbers of radio relay (RR) and commutation nodes enable an alternative telecommunication network in emergency situations. High system vulnerability related to energy supply can be solved by implementing existing electrical power aggregates, as well as installing new ones at the end-users involved in the emergency management system, because most of the communications can be performed by Internet.

Operative procedures and software for different functions during emergencies

Regarding operative procedures and software for different functions during emergencies, it is essential to increase functionality of the existing telecommunication system infrastructure. Part of the activity within this segment is related to standardised interoperable telecommunications functions and services, with the intention that survived devices and units from different operators (corporations) with different protocols can work as a unique system. For example, "roaming" between two operators has to be established (Cronet and VIP), which have GSM base stations on the County territory, by means that survived base stations could overtake calls from both networks. However, during relief of telecommunication functions it is necessary to use all resources regardless of different operators.

Another part of the activity is related to the definition of the various procedures and software within Emergency Management, enabled by contemporary technology. Establishment of Centre 112 provides an opportunity to increase functionality and quality of telecommunication system support in different Emergency Services.

Application of "Telecommunication Support Systems (TSS) in Complex Humanitarian Emergency Situations".

The forthcoming text shows illustrative examples of the application of "Telecommunication Support Systems (TSS) in Complex Humanitarian Emergency Situations".

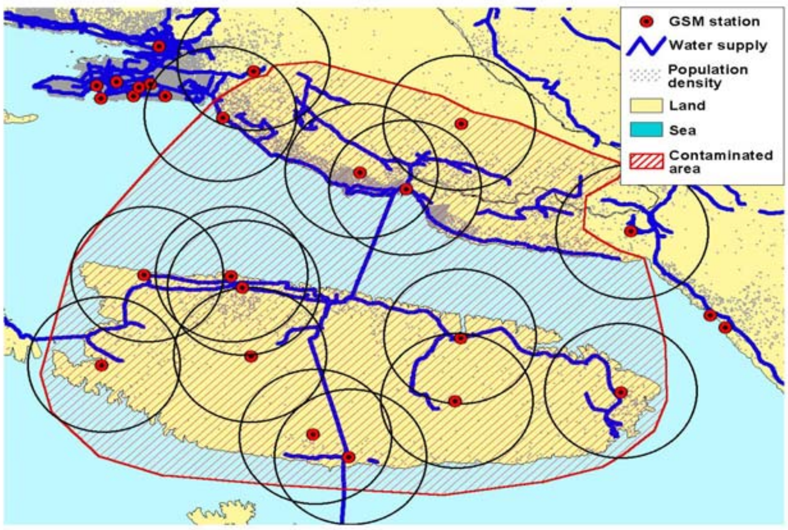
Scenario 1 – contamination of water supply system

Biological or chemical terrorist attacks on the water supply system have occurred in one part of County. More frequently, in the vicinity of a water chamber, a spillage from a cistern carrying hazardous chemicals has occurred, thus drinking water quality and the health of inhabitants and tourists in the area have been endangered.

The procedure of Centre 112, besides alerting technical services to eliminate contamination, is partly directed at alerting inhabitants not to drink the water and put their health in danger, because it is technically impossible in a short period to stop water flow into the system. To alert inhabitants, besides conventional methods (sirens, TV and radio), a telecommunication system can be used in the following way:

- After a warning about water contamination is sent, GIS support with data about the water supply system is activated in order to determine the endangered territory.
- After determination of endangered territory borders, all fixed landline connections are identified by MSAGA (Master Street Address Guide), as well as fax and Internet prepaid users. They are all supplied from the computer with textual messages not to drink water.
- Regarding the fact that a large number of people, as well as tourists, are outdoors, in intention to alert them, all GSM stations are identified within and near the endangered territory.
- All mobile phones that are in connection to the GSM base station via Cell Broadcast (CB) system are alerted by SMS (Short Messages Services) not to drink water and to call information centre.
- For the mobile phones that are in roaming connection with the alarm GSM base stations, an identification via ID is performed, and they receive messages on their language (it is supposed that it is one of the European languages or if it is not, message could be sent in English).

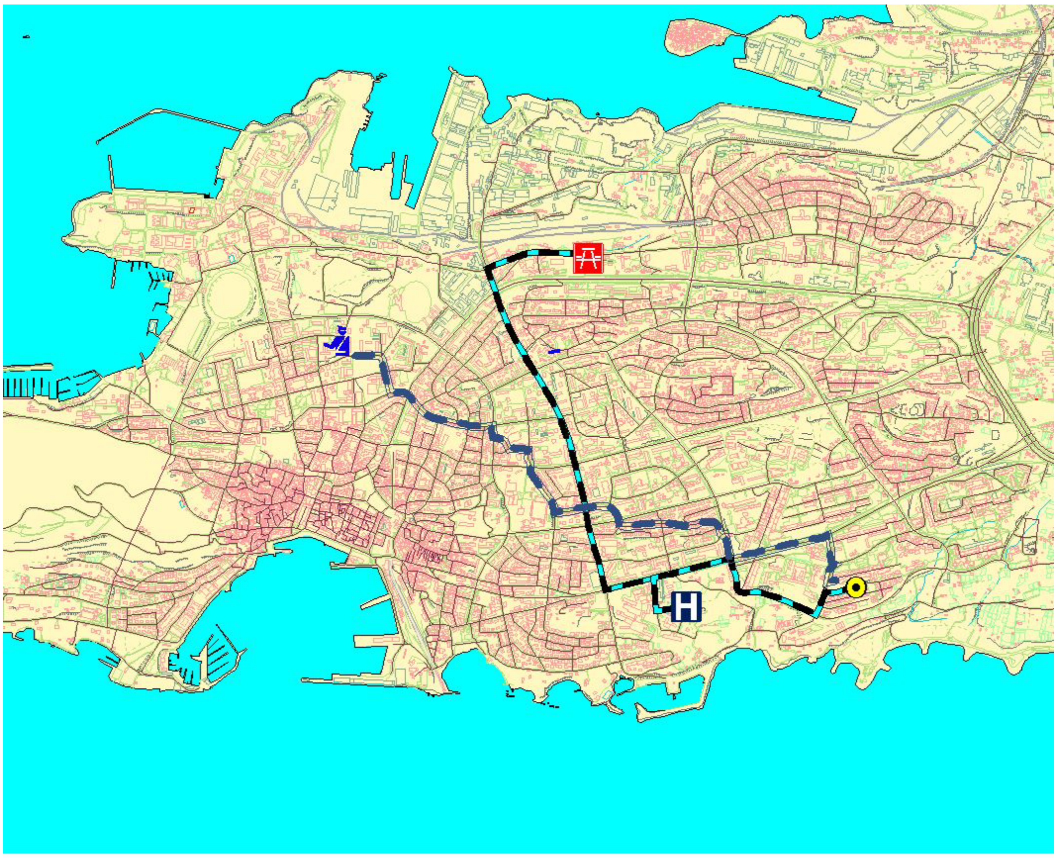
Figure 2: Layout of the area and GSM base stations included in the alert procedure
Explained model support can be used in any other "Complex Humanitarian Emergency Situations" such as earthquakes, consequences of terrorist attacks, etc, when lives and health of inhabitants of a certain area are endangered.



Scenario 2 – emergency call in urban areas

The following example presumes that a gas explosion has been occurred in one of the buildings in the town of Split (urban place) causing a fire and injuries to the people. The call was from the fixed landline network, so the Centre 112 located the emergency place (yellow point) on the existing digitalised map of the town (scale 1:5000) using MSAGA (Master Street Address Guide). The dispatcher in the Centre chooses the nearest police station (policeman symbol) and by "Network" software and option «Find best route» defines the fastest and most convenient route to the emergency point. The same procedure is being performed for the fire brigades and ambulance cars (H symbol). GIS contains thematic layers with positions of hydrant valves, so the fire brigade can be supported with information about the best valves regarding the water pressure.

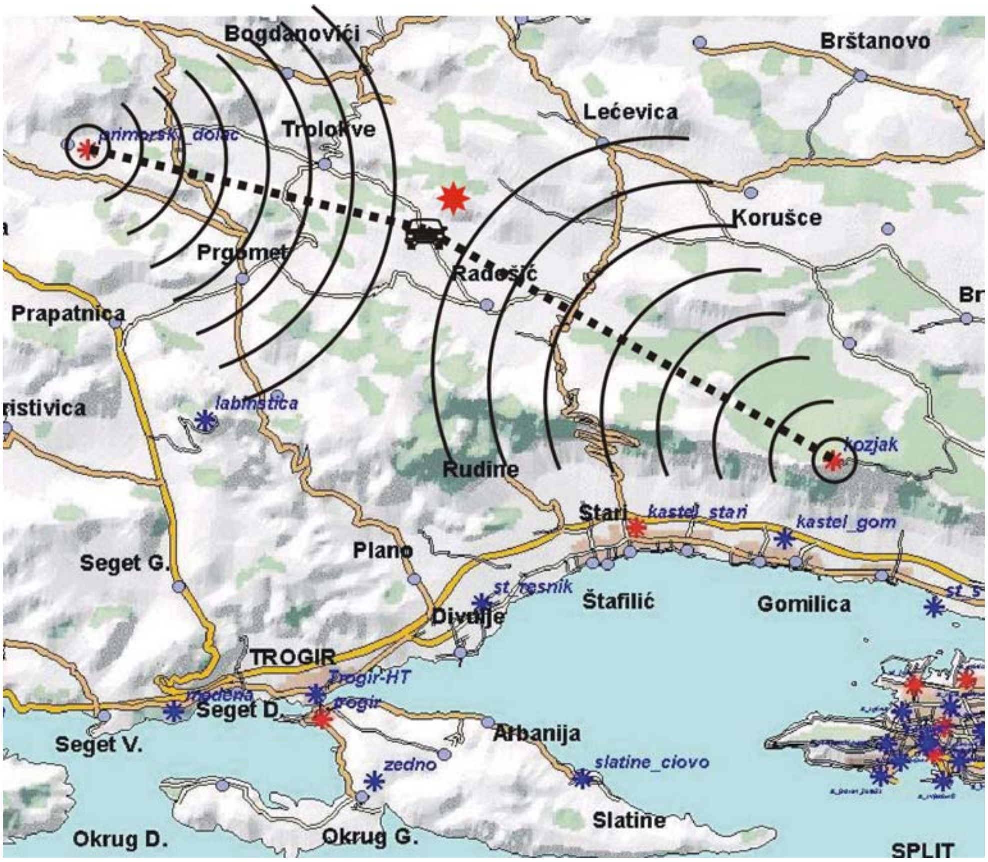
Figure 3: GIS support for locating emergency call and definition of intervention routes



Scenario 3 – fire location based on mobile phone calls

For Split – Dalmatia County, as well as for the whole northern Mediterranean region, during summer there are a huge number of wildfires, which spread very fast, causing risk to property and human lives and health. Therefore, it is very important to promptly notice the fire, determine precise location and start with the intervention. Warnings about wildfires usually come from inhabitants, which are not able to give precise information about fire location, so it is necessary to locate the caller, and according to their position, locate the fire. Figure 4 shows a situation where a warning about a fire is sent by a mobile phone from a car, with the description that the fire site is approximately 300 meters in front - left from the car. In the Centre, a procedure for mobile phone location via GSM base stations, which receive a signal from sender (caller), is launched, so an approximate fire site is determined and an alert to the nearest fire brigades is sent. Another possibility is to use GIS for identification of all phone prepaid connections nearby a fire site, and using Centre 112, inform them about the fire and eventually include them in the intervention. If there is a bigger fire that causes risk to the roads, all mobile phones in the cars on the nearby roads are identified and informed about possible road blockage via CB (cell broadcast) system. The described procedure can be used in any urban or sub-urban areas with the condition that during the modelling phase all GIS thematic maps with adequate information have to be prepared. However, higher density of GSM base stations enables more precise call location and fire site position. Report of CGALIES (Coordination Group on Access to Location for Emergency Services) (2) project states that possible precision in urban areas is 25 – 150 meters, in sub-urban areas is 100 – 500 meters, and on the highways and waterways is 100 – 500 meters.

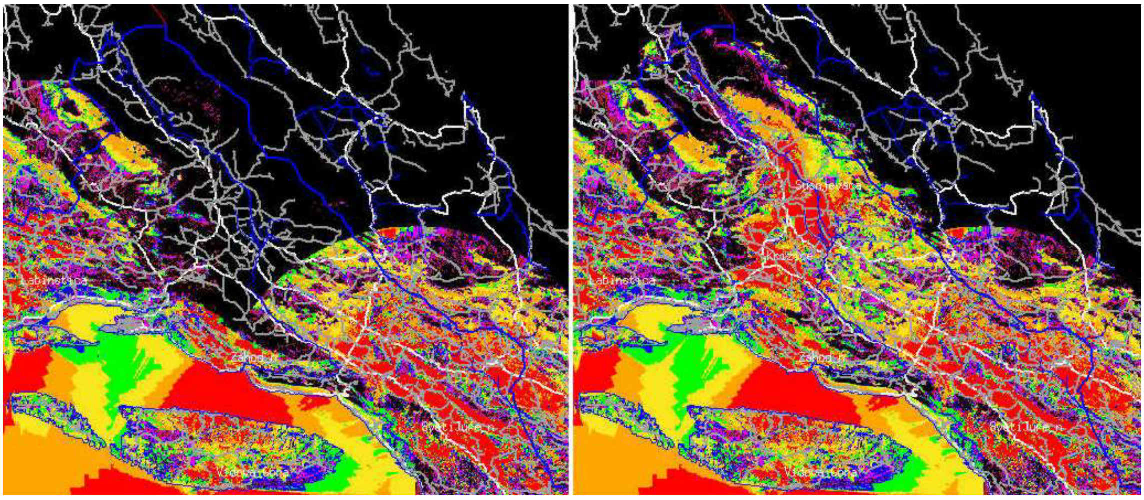
Figure 4: Layout of locating the vehicle that sent warning about wildfire via mobile phone



Scenario 4 – locating of GSM stations during emergencies

Loss of supply or physical damage of GSM base stations caused by natural disasters (earthquakes, heavy storms, etc) or damaged by any other cause, disable telecommunication services by mobile phone, which is important during emergencies. As a function of recovery and restoration of telecommunication services in the endangered area, during the planning phase it is necessary to predict implementation of temporary base stations at previously determined locations, at the locations of damaged base stations. Placement of temporary base stations can be performed by helicopters or by any other manner if adequate equipment exists. Figure 5 shows the endangered area (on the left) and survived base stations after a natural disaster. In the middle of the left part of Figure 5 there is an area with a lot of roads, but left without signal (black). By placing two mobile base stations at previously prepared locations (on the right), mobile network services are improved.

Figure 5: Layout of hearing before (left) and after (right) placement of two mobile base stations



Conclusion

Affiliation of Croatia in the unique European system PSABA and establishment of Emergency call Centres 112 initiated conceptualisation of "Telecommunication Support System (TSS) in Complex Humanitarian Emergency Situations". Classification of the telecommunication emergency support system to the part related to "telecommunication infrastructure" and the part which deals with "operative procedures and software" for different functions during emergencies resulted in the conclusion that existing infrastructure has more possibilities than it is used for in operational and planned telecommunication support in emergencies. The basic problem within the segment of "telecommunication infrastructure" is estimation of its vulnerability and efficient planning of its relief. Studies on "operative procedures and software" demand intensive research in order to use all technological possibilities offered by the telecommunication system. Achieving synergetic effect (4) is possible by intensive application of GIS support and, generally, information technology.

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The International Emergency Management Society
9th Annual Conference Proceedings
University of Waterloo, Canada, May 14-17, 2002

USING WIRELESS NETWORKS TO PROVIDE EARLY WARNING OF EMERGENCY INCIDENTS

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Keywords: early warning, rescue operations, wireless communication, mobile phone.

Abstract
Early warning to our citizens in case of emergency incidents, whether deliberate or accidental, can increase public safety substantially. Selective warnings and instructions can limit the negative consequences of an incident by making people on their way into, or passing through, the incident area aware of the threat, thus increasing the possibility for them to avoid the hazard. With the increased use of cellular phones and the infrastructure of the emerging high-capacity wireless networks with large geographical coverage, new possibilities arise to reach a selection of individuals in a specific area. Already today, the wireless networks have increased the ability for the public to report incidents and emergencies to rescue authorities. In this paper we explore the possibility to take additional advantage of the wireless networks in order to deliver selective early warnings to people in or close to a hazardous area. Sending appropriate information in a comprehensible format requires that the target audience can be identified, for example based on geographical location, means of transportation, movement in relation to the incident, and language preferences. We investigate criteria for selecting the target audience, means of customizing message contents, suitable media, and technical requirements and limitations. We analyze these points in relation to practical examples and discuss potential applications.

Introduction

Early warning of an emergency incident to citizens is an important instrument for saving lives, reducing injuries, and limiting property damages. Such warnings can instruct people to evacuate a hazardous area and to keep away from an area. Because many types of emergencies are impossible to predict, such as toxic spills from transportation vehicles and toxic gas leaks, it is important to communicate appropriate warnings as soon as possible to those affected by the incident.

Warnings usually come after the response teams arrive. At the scene, the arriving rescue workers and police officers take part in warning and evacuating people. However, the time between the first

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call reaches the emergency operator and the arrival of rescue workers and police officers on the scene is usually lost in terms of warning the public. Today, it is not possible to warn people from entering the area (e.g., by posting signs and blocking streets) within this early time frame.

For larger incidents, it is possible to use commercial broadcast radio and television for broadcasting a warning. However, warning people by radio and television is quite a significant step, and there is a time lag between the incident and the actual broadcast. Delays occur at several stages, such as contacting the appropriate decision maker, making the decision and preparing the message for broadcasting. Moreover, such warnings assume that people have receivers turned on and are listening or watching. In practice, broadcast warnings are rarely used because most everyday incidents are below the threshold for such general public warnings. We believe that mobile-phone networks are suitable for emergency warnings, because they can send messages promptly to a targeted group of people without involving such general broadcasts.

The proliferation of mobile phones in the 1990s has made it easier and faster for the public to contact emergency services by voice call. In this respect, mobile communication technology has helped shortening the delay between the emergency incidents occur and the arrival of rescue resources at the scenes. Meanwhile, the distribution of emergency warnings to the public has not evolved significantly during the last decades. Currently, it is not possible to take advantage of the mobile networks for emergency-warning purposes. However, there is an increased interest in using new technology to improve crises mitigation and management (The Global Disaster Information Network, 1997; Committee on Computing and Communications Research to Enable Better Use of Information Technology in Government, Computer Science and Telecommunications Board, Commission on Physical Sciences, Mathematics, and Applications, and National Research Council, 1999).

In our approach we want to take advantage of our society’s investments in wireless networks and the fact that the mobile-phone penetration in most industrialized countries is relatively high, for example in the year 2000, 80 percent of the households in Sweden had access to one or more cell phones (Nodicom, 2001). This reality makes it possible to reach a large proportion of the people in an area. We believe that emergency-management systems can make multiple-use of these networks for public emergency warnings. Early warning broadcast through mobile messages, such as the Short Message Service (SMS), can complement traditional sirens and radio messages. In addition to providing basic early warning, mobile-phone networks can deliver selective warnings to a group of people. For example, by using mobile positioning, it is possible to send selective messages to people in the vicinity of the incident. Interactive warnings go beyond selective warnings by adding support for feedback from mobile phones, for example manual confirmation and movements in response to warning messages.

In this paper, we discuss the background in terms of human responses to warnings and examine the possible approaches to public warning though mobile-phone networks. We suggest three technology levels for mobile warnings, and list possible services for these levels. Finally, we discuss the implications of our approach, and draw conclusions.

Background

Before we present different approaches to emergency warnings through wireless networks we have to consider some important aspects of warning response. Drabek (1999) stated, “The first principle in understanding disaster warning responses is to recognize explicitly that *the initial response to any warning is denial”* (p. 115, original emphasis).

In the report *Effective Disaster Warning* by the Working Group on Natural Disaster Information Systems Subcommittee on Natural Disaster Reduction (2000) the individual warning reaction process is categorized into the following seven components: (1) perceiving the warning (hear, see, feel), (2) understanding the warning, (3) believing that the warning is real and that the contents are accurate, (4) confirming the warning from other sources or people, (5) personalizing the warning, (6) deciding on a course of action, and finally (7) acting on that decision.

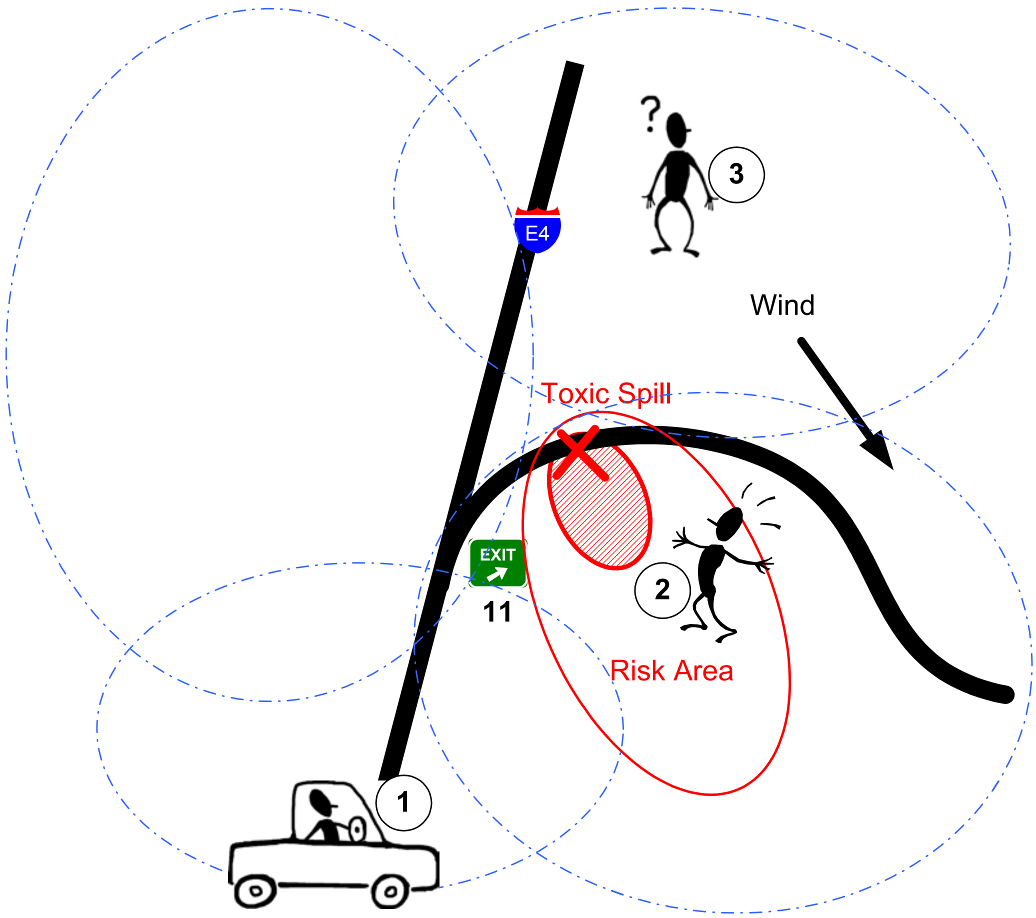
There are a number of factors that affect how people respond to a warning. *Receiver characteristics* describe how various groups of people react in different ways depending on their social, economical and ethnical situation. Receiver characteristics are primarily environmental (cues, proximity), social (network, resources, role, culture, activity), psychological (knowledge, cognition, experience), and physiological (disabilities). Furthermore, a distinction is made between sender and receiver characteristics (Nigg, 1995). *Sender characteristics* focus on the nature of the warning messages (content and style), the channels through which the messages are given (type and number), the frequency by which the messages are broadcast (number and pattern), and the persons or organisations sending the message (authoritativeness, credibility, and familiarity). *Message Characteristics* describe the questions that the warning must answer to be seen as credible to the majority of a population. Table 1 gives an overview of seven important questions when formulating a warning message. *Contextual Characteristics* tell you for example weather a person is at home, at work or travelling. *Event Characteristics* describe the situation to the person who receives the warning. Two event characteristics that have considerable influence on warning acceptance and warning denial are length of forewarning and accessibility of escape routes (Drabek, 1996, p. 261). A comprehensive review of the literature regarding communication issues in disaster management can be found in Mulilis (1998).

In addition to the cognitive aspects of warning we also have to review the technical aspects of existing system and services. The GSM Short Message Service (SMS) is a widespread service that makes it possible to send a 160-character (70 when non-Latin alphabets) message to a mobile phone user. The message can be sent from another mobile phone or from the Internet as long as the network provider supports the service. Several receivers can be addressed as a group using any mail client, either through an SMS-gateway directly from a web page, or by a dial-up PC-modem. SMS has several unique features such as confirmation of delivery to the sender and storage if the recipient is not available. The receiver is notified of an incoming message by sound and vibration. The delivery confirmation service has to be activated by typing a character combination (e.g ##), which is unique for different service providers. This service will confirm that the message has reached the receiver unit, but not whether it has been read. A problem could appear if the receiver unit or the SIM card is out of memory when a message is coming. In this case, most mobile phones will notify the user that the memory is full and that old messages has to be deleted before the new message can be received.

The reliability of SMS services vary considerably between different mobile networks because they deploy different SMS Centres. Not all mobile network operators can support SMS for time and mission critical applications.

Despite little proactive marketing by network operators, SMS growth has been steady across all markets. The GSM Association (2002) estimates that more than one billion SMS messages are sent every day throughout the world.

Figure 1: A simplified example of an emergency incident that we will use to illustrate the different technology levels for a warning system using wireless networks. (1) One person is heading north in a car on road E4. (2) Another person is close to the toxic spill and in the risk area. (3) A third person is observing the incident and does not know what to do. The four dotted ellipses show the boundaries for the cells in the network.



Introduction to the three technology levels for mobiles warnings

With the background of both the human and technical aspects of early warning we have identified three technology levels for communicating warnings to citizens: early-warning broadcast, geographical selective warning, and interactive network warning. Early-warning broadcast is a basic approach to complement sirens and radio messages. Geographical selected warning can send messages to a specific area. Finally, interactive network warning can take advantage of information feedback from mobile phones, such as movements and behaviour.

Table 1: Seven important questions when formulating a warning message.

Questions to be answered by the warning	Comment
Who is issuing the warning?	Credibility and trust. Do I trust the authority or person that is issuing the warning?
What is threatening?	What knowledge do I have about the threat type and possible consequences of the threat?
What exact geographical area is threatened?	Am I in the area? Is our home in the area?
When is it coming?	What is the time reference and is there time to act?
How probable is the event?	Has this type of situation occurred before?
Are there high-risk locations?	What areas must be avoided? Alternative routes?
What specific protective actions should be taken?	Individual training level (Liu et al., 1996) and available resources.

Figure 2: Example of a warning message sent using Short Message Service (SMS) and received on a cellular phone.

Level 1: Early Warning Broadcast

Early warning broadcast messages through mobile-phone networks can be seen as a complement to sirens and radio messages that are available in most countries today. The principle is similar, but with extended use of wireless networks to broadcast the warning. The purpose is to reach more people in case of an emergency than today. Another goal is to provide more detailed information about the emergency than just the warning message, in order to increase the warning acceptance rate among the people warned.

Figure 1 illustrates an emergency situation where a toxic spill has occurred as a consequence to a traffic incident. In addition to the people directly involved in the traffic accident, there are three persons close to the incident area when the accident occurs. Figure 2 shows a cellular phone and the beginning of the broadcast warning message sent from the fire brigade. This message is sent in parallel with the dispatch of rescue units to the incident scene. To be as effective as possible the message should answer the questions in Table 1. The complete message reads:

```
Warning from the Fire Brigade.
Toxic spill at road E4, exit 11.
The accident occurred at 14:34, 14 May 2002.
Danger in and around road E4, exit 11.
Rescue units are inbound.
Do not approach the incident area.
If you live close to road E4, exit 11: Close doors and windows and stay
inside.
For further instructions and information about the incident turn on
your radio or call 911.
```

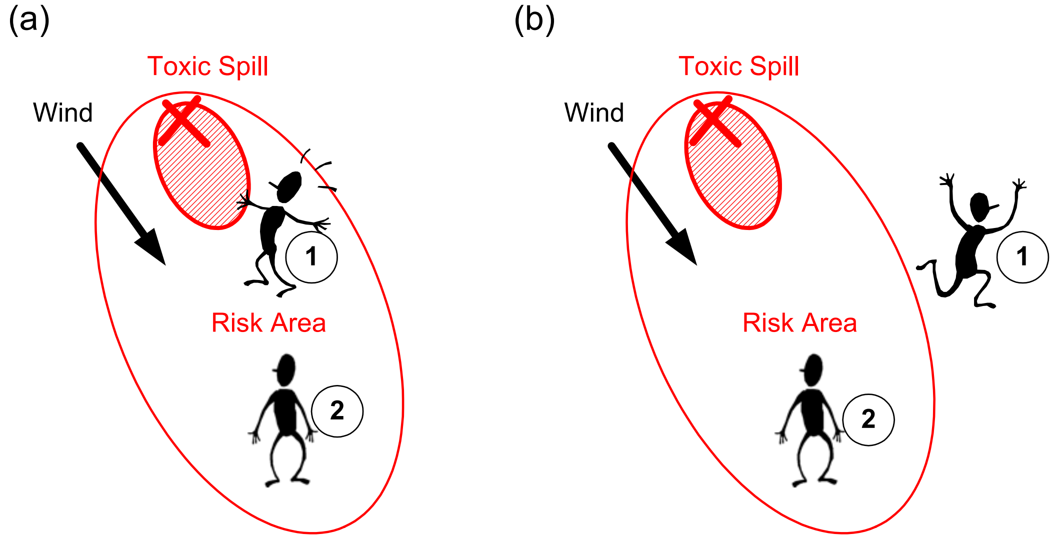
Level 2: Selective Area Warning

A problem with broadcast warnings is that several people who are not in danger are warned (The Working Group on Natural Disaster Information Systems Subcommittee on Natural Disaster Reduction, 2000). In the long run this can have a negative effect on how a relevant warning is received by a population. As a consequence the authorities are often restrictive when it comes to broadcast warnings. This is one reason why selective warnings are an attractive approach for incidents and emergencies that affect limited geographical areas.

With the use of wireless networks, for example cellular phones in GSM networks, it is possible to transmit selective warnings to individual network cells. A cell is typically 3 miles in radius, but the range depends on the geographical conditions. In this way it is possible to give tailored warnings depending on the location of the cell in relation to the incident area. Particularly, we want to use the time more efficiently between the incident and the time when the first rescue vehicle arrives at the incident scene by providing the people in and around the incident area with an early warning accompanied by instructions on how they should behave in order to protect themselves.

In the situation illustrated in Figure 1 the warning messages could be tailored and limited to the different geographical areas around the incident. In this case person number one should receive the general warning about the incident together with additional instructions to stop the car in order to avoid exit 11 and stay clear of approaching rescue vehicles. Person number two should receive the general warning message together with instructions to immediately leave the risk area in the east or south-eastbound direction. Person number three should receive only the general warning message.

Figure 3: An example of monitoring of individual behaviour after a selective warning. In Figure 3a the two persons get the warning message and instructions to evacuate. In Figure 3b, some time has elapsed and person number one has left the risk area, but person number two has not reacted.



Level 3: Interactive Network Warning

In a more advanced system the network can be used both to continuously collect information from the field and to provide early warning and monitoring of people in or close to a dangerous area.

Immediately after an incident the network can retrieve information about the circumstances at the incident scene. For example to give the basis for an early estimation about how many people are in or close to the incident area.

With the interaction capability it would be possible to check the settings for each individual phone. This could for example be used to send the warning message in the same language that the individual phone is set to, thus increasing the individual understanding of the warning. This capability could be useful in multilingual areas and situations, for example international sport events and internationally well-known tourist attractions.

With a classification of the individual subscriber in the network it would be possible to record in advance and during an incident, identify individuals with specific knowledge or competence. For example, it could be possible to find physicians, nurses, paramedics, fire and rescue personnel and police officers, on or off duty, among a large population in case of an emergency. Extended use of active members of non-governmental organisations like the Red Cross could also be possible with their permission.

A monitoring capability could make it possible to send a second alarm to people who for example are moving towards instead of away from a hazard. Table 2 shows how different sequences of warning messages could be sent to the two persons illustrated in Figure 3 during a period of time after an incident. At the time t_1 the two persons get the warning message and instructions to evacuate. In Figure 3b, some time has elapsed and person number one has left the risk area and receives a confirmation message that he has exited the risk area. At this time person number two has not reacted and a second message is sent by voice. The system could at this time automatically make a list of both responding persons and non-responding persons, to be presented for the commander of the rescue force, in order to direct rescue units to the locations with possible victims.

Table 2: Sequences of warning messages during a period of time after an incident illustrated in Figure 3.

Person in Figure 3	Time t_1	Time t_2
1	Message to evacuate	Confirmation message: You are in a safe area.
2	Message to evacuate	Repeated message to evacuate by an automatic voice call.

Discussion

There are many types of situations where emergency warnings can save lives, reduce injuries, and protect property. Examples of such situations are chemical incidents, bomb threats against large buildings, large traffic incidents, and missing persons or children. We believe that messages transmitted to mobile phones can add a new medium for emergency warnings. The messages must be carefully authored to ensure acceptance and the desired response.

Research Questions

Although this approach seems feasible technically (in terms of communication), there remain important research questions:

1. What is the level of mobile-phone customer penetration in the region? There exist statistics for mobile market penetration, which give a general idea of how widely used the mobile phones are in different countries and market segments. However, such statistics are based on ownership of mobile phones (e.g., the number of phones in the family). For emergency warnings, the interesting question is the percentage of reachable people in an area (i.e., people carrying reachable, active phones).
2. How long time does it take until you actually read (and understand) a message? Sending a textual message, such as SMS, to a mobile phone does not automatically imply that it will be read. For example, there is often a time lag between receiving a message (audio signal from the phone) and reading it (e.g., due to meetings and other activities).
3. How many messages are not read at all? A related question is the percentage of messages never read. Some people may not understand how to read messages (e.g., received SMS) because they never use this function, or they may have their phones turned off for a long period of time.
4. What is the mobile-phone penetration and message throughput required for a given task? These questions lead to the general question of what level of communication is needed for a particular emergency-warning task. Because of people-to-people communication, some task may require reaching only a small percentage of the public to get the message across (e.g., evacuation of large buildings), while other tasks require reaching almost everyone (e.g., warning people in sparsely populated rural areas of extreme weather conditions).

In addition, there are psychological aspects that warrant further research. Further work is required on how people read and understand emergency messages, especially messages delivered to their mobile phones. It is especially interesting to find approaches to formulate effective emergency messages for mobile phones, and to monitor responses to messages. We believe that reducing denial is a key factor for success. Therefore, an important goal is to develop authoring guidelines for reducing denial while avoiding unnecessary concern.

Preventive Safety Warning and Stationary Warning

As a preventive measure, wireless networks could be used to inform the public of various potential hazards. This could include warning to tourists in areas of danger in case of specific weather conditions. For example, heavy snowfall in the high mountains with increased risk for avalanche. Coastal warning in case of high winds and warning to swimmers of tidewater with strong currents are other examples where a wireless network can provide valuable information regularly or if the environmental condition changes.

The websign approach presented by Pradhan and colleagues (2001) could provide a transparent linkage between the physical world and safety critical information available on the Internet. The main idea is to dynamically present messages or websigns to the holder of a wireless device, depending on the geographical location and current situation. One of the original applications for websigns was as an electronic tourist-guide, which provided you with information associated with physical objects. We think however, that the websign approach could be used for example to alert people not to enter a subway station in case of an incident or potential threat or to select another route with their car in case of a traffic accident.

Future mobile devices

The technological development on the consumer mobile-phone market is astounding. During the 1990s, the size, weight, and cost of mobile phones were reduced as the market penetration increased. However, the manufactures did not add much communication functionality to the phones beyond voice calls and SMS. Recently, extensions to SMS (such as multimedia-based SMS), WAP, and GPRS have emerged (Ralph & Aghvami, 2001). This development is likely to continue even further with the introduction of third-generation networks (3G). In the near future, consumers will have access to mobile multimedia devices with high-speed network access.

Mobile multimedia devices will provide a new level of emergency-warning communication. High-resolution colour screens make it possible to send multimedia warnings and interactive messages. For example, video clips with instructions and maps can inform the public of hazards and streaming media can deliver broadcast news to emergency areas. Another possible use of sophisticated mobile devices is data collection from an emergency area. For example, handheld devices can stream video from an integrated camera. In some cases, portable devices may support other types of sensors, such as sensors measuring physiological variables and ambient temperature. Emergency operators can take advantage of such information for situation assessment (e.g., from the emergency area and from escape routes), and for allocating appropriate medical resources.

At the same time as these devices are becoming increasingly complex, they begin to resemble portable computers (laptops) in terms of functionality. However, from the emergency-warning perspective, there are disadvantages of such increased functionality. Examples of such disadvantages are shorter battery life (because of increased power consumption) and exposure to tampering (e.g., viruses, worms, and break-ins). This development means that such devices can be less suitable for warning messages than conventional mobile phones, because of reduced availability as message receivers. Nevertheless, we believe that mobile multimedia devices will become an important tool for emergency warnings.

Conclusion

Early warning through mobile-phone networks is a promising approach. Our general idea is to take further advantage of our society's investments in mobile-phone networks and the fact that a large part of our population has access to a mobile phone, in order to provide increased public safety by introducing the capability of early warning.

We have identified three technology levels for communicating warnings to citizens: early-warning broadcast, area selective warning, and interactive network warning. Early-warning broadcast is a basic approach to complement sirens and radio messages. Selected area warning can send messages to a specific area. Finally, interactive network warning can take advantage of information feedback from mobile phones, such as movements and behaviour.

There remain several research issues. Most of these issues concern the ability to reach a sufficient proportion of the population, and psychological responses to the message. Further research is needed before we can deploy an operational early-warning system. Nevertheless, we believe that the approach is viable and that citizens and rescue workers can benefit from early warnings to mobile phones.

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EVALUATION OF THE FERNY CREEK FIRE ALERT TRIAL

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Keywords: Ferny Creek Fire Alert Trial

Abstract

Following the 1997 wildfire that decimated the area of Ferny Creek (3 lives lost and 33 houses destroyed) in Victoria, Australia, affected residents began a campaign to be provided with some form of warning. In response to that community's drive, supported by subsequent comments from the State Coroner, local government (the Shire of Yarra Ranges) initiated the Ferny Creek Fire Alert Trial Committee. Various warning systems were explored but the key factor challenging the committee was the lack of lead-time to provide adequate warning to the affected community, therefore an alert system was the only viable solution. A siren system was devised whereby the activation of a fire unit response to a fire near the township would simultaneously activate sirens in the area thus alerting residents to the imminent threat of wildfire. Intrinsic to the project was a concentrated and carefully orchestrated community communications strategy that raised residents' awareness to their vulnerability to wildfire and assisted them in their personal wildfire survival planning. An independent evaluation of the project was conducted by the Department of Justice. The review focussed on the social factors of the project rather than the technological aspects. It examined whether the alert system increased the level of preparedness by residents and the process by which proper consistent information was disseminated to residents to enhance and reinforce appropriate behaviour in the event the siren activated. This information process involving a multi-agency approach has been labeled the "integrated warning system". The evaluation also raised issues regarding shared meanings and expectations and the concepts of risk perception and risk communication. The findings from this evaluation have much broader implications for community warnings in general.

Introduction

"*No significant benefit will be attained from research on any component of warning systems unless what is currently known and what is discovered and put to use in specific communities for preparing for specific events*"(D. Mileti, Natural Hazard Warning Systems in the Unites States: a Research Assignment, University of Colorado, USA, 1975).

On the 21st of January, 1997, five separate fires were ignited in the Dandenong Ranges. The cause of ignition remains unknown but is considered to have been deliberately lit by person/s with malicious intent. The damage caused by the fires in short totalled a loss of three lives, 41 houses and 400 hectares of State forest. Of the five fires the most significant, which attributed to the loss of the three lives, occurred at a residential sub division within the township of Ferny Creek.

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The township of Ferny Creek is located on the western side of the Dandenong Ranges approximately 35 kilometres east of Melbourne, Victoria, and covers an area of 1,093 hectares. It has a population of 1,960 and a total of 680 households (National Census 1996). The specific subdivision of Ferny Creek impacted upon by the 1997 wildfire is located on the north/western aspect of the Dandenong Ranges. The topography relating to this site is unique for a number of reasons. Firstly it faces a north/westerly direction which is vulnerable to the hot and dry summer winds conducive to wildfire. Secondly this specific area comprises of a gully referred to by locals as the "Devils Chimney" which under extreme conditions forms a sub climate that funnels and concentrates the effects of the prevailing winds to support wildfire behaviour. Thirdly and most importantly is the fact the subdivision abuts the Dandenong Ranges National Park, a heavily treed forest. Past resident, previous member of the Sassafras-Ferny Creek volunteer Fire Brigade and journalist, John Schauble, identified thirty-five incidents of wildfire in Ferny Creek and surrounds since 1851 (Schauble J. Fire in the Hills Dudey Gay Printing, Ferntree Gully, Victoria 1972 Appendix 2).

The 1997 wildfire at Ferny Creek originated in forest near a roadside approximately 750 metres below the subdivision. It has been estimated that it only took between ten to fifteen minutes from the time of ignition to the point where the fire front reached homes in Ferny Creek. The Police Arson Squad report found: "…This fire progressed into the …streets without any warning. Most of the residents who were interviewed didn't know that there was a fire in that area until it was burning around their homes. Some criticism has been laid relating to the lack of warning of the impending fire however this fire was burning through Mount View Road well before the arrival of the C.F.A. and police…."(1997 Dandenong Ranges Fires Inquest Report p.15)

Following the fire local residents of the affected area began lobbying for a warning system, initially requesting an extension to the Sassafras-Ferny Creek Rural Fire Brigade siren used to alert volunteer fire fighters to attend the brigade. Many residents on that westerly aspect complained that they could not hear the brigade siren from their home. It is important to note that the brigade siren was not activated for the Ferny Creek Fire in 1997 as the appliances were away responding to another fire.

In advocating for the residents the Councillor Robyn Hale, then Mayor of the Shire of Yarra Ranges, established a formal committee with a membership including the Mayor and Emergency Management staff from the Shire of Yarra Ranges, Ferny Creek Residents, The Department of Justice, Country Fire Authority (including both regional and local brigade representation, Victoria Police (including regional and local) and an anthropologist with expertise in human and fire behaviour.

The aim of the Committee was to examine the feasibility of having a suitable fire alert mechanism in place on a trial basis for the 2000 fire season to alert Ferny Creek residents to the eminent threat of bushfire.

The Ferny Creek Fire Alert Trial Committee aimed to achieve the following objectives:

- To initiate and maintain a high degree of local resident participation in the Ferny Creek Fire Alert Trial Project and ascertain the level of need of local residents for a bushfire alert system in the trial area;
- To ascertain the feasibility of a bushfire alert system in the trial area of Ferny Creek;
- To explore various alert systems available and identify a practical, simple, cost effective and reliable bushfire alert system;
- To achieve the installation and activation of a selected suitable alert system by 1st November, 2000;
- To conduct a full review of the effectiveness of the bushfire alert system after the end of the fire season to be completed by the 1st of May, 2001.

Issues Related to Public Warnings

From the inception of the committee it was obvious aware that the key response agencies, namely the Police and Country Fire Authority, faced a dilemma as to their role in the operation of an alert system.

The Country Fire Authority is responsible for fire suppression and community fire awareness. It had previously denied the requests of residents to install an extension of the Brigade siren system, as the role of the siren was to activate brigade members to attend the brigade to respond to a call. The Country Fire Authority is not vested with a role to warn residents.

The Victoria Police is responsible for the protection of life and property and is vested with the responsibility of issuing community warnings and undertaking evacuations at the request of the controlling emergency service, which in the case of fires is the Country Fire Authority. The police currently possess a mechanism known a the State Emergency Warning System (SEWS) which involves a distinctive tone being played over television and radio stations to attract attention and then following the tone a message detailing specific information is broadcast. Evidence submitted before the Corner during the inquest into the 1997 fire indicated that there was insufficient time for a response brigade appliance to attend the scene and evaluate a fire before it had already impacted upon the residents. It follows then that there would be insufficient time to provide adequate and reliable information to warn residents. There was unanimous agreement that a warning system would not meet the requirements of the Trial community.

Hence the term 'alert' and its specific connotations was applied. An alert would provide a minimum of five minutes notice to residents of the threat of an impending fire. It would and could not provide information pertaining to the extent of the threat or provide advice to residents on how to act. The alert would act as a trigger in activating residents who already were in a state of readiness and provide them with sufficient time to activate sprinkler systems, collect children or pets and prepare to defend the property. The key to an appropriate response by residents relied upon their level of awareness and preparedness.

Initial Trial Community Survey

On the 10th of August, 2000, a questionnaire was posted to the 180 landowners in the trial area to gain further input from the residents. Whilst some properties would be occupied by the registered landowners, others may be holiday homes, vacant lots or leased houses. The aims of the questionnaire were to check the level of fire awareness and preparedness of residents, to ascertain residents' viewpoints on whether an alert system was needed for the area, and, if an alert system was considered appropriate, to establish which alert option was most preferred.

A total of 114 (63%) questionnaires were returned for analysis. A high response rate was anticipated due to the high level of community awareness of bushfires in the area. A total of 96% of respondents use English as their first language thus facilitating communication strategies with this group. Over 60% of respondents indicated that they were a member of Community Fireguard. The majority of all respondents (86%) advised that they possessed a bushfire survival plan. Approximately 65% of all respondents planned to stay and defend the home in the event of a fire with the remainder either leaving early on a total fire ban day (23%) or a significant number of (12%) who made no response to this question. When asked if there was a need for a dedicated bushfire alert system in their area, which might provide only ten minutes notice, almost ninety per cent of respondents replied in the affirmative. This result indicated a strong desire by respondents that they would like some advance warning, however short, of an imminent fire.

Selected Fire Alert System

The committee was and remains committed to exploring all viable options for an effective and reliable alert system. Research to date including international queries via the Internet reveal that while there are numerous public warning systems there are no commonly used alert systems which are used for the short time frames intrinsic to this project. Most warning systems involve extensive lead times (at least a number of hours) in which time relevant and accurate information can be disseminated to target communities. After considerable research and deliberation the Committee agreed that a siren system was the most viable solution considering the cost, time frame for implementation and reliability.

The issue was raised regarding which individual, group or agency would be responsible for actually activating the system. The need to absolve any individual of the responsibility to activate the siren was imperative therefore a systems approach was explored. In order to provide the most timely response providing the optimum alert time focussed the Committee on the Country Fire Authority Communications Centre, referred to as VicFire.

Activating the alert system at the earliest report of an impending fire would meet this goal. The current response by VicFire to the receipt of a fire call via the emergency telephone number 000 is to enter the details of the required location into a computer system and then activate Brigade units' appliances, which are responsible to respond to the desired location. The computer system automatically selects the appropriate response Brigades according to the location of the fire. Software was developed defining the geographical areas where the presence of fire would threaten the Ferny Creek Trial area. Once a call to a fire was received the computer would then automatically activate the Ferny Creek Fire Alert System simultaneously with the response Brigade/s.

Communication Strategy

The Committee devised a communication strategy to ensure residents in the Ferny Creek Fire Alert Trial Area and other stakeholders had a clear understanding of the alert system and, to provide them with the tools and advice to develop a personal bushfire survival plan involving the CFA endorsed “leave early” or “stay and defend” principles. In its education to residents in high wildfire risk areas the Country Fire Authority promotes a ‘leave early or stay and defend strategy’. The strategy is based on the research of fatal bushfires between 1962 and 1998 that showed over half the deaths resulted from people being caught in the open or in vehicles (Krusel, N. and Petris, S. (1992). Staying Alive: Lessons learnt from a study of civilian deaths in the 1983 Ash Wednesday bushfires. Fire Management Quarterly, 2, 1-20.). The Country Fire Authority endorses that people who are not physically or mentally capable to stay and defend their property in the face of a bushfire should leave early in the day. In the event that a person is capable to stay and defend their property then the Country Fire Authority encourages the adoption of suitable equipment and training to allow them to perform this act more safely and effectively.

Resident, Anna Marie Shew drew upon an analogy of likening the alert to a piece of a jigsaw puzzle in that it is only one component of the response to the threat of an impending fire. Other components relate to a heightened state of awareness though using the individual’s senses in smelling or sighting smoke, seeking further information from a Country Fire Authority radio scanner, the electronic media, the Community Fireguard telephone tree (involving members contacting other members in a systematic manner), through the activation of a Country Fire Authority Pager or by contacting the Country Fire Authority direct.

A Shire newsletter titled On The Alert was circulated to all residents in the trial area and to local Country Fire Authority Brigades to keep everyone apprised with the progress of the Trial and to provide advice on survival plans. The newsletter was designed in a distinctive manner to attract the interest of residents. The Shire provided the broader community with information pertaining to progress of the trial though local newspapers and radio stations. The media was very supportive of the trial.

Almost 80% of questionnaire respondents indicated that they wished to attend a public meeting. A meeting was held in Ferny Creek on the 10th of November, 2000, to disseminate questionnaire results, stress the need and provide advice on devising personal survival plans, explain the role of the alert system as one component of the personal survival plan and to gain feedback from the community. All participants were registered to identify residents from the trial area who did not attend the meeting. The community meeting provided an excellent platform to present the project to residents, answer any concerns and to provide the Country Fire Authority with an opportunity to market its survival strategies and provide assistance to the community in preparing survival plans.

Between the 13th and 30th November, 2000, Shire staff conducted personal visits to all individual Ferny Creek Fire Alert Trial residences not represented at the meeting and provided an information package with the same information relayed at the meeting. In the event that the resident was not at home an information package was left at the address with a covering letter to contact the Shire and confirm receipt of the information.

Evaluation

A research officer appointed by the Office of the Emergency Services Commissioner, Department of Justice conducted an objective evaluation of the trial. The evaluation has included personal interviews of all Committee members regarding the process involved in the project, a follow up questionnaire to establish level of change of residents' awareness and survival planning and establish effectiveness/need for alert, and an examination of the incidence of alert activation. The evaluation had three main aims:

- "To measure the impact of the 'communication strategy' on the Ferny Creek residents' awareness and behaviour for bushfire survival and preparedness;
- To explore and evaluate the process of the fire alert trial working group's activities and communication, including community and stakeholder consultation about the fire alert system and subsequent operation of the siren;
- To evaluate the impact and consequence of the fire alert siren's development and operation for Ferny Creek Resident." (Betts R., Ferny Creek Fire Alert Siren Evaluation Report, Office of the Emergency Services Commissioner, Victoria August, 2001)

Evaluation of the Impact of the Communication Strategy

The evaluation found a high level of participation by residents at the public forum and in completing and returning questionnaires. Residents also found that the project newsletters and personal door knock beneficial. A mid-project questionnaire conducted by the researcher (involving 46 respondents) found that; "The most effective bushfire survival actions seemed to be undertaken by residents who were members of Community Fireguard; For those residents who had decided to not defend their home, (7 respondents) they may not be influenced by wither the community education material or the fire alert siren; Some concern needs to be expressed however that some residents (6 respondents) viewed the siren as a prompt to evacuate their home either as a result of 'Leave Early' message (the choice not to defend their home) or because evacuation was identified as their response to bushfire survival." (Betts R., Ferny Creek Fire Alert Siren Evaluation Report, Office of the Emergency Services Commissioner, Victoria August, 2001)

Upon the conclusion of the 2000/2001 fire season the researcher conducted another survey to which 54 responses were received. In relation to their knowledge of the siren and opportunity to comment over 70% of respondents stated they had a thorough knowledge of the siren operation and sufficient opportunity to comment. Of interest is that eight respondents were not interested in commenting, eight required further information and two had no knowledge or were aware of opportunity to comment. When questioned as to the mediums through which residents received knowledge of the system operation the responses ranged between 77% being advised through the project newsletter, 39% from friends and neighbours, 31% from local newspapers.

Half of the respondents responded that they had no dislikes of the siren system, whilst others commented on concerns regarding the number of false alarms, ownership of the system, the sound and volume of the sirens, unclear as to what action the should take after the siren activated and that the siren had no provision to advise if a threat was overcome.

A question linking the value of the siren to the concept of safety found that 55% of respondents found that the siren had positively contributed to their feelings of safety. An examination of a response to the value of the siren to the community found that "The comparisons between self and other seemed to be important variables in understanding community residents' perceptions about safety. Examining these views from residents revealed that 20 of the 54 respondents (38%) believed the siren would be of high value to the community but they found the siren to be of little influence to their own bushfire survival actions."

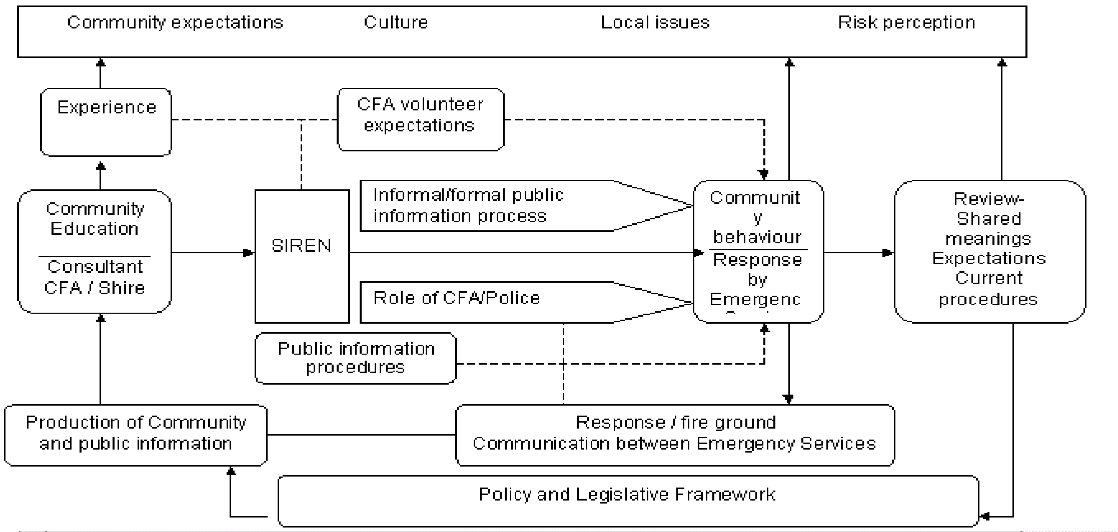
One of the most concerning findings of the evaluation related to responses pertaining to the intended actions of residents upon hearing the siren. A number of respondents (16%) advised that they would evacuate upon hearing the siren, 11% stated they had no specific actions/plans and another 13% indicated they were unsure about what actions they would take. In determining whether the alert system and community education had influenced individual bushfire survival plans, almost 60% of respondents reported that both the system and education were of equal influence, 20% indicated that both the siren and education was of little or no influence to their plans, 11% reported that education was more influential than the siren and 9.5% found that the siren was more influential than the community education. (Betts R., Ferny Creek Fire Alert Siren Evaluation Report, Office of the Emergency Services Commissioner, Victoria August, 2001)

An Integrated Warning System

The evaluation discussed the Ferny Creek Fire Alert System as developing into an 'integrated warning system' whereby the focus of the project shifts from the technological aspects to the social behaviour of residents within the Trial area. Mileti described such a system as possessing three functions, threat evaluation, dissemination of warning and response to warning, each of which involves a distinct group of people respectively. (D. Mileti, Natural Hazard Warning Systems in the United States: a Research Assignment, University of Colorado, USA, 1975). The broader concept of the system includes the provision of an educative process that aims to influence appropriate behaviour by residents following activation of the system.

Such a system would also involve a collaborative and cooperative approach between official (government agencies) and unofficial systems (community groups) such as defined by Parker and Handmer (Parker, D. and Handmer J., The Role of Unofficial Flood Warning Systems Journal of Contingencies and Crises Management, Vol 6, No.1, USA., 1998).

Figure 1: An integrated warning system



In order to encourage appropriate behaviour the committee first has to identify factors leading to a deficiency in the information process. Such factors have been called weak links and each step in the alert activation and communication processes are currently being dissected to identify weak links and ascertain how this information dissemination can be modified and improved with a view to achieving appropriate behaviour when the siren is activated. Further surveys of residents can focus on information deficiencies and monitor the progress in the effectiveness of this process. Importantly there needs to be an acknowledgment by all involved that the integrated warning system as a process demands a collaborative and supportive approach to ensure the delivery of clear, consistent and reinforced messages to residents. Any ambiguity of intended educative messages has the potential to decrease the receiver's trust and undermines the effectiveness of the objective, i.e. to encourage appropriate behaviour.

Throughout this process is the need to acknowledge that the individual's perspectives, feelings, personal knowledge of risk and relationships with the home, community and environment all impact on their behaviour (Sime J.D. Informaive Flood Warnings: Occupant Response to Risk, Threat and loss of Place) in Handmer, J (ed.) Flood Warnings: Issues and Practice in Total System Design, Middlesex University U.K. 1997). Regardless of all the best intentions it is arguably undeniable that some individuals will continue to behave inappropriately in a disaster situation regardless of all efforts to educate them otherwise.

Evaluation of the Working Group

The evaluation of the trial working group processes found that there was a strong acknowledgment of the leadership role provided by the Mayor, who provided opportunity for open debate and maintained the public profile of the project. The CFA and Police both expressed views that the final selection of the sirens as the system was preconceived in that it immediately met resident needs and comments made in the Coroners report and may have restricted the opportunity to other alternatives. The community representatives were very supportive of the role of local government in its leadership and active communication with the local community.

Alert System Activation and Issues

Throughout the project concerns were also raised that the sirens would be activated by calls occurring in conditions when the threat of wild fire was negligible such as during the night when temperatures and humidity are not conducive to wildfire conditions or on a rainy day. Such activations could then lead to a 'cry wolf' or false alarm syndrome which has been postulated as reducing the attention and response of the public. (E.L. Atwood and M.N. Major 'Exploring the "Cry Wolf" hypothesis, International Journal of Mass Emergencies and Disasters, USA.Vol 16,N3, 1998.) The evaluation identified the need to ensure residents were advised of the reason for an activation of the sirens to ensure that confidence in the integrity of the system was maintained.

Legal advice received during the project advised that the possibility of a failure of the system to activate due to causes beyond control also needed to be conveyed to the community to ensure residents were not solely dependent on the operation of the sirens to activate their plan. If residents were not informed that the system was not infallible then there was a possibility that they could find the Shire and committee liable. Information detailing the operation of the siren and emphasising that it was not foolproof was communicated to the trial community via the Project newsletter and at a public meeting conducted prior to the 2001/2002 fire season.

Whilst Victoria experienced an unusually hot and dry summer during 2000/01 fire season no actual bushfires occurred in the vicinity of the Ferny Creek Trial Area to test the system and residents' reactions, although there were five instances in which the system was activated. All of theses activations occurred prior to the software programming being installed limiting the system to the extreme Fire Danger Index factor. Three of these incidents occurred between 11.20 pm and 8.05 am in relation to calls of a grass and scrub fire, a smoke sighting and a fence fire. Two incidents between 3 pm and 5.40 pm relating to calls of a car fire and a grass and scrub fire. Both incidents also occurred under conditions not conducive to wildfire. Some residents were observed to respond to the activations by going out to the front of their properties and checking their surroundings and then seeking further information to establish the nature of the incident.

Conclusion

Fortunately the 2000/2001 fire season was uneventful regarding the incidence of bushfires. Whilst the alert system was activated (in accordance with the activation criteria) on a number of occasions there was no threat to the Trial community. Such activations have however introduced debate on the need for a 'stand down' signal. Given the relatively quiet fire season the committee decided to extend the trial period for a further two fire seasons and conduct further surveys and evaluation at the completion of each fire season. As the committee shifts its focus from the technological aspects of the alert system to the behavioural 'integrated warning process' the opportunity for progressive surveys should provide considerable information in assessing the effectiveness of the information disseminated and its impact on the trial community.

In closing it would appear appropriate to quote the final paragraph of the Office of the Emergency Services Commissioner evaluation report, which provides a very positive assessment of the project: "Community based warning and alert systems have not been previously developed and evaluated for bushfire survival and although the research literature has identified the needs for broad thinking across multi agencies and community consultation, this project has enabled an initial analysis of a community engagement process. These discoveries and achievements have enabled this Project to be at the cutting edge of warning/alert system and community engagement development and research. This project has set in place some positive practices of community engagement and multi-agency cooperation and has also exposed the complexities which are involved in the development of a community based alert system for bushfire survival."

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Author Biography

Norm Free is a Senior Executive Officer appointed to manage the Shire of Yarra Ranges' Emergency and Safety Planning Unit and has represented local government on emergency management at State National and International Forums. He previously served for over twenty years as an officer with the Victoria Police Force and was awarded the Australian National Medal and Victoria Police Service Medal & 1st Clasp He has completed a Graduate Certificate in Disaster Management Swinburne University and was elected as a Director on The International Emergency Management Society in 2001.

SECTION 15:

INCIDENT MANAGEMENT

The International Emergency Management Society
9th Annual Conference Proceedings
University of Waterloo, Canada, May 14-17, 2002

RAM**SAFE** AT THE OLYMPICS

A Stand Alone Responder Assets Management System Software Tool Designed to Dramatically Improve Crisis Response is Put Through its Paces at the 2002 Winter Olympics

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Keywords: preparedness planning, decision support, crisis management, emergency management/response, pre-incident planning

Abstract:

Situation awareness is a key factor in effective response to crises. Yet today, first responders typically arrive at the incident scene with little idea of what they will face. In cases where pre-incident plans exist, they are invariably labor-intensive paper products that are out-of-date and difficult to assimilate, therefore providing little help to an incident commander in the heat of a crisis. RAMSAFE features leading edge integrated fire and tactical pre-incident planning tools and state-of-the-art virtual tour visualization iPIX technology, and has recently been employed during the Winter Olympics at Salt Lake City, Utah. It travels on a laptop with the incident commander, can be accessed en route to the scene, and provides detailed visual information that helps the commander to better understand and manage a crisis situation. With this tool, the incident commander can view accident facility floor plans and access 360^o x 360^o iPIX pictures of key strategic locations such as entrances and exits, hazardous material storage sites, and alarm panels, simply by clicking on icons located on the floor plans.

RAMSAFE provides integrated planning, training, logistics, and operations support for police, fire, medical, and other emergency responders. It can be used at all levels of operations including city or EOC, police or fire headquarters, field command or precinct, and incident command, where it literally can be a laptop computer command post on the hood of a vehicle. RAMSAFE can be tailored to accommodate the needs of small towns and county jurisdictions as well as large metropolitan areas or states. It is designed to look and operate like a web browser and features a specially designed GIS engine that updates lightning fast. In a crisis situation, RAMSAFE scales up to manage the emergency response, including automated templates for managing disasters, compilation of data required for expenditures, equipment tracking, and time accounting reports for FEMA reimbursement. Its automated disaster management tool, called Response Options Generator (ROG), can be configured for any type of potential mass casualty, area-wide disaster. For the bioterrorism threat, use of ROG has the potential to reduce death and economic loss by approximately 50%, according to specialists at the June 2001 *Medical Disaster Conference* held at Dartmouth College [1]. RAMSAFE can also be used effectively to plan, execute and evaluate tabletop exercises. The program is inexpensive, easily mastered, and a substantial time saver.

This paper describes the design logic, functional capabilities, and future plans for RAMSAFE. Selected capabilities of RAMSAFE and its use as part of the 2002 Winter Olympic Games in Salt Lake City, Utah, will be demonstrated as part of the presentation.

Homeland Defense: Defending the Olympic Stage

Following the World Trade Center (WTC) tragedy of September 11, 2001 (911), extensive efforts were directed towards ensuring the safety and protection of the Salt Lake City Olympic Games, scheduled only a few short months away. Clearly, the Olympics were going to be a grand worldwide stage, and a follow-on terrorist incident on this stage, with the eyes of the world upon it, was unthinkable. Already well into the implementation stage, security planners for the Olympics were faced with the very real need to substantially upgrade their planning and resources. Scenarios considered unlikely prior to 911 now seemed very realistic, and priorities shifted from ensuring unobtrusive crowd control to absolute assurance that terrorist groups could not gain access and opportunity to attempt or carry out an attack. The magnitude of the task was monumental. Everything from the airport to the multiple Olympic venues, the Olympic Village, and Salt Lake City itself required a coordinated protection effort. Even with additional funding, complete sets of law enforcement and first responders for each of these potential targets were unobtainable. Instead, the available reaction force had to be able to respond to any of a number of these locations, rapidly assimilate any crisis situation, and be effective immediately to mitigate the consequences. What they needed was situation awareness.

Computer Enhanced Situation Awareness

Situation awareness is a key factor in effective response to crises. The current inability of the emergency responder community to share time-critical information and use this data to make informed decisions has been recognized by emergency response decision-makers. At the incident scene, arriving first responders need to be armed with up-to-date situational information in order to make the timely, informed decisions necessary to mitigate the potential crisis. In this respect, the fire ground is little different from the battleground, except that first responders are invariably "latecomers," arriving "cold" after the initiating event, potentially faced with a demand for immediate action. Yet today, first responders typically arrive at the incident scene with little idea of what they will face. In cases where pre-incident plans exist, they are invariably labor-intensive paper products that are out-of-date and difficult to assimilate, therefore providing little help to an incident commander in the heat of a crisis.

The Jefferson County, Colorado, Sheriff's Commission Report on the Columbine High School shooting provides relevant anecdotal insight into the value of current information to situational awareness. Numerous media reports chronicled the SWAT team's long delay in entering the high school. In the "SWAT Team Activities" chapter, the Sheriff's Commission reported that the SWAT team commander's knowledge of the school layout was based on the original floor plans, however a subsequent major remodeling had relocated the cafeteria and library to the opposite end of the school. Unsure of his knowledge of the school layout, the commander had several students sketch a floor plan for him, yet still sent the SWAT team into the wrong end of the school. As a result, the SWAT team had to clear nearly 75 classrooms as it worked its way through the length of the school to the library where the suspects were [2].

Whether on a military battlefield, responding to natural or man-made emergencies, or in law enforcement operations, critical elements of information have always been necessary in order to make sound, timely and informed decisions. Today, this problem is further exacerbated by the particularly short response times inherent in the resolution of terrorist acts. In the war on terrorism, decisions must be made ever faster, necessitating the need for information sources that can keep up with the pace, in order to ensure adequate homeland defense. In the midst of the information age, it would seem apparent that effective application of information technology (IT) could harness existing information, and provide decision-makers with the tools necessary to make speedy, informed decisions that would lessen the severity of potential terrorist crises, emergencies and disasters.

Such computerized information technology has been obtained by replicating capabilities used by the military, where computer based decision support tools have been employed to reduce data gathering, processing, and display time in order to provide the military commander as much reaction time as possible [3]. In fact, just as the military has found, computer based tools lend themselves well to the emergency response environment. It is at the very moment of arrival at the crisis scene, where immediate access to up-to-date, accurate information on the crisis environment and available resources is so vital, that a computer based support tool would be particularly beneficial. A computerized tool would filter stored pre-incident planning data and current crisis information to the minimum necessary to aid the commander in making a decision. It would then rapidly produce it and provide immediate access to it, as well as provide it in a way that ensured rapid assimilation in the heat of the crisis [4]. Yet at the same time, it must not impede the decision process. The tool would allow the incident commander to focus attention on assessing the extent of the emergency, alerting relevant authorities, and directing available resources to mitigate the consequences of the incident. Such a tool exists today in RAMSAFE.

Solving the Olympic Situation Awareness Need with RAMSAFE

The advent of foreign and domestic terrorist acts as retaliatory tools for US policy actions has necessitated a national program to prepare local medical, fire, and law enforcement first responders for the increased risk that may be encountered at an incident scene. The resulting Domestic Preparedness Program is an interagency cooperation designed to improve first responder training, equipment, and procedures across the country in order to mitigate the threat posed by the potential for terrorism on US soil. As part of this program, great strides are being made in computer based tools for first responders by combining the experience of the military and interagency counter-terrorism organizations, as well as input from state and local emergency response communities. Software decision support tools developed in support of this program promise wide applicability to all forms of natural and man-made disasters and crises.

One such program, SituationMaster, a decision support software product designed primarily to support the incident commander at the scene of a crisis, has recently been released by Public Safety Systems, LLC (PSS), a private company in Oak Ridge, Tennessee as part of their RAMSAFE emergency management system. RAMSAFE (previously called Responder Assets Management System (RAMS)), was jointly developed by the Department of Energy Oak Ridge Facilities and Public Safety Systems, LLC for the U.S. Department of Defense and Department of Justice. Developed in support of the nation's Domestic Preparedness Program, RAMSAFE provides integrated planning, training, logistics, and operations support for police, fire, medical, and other emergency responders. RAMSAFE can be used at all levels of operations: city or EOC level, police or fire headquarters level, field command or precinct level, and in a mobile version for incident command. It can be tailored to accommodate the needs of small towns and counties as well as large metropolitan areas and states.

The RAMSAFE SituationMaster program features advanced integrated fire and tactical pre-incident planning tools and state-of-the-art virtual tour visualization iPIX technology designed to eliminate many of the paper pre-planning problems caused by out of date and extraneous information. It travels on a laptop with the incident commander, can be accessed en route to the scene, and provides detailed visual information that helps the commander to better understand and manage a crisis situation. The tool stores current, accurate pre-incident planning information that is critical to the incident commander's situation awareness. It is designed to look and operate like a web browser and incorporates in its simplicity of design a hierarchical filter format and easily assimilated display that greatly reduces data overload caused by irrelevant information. The net result is a clear and comprehensive understanding of the situation, in other words- situation awareness.

SituationMaster incorporates iPIX image technology that significantly enhances site visualization. With this tool, the incident commander can access 360 by 360-degree iPIX pictures of key strategic locations such as entrances and exits, hazardous material storage sites, and alarm panels, simply by clicking on icons located on the floor plans. This imaging technology is coming into wide use in a number of fields where visualization in every direction is critical, such as computerized virtual tours of homes for sale and vacation rentals. Once the iPIX icons are accessed, the incident commander can steer the visual image in any direction, up or down the hallway, up on the ceiling or down on the floor, or side to side, as necessary to see the features he is interested in, just as if he was standing at the spot.

Let the Games Begin

In November, 2001, RAMSAFE was selected by the Utah Olympic Public Safety Command (UOPSC), the joint command in charge of overall security at the 2002 Salt Lake City Winter Olympics, to assist with security operations at every organizational level. Responding in mid-November, a small team of PSS and their national strategic partner, Electronic Data Systems (EDS), took nearly 4,000 iPIX images of key locations throughout the various Olympic indoor and outdoor venues, the Olympic village, Washington Square, and the Salt Lake City International Airport. Site plans, floor plans and over two hundred other documents, including hazards listings, response plans, operations plans, available equipment and resources, were obtained, and numerous aerial photographs of Salt Lake City and surrounding areas were taken.

180-degree video cameras for live feed were strategically placed at the downtown Salt Lake City Washington Square events site and linked into the Salt Lake City Police Department Command and Control room. In just 60 days, all of these documents and images were produced or obtained, loaded into the RAMSAFE program database, and fully integrated with the other participating emergency and security organizations.

More than 225 federal, state, and local law enforcement officials representing twenty different agencies were trained to use RAMSAFE SituationMaster, and laptop computers were provided to responder teams strategically situated to respond to an emergency or terrorist attack at any of the more than 20 venues and Olympic related sites.

Performance in the Field

Although public safety personnel responded to a small number of incidents, including bomb scares, arrests for rowdiness, and a man arrested for trying to scale the fence that surrounded the living quarters of the athletes, a significant terrorist event or other major crisis did not occur at the winter Olympics. However, the Olympic stage proved an outstanding test bed for RAMSAFE, and reinforced the value of computer software that combined aerial photos, facility floor plans, 360-degree images, security documents, emergency strategies, and real time 180-degree surveillance video into one single comprehensive database providing situational awareness to all levels of security, from the potential incident commanders in the field to the UOPSC command center, in ways that had not previously been fully comprehended. RAMSAFE demonstrated its worth at every phase of an incident, crisis or emergency.

<u>Planning Phase</u>

The value of advanced computer software technology was never more evident than in the planning stage of the Olympics. In a 60 day period, the entire RAMSAFE data base was developed and the system integrated into security operations, demonstrating the superb deployable capability of a software system that combines all forms of information rapidly and then can provide it in user friendly formats on demand.

RAMSAFE was a key tool in pre-incident planning and training for the Games. Using the virtual tour capability provided by the iPIX 360-degree images imbedded in the program, planners could take virtual tours of the venues, plan their strategy for rescue and assault, and then try other options and methods until they fully honed their operational plans. Once validated by these virtual exercises, the plans were then scanned directly into the program and set up as "hot" icons on the drawings, floor plans, and aerial views, right where they would be useful for managing an actual incident at that location. The operational plans were also indexed into the toggle menu tree alongside the floor plans and other documents applicable to that venue. Symbols representing command posts, protective positions, entry/exit routes, etc., could be dragged and dropped according to the scenarios, and then moved and tried from different locations to see if response improved (Figures 1 and 2). In this way, a myriad of potential combinations could be tried and evaluated until the best approach was determined.

Figure 1: Virtual exercise of a tactical plan at the Deer Valley Olympic Venue recorded directly off of RAMSAFE.

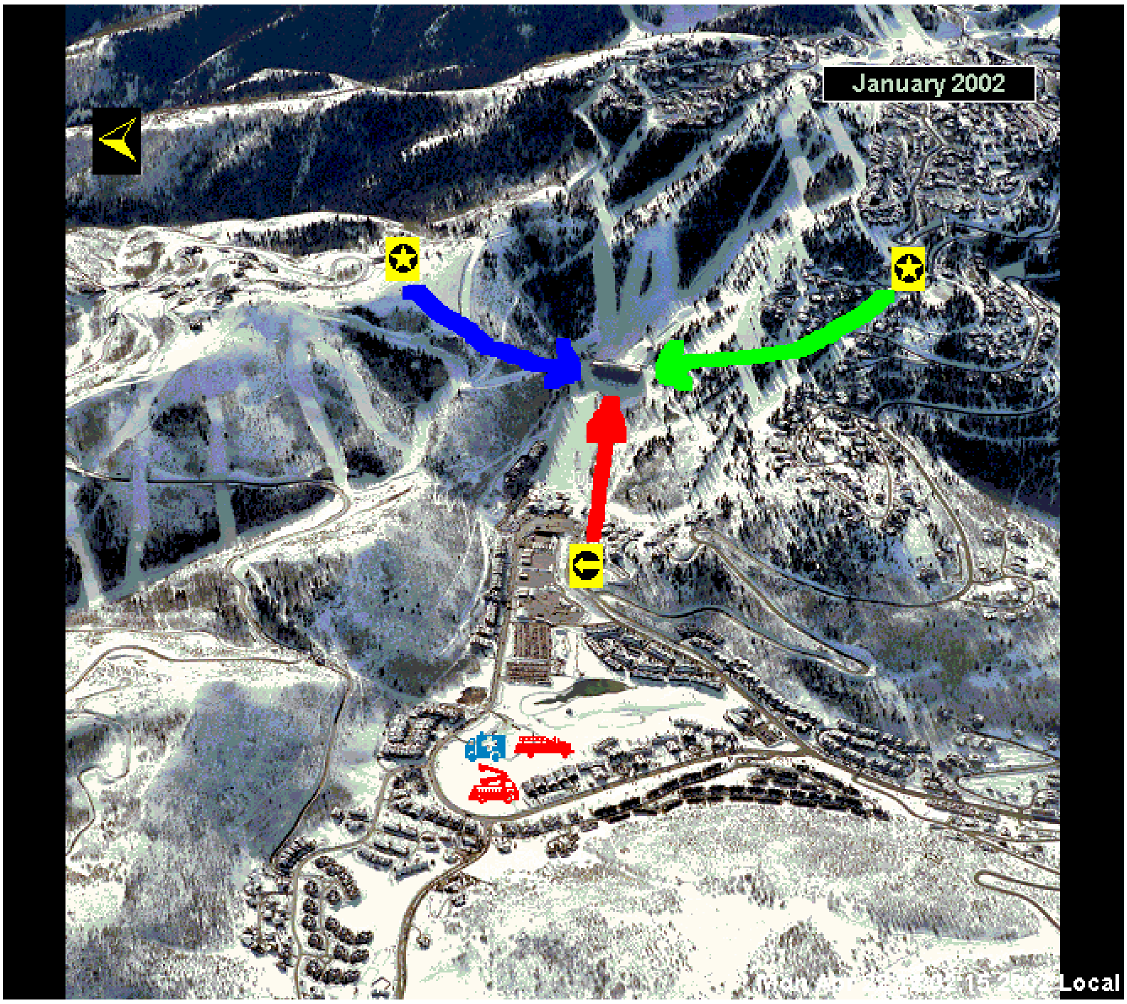
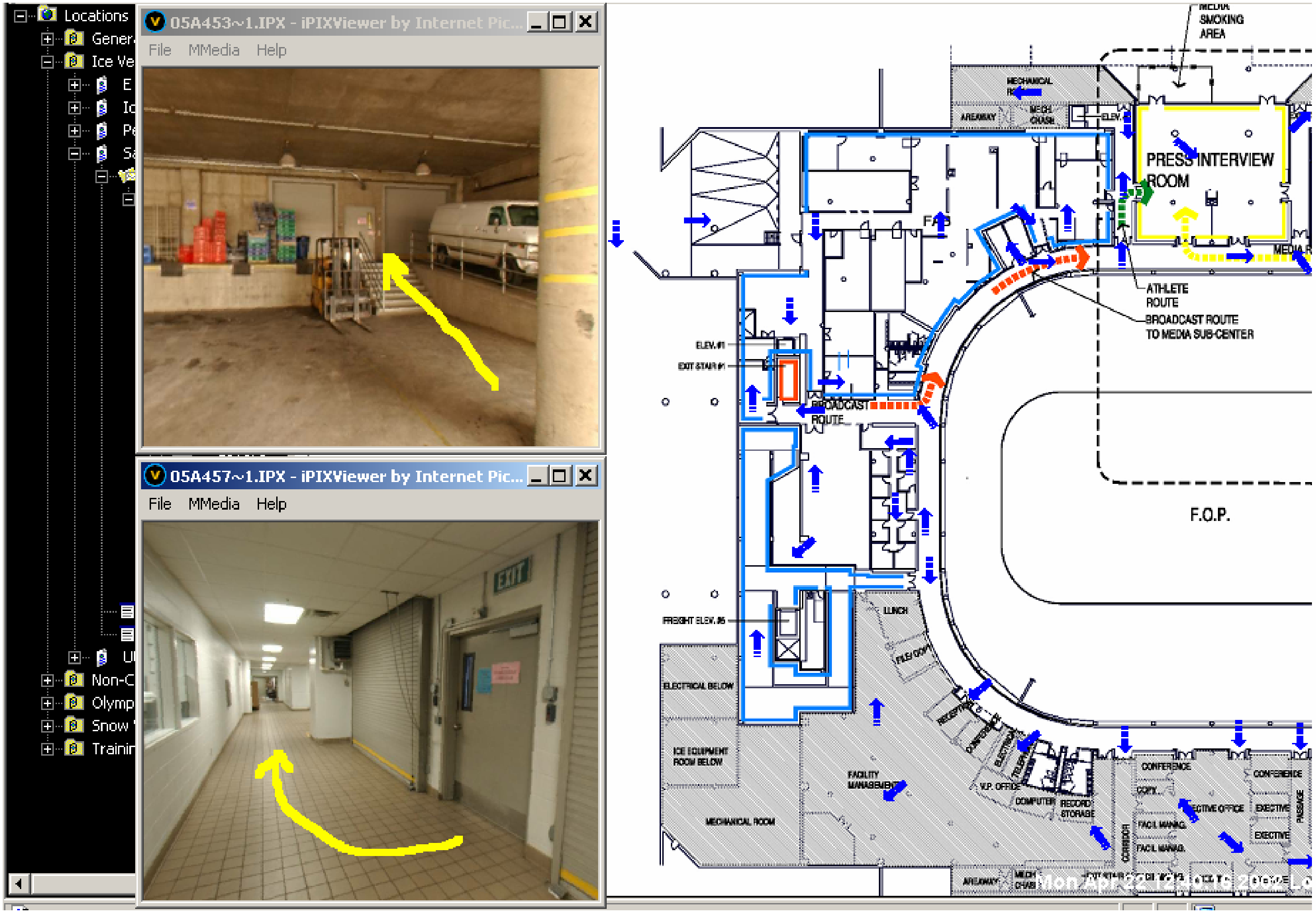


Figure 2: Use of RAMSAFE iPIX 360° x 360° images with floor plan for tactical entry planning.



Operations Phase

With the advent of the Games, it was possible to integrate all phases of operations, from traffic control to management of the several minor incidents that occurred, yet the program always remained ready to scale up to support first responders and senior emergency decision-makers in the event of an actual crisis or terrorist act. The imbedded pre-incident planning information provided first responders and senior emergency decision-makers with immediate situation awareness, including an understanding of the layout and the operations procedures, resources and other tools available for employment and mitigation of the event.

Anecdotal evidence of the value of the software came from numerous venues, staging areas, and command centers. During lulls in activity, pre-staged responders were found independently reviewing their venues and facilities on their laptops, conducting their own virtual tours and reviewing the pre-stored operations plans, improving their knowledge of the venues and the actions they were responsible for in the event of a serious incident.

Largely as a result of the bomb explosion in the Olympic Park during the Atlanta Olympics, comparable sites in Salt Lake City, such as Washington Square, were monitored by live video cameras as part of the pre-incident plan. 180-degree iPIX lenses and camera systems installed in discrete locations enabled a number of users from different computers (including one on the desk of the chief of police) to simultaneously view live incidents from several different angles of their own choosing. These recordings were later extremely valuable for training activities, lessons learned, and for use as evidence in claims litigation.

RAMSAFE was repeatedly used to conduct briefings for dignitaries and VIPS. The visual capabilities of the software and ease of use made it a particularly effective ad hoc briefing tool, effectively used to demonstrate Olympic preparations to senior federal and state decision-makers (see figure 3).

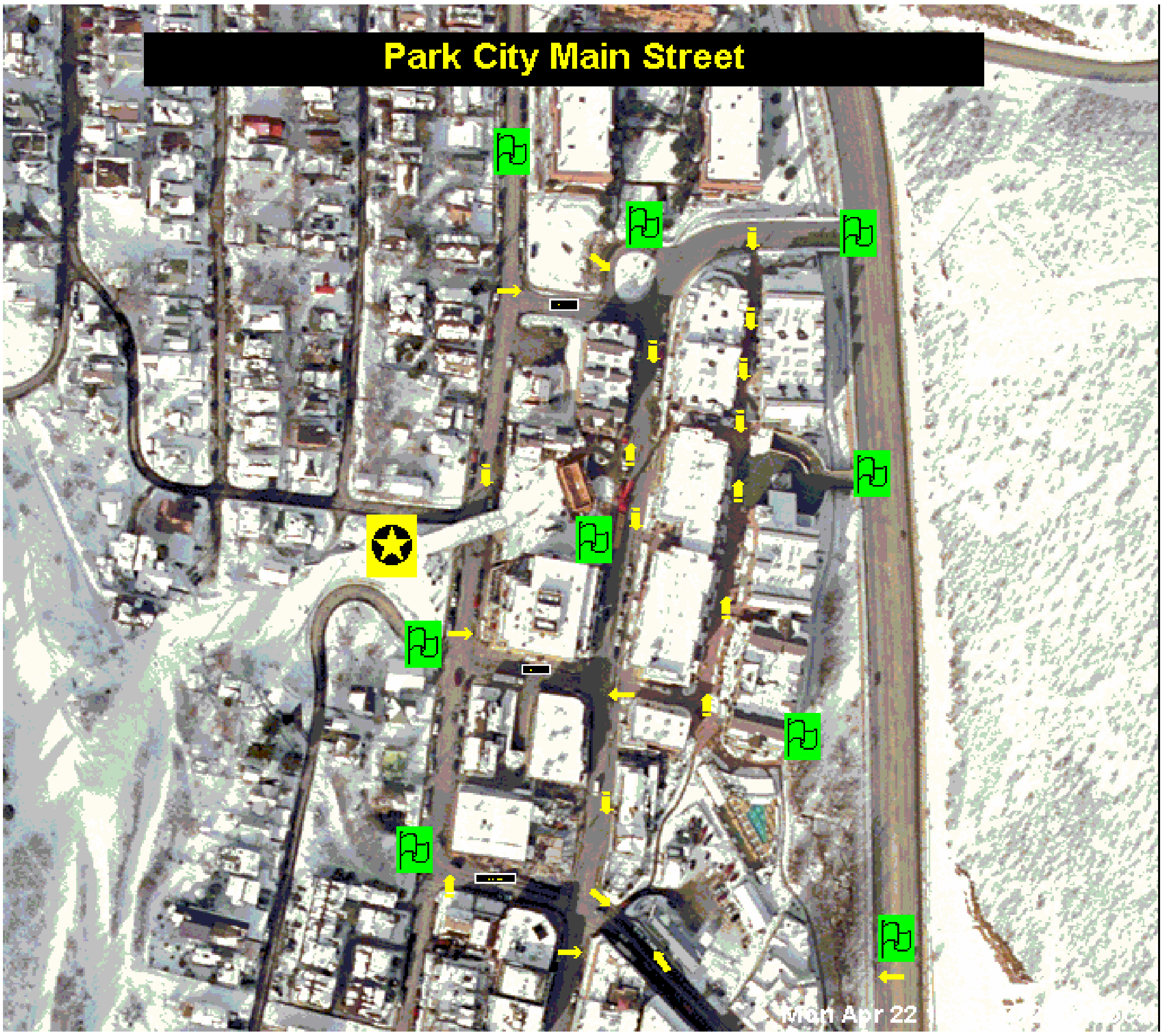
Consequence Management Phase

In the consequence management phase, RAMSAFE is highly effective for many different types of after action reporting. Information recorded in RAMSAFE during an operation, crisis or incident is automatically time and date stamped, and readily retrieved and formatted within the program for providing lessons learned, training documents, or presentation in FEMA reimbursement reports. Social services as well as non-profit and government agency post disaster capabilities can be loaded in the program and accessed during consequence mitigation to minimize complications caused by an emergency and shorten recovery time. The recovery manager will know where to go for specific resources, can file for reimbursement for resource usage, and keep accurate records of recovery decisions and operations.

Conclusion: Emerging Decision Support Software Programs Show Great Promise

911 educated the public to a new reality - that the vertical battlefield had reached U.S. soil, and now included American cities and homes previously considered secure. A chronological review of the last decade is punctuated with an increasing trend of domestic terrorist acts, in both frequency and human cost. Paper-intensive plans necessitated by traditionally low government funding structures can no longer be considered a satisfactory trade off for this higher anticipation of casualties.

Figure 3: RAMSAFE was used to brief senior federal officials on Olympic security preparations for Park City, Utah.



A paradigm shift towards computer software emergency management decision support tools has been mandated in order to respond to the very real reaction times required to protect homeland targets from terrorist extremists. Fortunately, homeland defense funding initiatives coupled with the relatively low costs of emerging powerful software programs like RAMSAFE have been demonstrated to meet the challenge. Even as computer information and connectivity result in force multipliers for the military, a revolution in the tool set required for emergency managers and law enforcement crisis decision-makers is necessary at home in order to substantially reduce the morbidity/mortality rates portended by 911. Decision support software tools like RAMSAFE can be that crisis and emergency response force multiplier today, substantially improving pre-planning and training before the event, enhancing situational awareness and resource management during a response, and organizing post-action information to rapidly provide valuable lessons learned.

The critical mass is present today to take this step. The funding is becoming available through the various homeland security initiatives, and the software programs themselves are demonstrating their viability in challenging situations such as the Salt Lake City Winter Olympics. The costs of the software and hardware to implement this technology is falling, and economies of scale can bring these costs in line with federal, state, and local budgets. Properly implemented and effectively executed, emerging decision support software for crisis and emergency planning and response can be one of the most cost effective, value added improvements federal, state, and local decision-makers can make to enhance our homeland defense.

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Dr. Susan M. Smith is an Assistant Professor at The University of Tennessee Department of Health and Safety Sciences in Knoxville, Tennessee. Prior to accepting her current position Dr. Smith completed a successful 20 year career working with rural communities on the complex issues of disaster mitigation, environmental protection, community safety and community development. She teaches graduate level courses in emergency management, accident prevention and environmental health. Dr. Smith's research areas include: emergency evacuation and warning systems affecting special populations such as the hearing impaired or mobility limited; and the evaluation of rural strategies to achieve disaster mitigation.

SECTION 16:

CRISIS MANAGEMENT

A TEN-POINT CHECKLIST FOR EMERGENCY PLANNING

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Keywords: Emergency Planning; Emergency Management; Evacuation Planning; Hazard Identification; Hazard Mitigation; Crisis Planning

Abstract

The World Trade Center disaster on September 11, 2001 (911) underscores the critical importance of evacuation plans for rapid escape from our nation's buildings. Since 911, a growing number of small businesses and non-profit organizations have recognized shortcomings in their emergency preparedness, and put in motion urgent reviews of their existing emergency, evacuation, and security procedures. However, most of these small businesses do not possess the emergency preparation expertise in-house, nor do they have the funds necessary to obtain outside consultant expertise. Recently, Dr. Susan M. Smith and health and safety graduate students at The University of Tennessee, Knoxville, under Dr. Smith's direction developed a ten-point checklist that addresses the emergency preparation needs of small businesses and nonprofit organizations. This checklist is presented in this paper, and was recently posted for download on the National Safety Council Web site (http://www.nationalsafetycouncil.org/issues/prepare.htm). This checklist guides the novice through the important phases of risk assessment and emergency planning, leading to a comprehensive written plan. Questions on evaluation of current preparedness are designed to identify gaps in communications, alarm systems, restricted passageways, as well as potential adjacent hazards, such as industrial parks, fuel storage tanks, and public transportation thoroughfares. Potential low cost solutions involving training, use of existing relationships with local fire and safety departments and building insurance underwriters, and effective use of existing staff are also explored. By implementing this checklist, small businesses and non-profits will have made significant progress towards preparedness without the resource expenditure of big business.

Introduction

The World Trade Center (WTC) disaster on September 11, 2001 (911) underscores the critical importance of emergency planning in reducing the potential number of casualties when disaster strikes, whether natural or man made. Following the World Trade Center bombing in 1993, the Port Authority of New York and New Jersey conducted an extensive review and upgraded their emergency evacuation procedures [6]. During the 1993 WTC evacuation, workers crammed into pitch-black exit stairways, bumping into walls and each other in the smoke and darkness [1]. As a result of these lessons learned, a series of improvements were added after the bombing. For example, batteries were added to every other light fixture in the stairwells in case of power outage, and handrails and a stripe down the center of the stairs were painted with yellow glow-in-the-dark paint [1]. In addition, a public address system was added so fire command stations could address evacuees. As a result, it can be argued that thousands of additional deaths were probably avoided on 911.

The events of 911 resulted in managers and employees everywhere evaluating the possibility of their business being targeted by terrorists for the first time. Obvious targets like the Sears skyscraper in Chicago and the Prudential building in Boston, as well as other building landmarks in New York, took extraordinary steps to upgrade their security posture and emergency preparedness [2]. However, large businesses such as these have existing security and emergency management expertise, or possess the funds to contract consultants if necessary. As was the case at the WTC, smaller buildings and businesses in the vicinity of these obvious potential targets also were at risk by virtue of their proximity. In addition, many smaller businesses and non-profits might be potential terrorist targets by virtue of what products or services they provide, or their worldwide recognition.

Since 911, a growing number of small businesses and non-profit organizations have recognized shortcomings in their emergency preparedness, and put in motion urgent reviews of their existing emergency, evacuation, and security procedures. However, most of these small businesses do not possess the emergency preparation expertise in-house, nor do they have the funds necessary to obtain outside consultant expertise [3].

Preparing to Plan

Recently, Dr. Susan M. Smith and health and safety graduate students at The University of Tennessee, Knoxville, under Dr. Smith's direction developed a *Ten-Point Checklist for Emergency Preparedness* that addresses the emergency preparation needs of small businesses and nonprofit organizations [4]. The *Checklist* is designed for use by novice planners, and helps them evaluate needs through a series of clear, basic questions divided into ten emergency preparedness areas. Properly executed, it provides the hazard assessment information necessary to formulate or update a comprehensive emergency plan.

In assessing potential hazards, the planners must first determine two things: (1) what types of emergencies might the business be susceptible to, and (2) how likely (relative risk) is the emergency to occur. In most cases, the primary hazard is fire, and the accompanying fire hazards of smoke, toxic gases, and superheated air rising to upper floors. Even if a fire is contained, confusion and panic inside smoky stairwells or blocked exit routes can have dire consequences. Many other potential emergencies might require full-scale evacuations, such as bomb threats, radiation or bacterial assault, or the aftermath of earthquakes. In other instances, such as chemical spills, tornado warnings, or severe storms, the best action may be to seek shelter, and then relocate to safer areas when conditions permit [5].

When assessing potential hazards, planners must not forget to consider hazards present in adjacent structures, businesses, and transportation routes. Industrial parks may support businesses engaged in a host of activities that might be risk factors for their neighbors. Fuel storage tanks, small airports, river barges, and rail lines may all provide hazards that must be accounted for in emergency planning [5].

The *Ten-Point Checklist*

Effective response to emergencies begins with prompt and effective warning. Therefore, the first point of the plan is an evaluation of existing warning systems. This section steps the evaluator through visual and audible alarm identification and reviews the appropriate requirements for each type of alarm. For example, the *Checklist* asks the evaluator if audible alarms are present, operational, and detectable from work areas. The *Checklist* then steps the evaluator through types of activation (manual, or automatically by types of sensors), proper placing (height above floor, distance between, etc.), and whether there are different sounds for different types of emergencies and "all clear."

Alarm systems should include both evacuation and indoor relocation to shelter signals. Although most emergencies require evacuation, there are situations where evacuation may be the wrong thing to do. In cases of severe weather and tornadoes, hazardous chemical spills, or some security scenarios, for example, following directions to an inside sheltering location may be required. Therefore, visual and audible warning systems must allow occupants to distinguish between these conditions and follow the appropriate direction to either evacuate or shelter [4] [6].

The *Checklist* also asks if battery backup capability exists for warning systems in case of a loss of electrical power, if there is a maintenance plan in place that checks operability, and if the alarm also automatically notifies the fire station, security, or other controlling station. Audible alarms by themselves are not sufficient. Hearing impaired people, as well as those who work in noisy areas, must be accommodated by flashing visual alarms, and newer buildings are required to have visual alarms in a number of public areas, such as bathrooms, changing rooms, doctors' examination rooms, hallways, and public areas [4].

The second *Checklist* point addresses communication capability. Good, reliable two-way communication is a key element in ensuring effective emergency response. If responders cannot determine where to respond to, or what equipment to respond with, situation awareness suffers, and valuable time is lost. Likewise, a method for directing evacuees away from the conflagration can be indispensable. In 911, conflicting public address announcements confused many inside the WTC, and many started to return to their offices instead of continuing to evacuate [6]. This section asks if there are accessible phones on every floor, and whether emergency numbers are posted on or near the phones. The availability of alternate means of communications, such as two-way radios, is also explored [6].

The longest series of questions forms Point 3, "Evacuation." This is the primary response for most emergencies, and a well thought out and exercised evacuation plan is the best protection for building inhabitants. Under current residential design standards, the goal is to evacuate a building in less than five minutes. However, the WTC towers were designed in the 1960's, and had only two main stairwells each. When firefighters started entering the building, evacuees were forced to go down single file in order to let the firefighters pass by on their way up. The stairwells quickly became overcrowded, and evacuees took 35-40 minutes to escape from the 32nd floor [6] [7].

Narrow stairwells also make evacuation of people with disabilities difficult. Assisting mobility-limited persons down narrow staircases may become problematic, since most lifting devices require room for three persons abreast. Fortunately, modern building codes mandate wider and more plentiful staircases. However, if the evaluated building has narrow, undersized, or insufficient numbers of stairwells, planning must be carefully undertaken in order to ensure orderly quick evacuations, or remodeling may be in order. The best way to gauge the adequacy of existing exit routes and stairwells is by measuring occupant evacuation times during evacuation exercises and assessing where the bottlenecks are and what can be done to remove them [5].

Evacuation times can normally be significantly reduced by training building occupants to recognize building alarms and evacuate promptly, coupled with well thought out evacuation plans that have been exercised repeatedly to identify and eradicate bottlenecks. Point 3 provides a number of questions that will lead to low cost improvements that will markedly improve evacuation time. First of all, are evacuation routes properly posted and correct, or have they become outdated due to building remodeling? Exit signs should be positioned appropriately, so they are visible to the evacuees, and point in the correct direction of the exit. Some may be positioned to point to blind alleys and padlocked doors, or back towards the flow of traffic, such that a bottleneck might occur in an actual evacuation. Are the exit signs illuminated and exit paths supported with emergency lighting that does not rely on normal electrical power? Every room should have at least two exits, and exit doors should open from the direction of exit so that evacuees to not have to stop and open a door towards themselves, causing a potential bottleneck. The operation and physical condition of self-closing fire doors should be checked to ensure they properly perform their safety function. Additionally, guardrails and handrails should be checked for sturdiness and freedom from rough edges.

Finally, evaluation of the evacuation plan does not stop with the building exits. Many of the casualties from 911 died in the streets and areas surrounding the WTC when the buildings collapsed. The *Checklist* asks the evaluators to determine if there is a designated assembly point outside the building a safe distance away from the building, as well as determine if the access roads and walkways to the building are free of obstructions, and accessible to law enforcement, fire department, and emergency medical services (EMS) vehicles and personnel [3][4].

Utilities is the fourth emergency guide point. Utilities such as natural gas, electrical power, or steam can initiate or greatly complicate an emergency. Likewise, backup utility systems such as emergency lighting can be of great benefit. Point 4 evaluates the condition of utilities in the building from all of these perspectives. The *Checklist* evaluates whether gas and steam isolation valves and electrical isolation breakers are clearly marked and function properly. It prompts an evaluation of electrical cords, outlets, and portable equipment for possible degradation or overloading that may lead to a fire, and assesses the adequacy of emergency lighting.

Fire suppression capability is evaluated in Point 5. Portable fire extinguishers, alarm pull stations, and sprinkler systems are evaluated. Portable fire extinguishers should be of the correct type, in sufficient numbers, and appropriately located. Annual inspections should be up to date, and the extinguishers should be clearly visible and clear of obstacles. Fire alarm pull stations should be operable, visible, and free from obstruction as well. Fire suppression sprinkler systems should be in good condition and the sprinkler heads should be free from obstructions.

Point 6 evaluates contingency planning for severe storms and tornados. In this section, sheltering in place or in an alternative facility is evaluated. Items of importance include having a plan for sheltering in place of sufficient size to accommodate the number of individuals it is designated for, and the adequacy of the protection the facility will provide. The *Checklist* determines if there are emergency power sources available to the facility that will function if normal electrical power fails, and ensures adequate food, water, first aid equipment, and blankets are available [5].

Although Point 7 is labeled "Management Issues," its primary focus is to evaluate the safety and emergency training, planning and motivation of the building occupants. If employees are programmed to assume building alarms are system malfunctions and fail to evacuate in a timely manner, response in an actual emergency will be slowed, and additional casualties may result. Management leadership by example is a vital ingredient in establishing the right safety and emergency preparedness culture in any organization. Senior leadership interest in the emergency preparedness and evacuation plans will enhance the quality of the plans. Actions supporting emergency management and safety initiatives should be assigned to well-respected, credible employees and managers, and cross all levels of the organization. All should be participators in drills and training. The more training and understanding managers have, the more they become an extension of the safety function, and the better they can supervise evacuations and safety actions. In fact, incorporating safety and emergency roles and duties in job descriptions and work rules are further methods of engendering a safety and emergency preparedness culture in the business [5].

Drills should be well planned and instructive. They should be designed to detect flaws in emergency planning, and to exercise alarms and communications systems, assess managers' performance, and to refine and improve the plan. Drills should be realistic, and few simulations should be used. Managers should look upon drills as opportunities to set an example, and should not excuse themselves from participating. The frequency of drills will normally vary according to the type of business and needs of the occupants. Scheduling drills a minimum of every six months is a good goal, but the date and time should not be predictable. Perhaps the best form of training is to critique the drills immediately after they are completed, and provide constructive feedback immediately to all participants. Evaluation sheets, which prompt evaluators to observe and evaluate the key elements the drill is designed to exercise, and comparative statistics should be used to ensure concrete improvement is being made [5].

Point 8 has the mundane title of "Housekeeping." However, this title belies its significance. Poor housekeeping can cause, complicate, or extend emergencies. Allowing materials to be stored in stairwells, or furniture to infringe upon exit routes, will result in restricting egress routes, and could cause bottlenecks or a general slowdown in exiting the building. The storage of hazardous materials such as cleaning solutions or flammable liquids is addressed. The amount and location of combustible materials is also evaluated. Often combustibles such as trash or discarded paper build up at the bottom of stairwells, resulting in a fire hazard with direct chimney effect right where evacuees expect to be able to find safe exit. Since smoking prohibitions have been instituted in many buildings, the propensity for smokers to congregate and smoke at stairwell exits has been observed. Such activity can result in a significant fire potential in the stairwells, often where smoke and fire detectors are not placed [3][4][6].

The last two points are a direct result of the times in which we live. Point 9 is "Bomb Threats." Although bomb threats have been with us for some time, they have taken on much more urgency since our sense of security has been so deeply shaken by 911. The *Checklist* evaluates the adequacy of bomb threat procedures, including ensuring call-in checklists are located by each phone, and where appropriate, telephones are equipped with recording devices. In some instances, threat assessments should be conducted, employees should be trained in letter/parcel bomb recognition, and trained bomb search teams established [4].

The last point in the *Checklist* is "Security Issues." Until recently hardly a thought had been given to security in many businesses. That situation changed dramatically after 911, and today, security concerns have clearly come to the forefront. This section looks for employee photo ID's, and client/guest sign-in logs. Mailroom procedures may require evaluation, and processes for handling security after hours should be in place. Plans should exist for securing office space and equipment, and receptionists should be trained in security and response to all types of crises.

The Comprehensive Emergency Plan

Once the *Checklist* has been completed, the next step is to fold the information into a comprehensive plan. All of the identified potential emergency events must be prioritized so that the most hazardous and most likely scenarios are given due emphasis. The plan should be tailored to take building design and construction materials, height and floor layout, occupancy rates, usage, activities, etc. into account. Local building codes and variances must be reviewed and complied with. However, some degree of liability will still exist even if minimum code standards are met [5].

The best plans are simple, easily implemented and effective. Complicated emergency procedures are difficult to execute, and will fail in the middle of an emergency. The high level of turnover in many industries should be recognized, and techniques to enhance recall in the middle of a crisis should be considered, such as emergency action postings, strategically placed abbreviated copies of emergency procedures, and trained cadres of emergency teams or leaders to provide direction and ensure correct actions are taken in the case of an emergency [3][6][7].

The *Ten-Point Checklist* will likely identify a number of discrepancies that should be corrected or potential good practices that should be implemented. Normally, discrepancies that can be corrected without substantial cost can be corrected on the spot or shortly thereafter. In some cases, funding to correct design flaws or provide important emergency equipment may be required. In either case, discrepancies that can't be corrected on the spot should be listed on a discrepancy list and tracked to completion.

Once written, the new emergency plan will soon become outdated and loose effectiveness unless the plan is reviewed and updated periodically. To prevent this from happening, management attention must be placed on the continuing validity of the plan. Responsibility for maintaining the plan and pursuing the corrective action list should be assigned to someone who has the time it takes and an interest in it. Usually, that is not the resident "old-timer" who does not have the time to devote to it, and assigning a junior manager to the role will likely be seen as a signal that the project is of low importance. Ultimately, the success of the plan rests with the organization as a whole's sense of commitment, from the owner to the supervisor, tenants and occupants. If the correct emergency preparedness culture is established, the plan should be an active, viable document that will result in minimizing casualties should an emergency occur [5].

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The International Emergency Management Society
9th Annual Conference Proceedings
University of Waterloo, Canada, May 14-17, 2002

COMPLEX SYSTEMS IN CRISIS:

Managing Response to Extreme Events

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Abstract

The events of September 11 demonstrated vividly that extreme events cross geographic, disciplinary, organizational, and jurisdictional boundaries. Mobilizing response operations across organizational and jurisdictional boundaries on a regional scale requires a collaborative effort among participating public, private and nonprofit organizations that is not yet defined by current administrative policy and procedures. I examine the 9/11 events using the analytical framework of a complex adaptive system, and propose that a well-designed information infrastructure can facilitate the flexibility and learning essential for adaptive response in extreme conditions.

Introduction

Etched indelibly in memory for most Americans is the searing image of United Airlines Flight #175 crashing into the South Tower of the World Trade Center in New York City at 9:03 a.m. on September 11, 2001. Eighteen minutes earlier, American Airlines Flight #11 had crashed into the North Tower, and the television cameras captured both towers engulfed in flames. The scene was replayed endlessly on CNN and television news stations around the world, so that virtually anyone with access to a television set has seen the powerful images, evoking horror in the minds of those who empathized with the victims. To some, the images undoubtedly elicited admiration for the boldness of the act or acknowledgment of the singular goals of the perpetrators, but to all, they represented an extreme event, one that could not be addressed by routine measures. When the towers collapsed, virtually the whole world knew of the extraordinary impact of the coordinated attacks upon U.S. civilian targets. The security of major U.S. cities had been breached, and public agencies, charged with legal responsibility to protect life, property and continuity of operations, mobilized in response.

For public agencies, the events of September 11 presented an extraordinary test of their capacity to function under the most severe conditions of disruption and destruction. Each of the public organizations and jurisdictions responsible for public security in New York, New Jersey and Virginia had emergency plans, but none had imagined an event that would turn civilian airliners into weapons of mass destruction. The challenge lies, first, in recognizing the danger and anticipating the scope of the damage. Extreme events demand resources and skills from a wider range of organizations than those in the immediately affected area. More difficult is the task of integrating multiple separate agencies and jurisdictions into a smoothly functioning inter-organizational, inter-jurisdictional response system under the urgent, chaotic conditions of full-scale disaster.

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The need for integration intensifies as the number of organizations engaged in response operations increases and the range of problems they confront widens. Since all organizations in the damaged area are affected, private and nonprofit actors become participants in the response system as well as public agencies. Some organizations may not have emergency plans, or may not have linked them to a larger community-wide response process. As the type and size of organizations involved in response operations varies, the disparity in skills, knowledge, access to information and equipment widens among the participants in the response process. Achieving coordinated action among a disparate group of actors depends fundamentally upon their access to timely, valid information and their capacity for information search, exchange, absorption and adaptation.

Reliable performance of information functions under stress is a critical factor in achieving coordination in action among a large and varied group of actors engaged in crisis response. This performance depends upon at least three basic sets of conditions that influence the interaction of agents involved in response to the event (Comfort 1999). The first set includes the technical structure needed to support information search and exchange. The second set of conditions involves the organizational policies and procedures that shape action both within, and among, the participating organizations. The third set involves cultural openness to new information, new strategies for addressing an unimaginable set of problems, and willingness to adapt to extraordinarily difficult conditions. These three sets of conditions shape in fundamental ways the evolution of an inter-organizational response system to the event. The interaction among the agents, further, shapes the next round of actions that each individual organization or agent takes. The result is the emergence of a complex, adaptive system that responds both to the demands from the environment and the degree of pressure or support given by other organizations as the response system evolves.

The 9/11 events were extraordinarily complex, with three different sites involved in the attacks and simultaneous demands made upon federal agencies from all three locations. At the same time, the evolving response system needed to integrate different state, regional, county and municipal agencies, as well as private and nonprofit organizations, into a coherent framework for action. The knowledge base to support response operations in such an event needs to be scalable. That is, it needs to provide specific information to support action by personnel operating at different sites within multiple jurisdictions and between multiple levels of jurisdiction simultaneously. Most public agencies have emergency plans, but they are not always current. Although some private companies and nonprofit organizations such as hospitals and schools have emergency plans, they often are not integrated with those of the public agencies to provide a comprehensive plan for a community, much less multiple communities in an affected region. Facilitating the evolution of response systems to extreme events in densely populated metropolitan areas is a major challenge in public policy and administration.

Mobilizing response operations across organizational and jurisdictional boundaries on a regional scale requires a collaborative effort among participating public, private and nonprofit organizations that is not yet defined by current administrative policy and procedures. In an earlier essay (Comfort 2002), I discussed the need to identify the potential points of breakdown, or fragility, in inter-organizational systems that evolve rapidly in response to extreme events. In this essay, I address the converse need to strengthen the capacity of the emerging response system in order to respond more effectively to threats on a regional scale. In doing so, I will undertake four tasks. First, I will briefly discuss the difference between linear and nonlinear models in public policy and administration, and the conceptual shift to nonlinear operations in the dynamic context of disaster. Second, I will examine briefly the theoretical background of response systems in extreme contexts as complex adaptive systems, identifying their characteristics and modes of adaptation in changing environments. Third, I will use incidents from the 9/11 events to illustrate different modes of adaptation among the multiple agents involved in response operations. Finally, I will conclude with recommendations for a preliminary model of auto-adaptation among public, private and nonprofit organizations on a regional scale to extreme events.

The dynamic context of disaster

The effective mobilization of response to extreme events on a large scale is one of the least understood problems in public management. This process requires the rapid search, exchange, and absorption of valid information regarding sudden, damaging events transmitted through a network of organizations that crosses disciplinary, organizational and jurisdictional boundaries. It requires pre-disaster planning among organizations to identify what information will be required and how this information may be accessed. It entails the rapid comprehension of danger that, under ordinary circumstances, is unimaginable. It requires the capacity to use that powerful insight to anticipate the spread of risk through an interdependent community and to devise actions that will interrupt or limit the risk. It means discovering the 'logic' that will govern the ensuing uncertainty in technical and organizational performance (Comfort 1989). This is an inference process that functions more through the rapid recognition of signals and symbols (Feldman and March 1988) and the use of mental models (Weick 1995), than on rule-based reasoning (Hayes-Roth, Waterman and Lenat 1983).

Extreme events pose a distinct problem for theorists in public policy and administration. In the past, practicing managers preferred to consider these events rare occurrences, calling them "acts of God" or calculating the chances of occurrence vs. costs of mitigation in terms of defining "acceptable risk" (Kartez and Kelly 1988). But when extreme events do occur and public agencies fail to respond promptly and efficiently, the political as well as social and economic consequences are severe (Gawronski and Olson 2000; Carley and Harrald 1997). Public agencies bear legal responsibility for the protection of lives, property and continuity of operations, and local agencies bear the brunt of first response. Consequently, disaster management remains the quintessential function of government, and public managers at all levels of government are rethinking their odds on the probability of disaster.

The extraordinary losses incurred on September 11 compel a review of the capacity of government agencies to mitigate and respond to extreme events. While much work has been done to assess planning and response activities at municipal and federal levels (Mileti 1999; Platt et al. 1999; Sylves and Waugh 1996), little attention has been given to structuring inter-organizational response to extreme events on regional levels. Nor has there been careful study of how response systems, once constituted, could contribute to the capacity of the region to mitigate recurring risk. The challenge to current administrative theory and practice is how to design and support governmental systems that are able to adapt readily to the urgent demands and complex operating conditions in extreme events.

The standard administrative approach toward solving complex problems has been to organize work involving multiple agents and tasks hierarchically (Simon 1981; Newell and Simon 1972). Hierarchy is used to establish control, specify tasks, allocate responsibilities and reporting procedures, and presumably gain reliability and efficiency in work flow. This approach works reasonably well in routine circumstances when there is time to plan actions, train personnel, identify problems and correct mistakes. Under the urgent, dynamic conditions of disaster, however, such procedures almost always fail. Carefully developed emergency plans may not fit the specific conditions of the disaster. Information required by disaster managers may be old or incomplete. Key personnel may be missing or unavailable for decisions. Under cumulative stress, hierarchical organizations tend to break down, and personnel are hindered by a lack of information, constraints on innovation, and an inability to shift resources and action to meet new demands quickly (Comfort 1999).

In extreme events, public organizations need the capacity to adapt quickly and effectively to rapidly changing conditions. Such capacity relies upon a continuous exchange of timely, valid information among multiple participants regarding their shared goal in dynamic operating conditions. The two types of operating environments – routine and extreme – illustrate the difference between linear and nonlinear systems in theory and the difference between organized hierarchy and complex adaptive systems in practice. Routine environments assume a complete knowledge base with all relevant information available, so that organized hierarchy can apply known information efficiently to known problems. In this context, linear systems function well. Extreme environments, in contrast, acknowledge that all relevant information is not known, and that previously known conditions may be in a state of flux. Relations between organizations and their operating conditions are nonlinear, and actions must be based upon incoming information integrated with known information to adapt effectively to the changing environment. This fundamental difference in operating conditions shifts the system's focus from control based upon known information to continuous search and exchange processes to develop valid information as a basis for action.

The distinctive advantage of human organizations is that the individuals within them are able to learn. This ability to learn from incoming information and observation creates the potential for developing self organizing agents or auto-adaptive systems in dynamic environments (Gell-Mann 1994; Holland 1995). It acknowledges the organizational and policy processes that contribute to change, learning, and innovation in dynamic environments (Peitgen, Saupe and Jurgens 1992; Argyris 1993; Comfort 1994), but it considers these processes on a different scale, that of system-wide response to a massive event.

While the collapse of organizational capacity to act under extreme conditions has been vividly documented in actual cases (Weick 1993; Carley and Harrald 1997; Comfort 1999), the opposite phenomenon, the design and development of communities capable of innovative and responsible performance under threat of extreme danger has not been studied systematically. There has been no rigorous effort to model the effects of the rapid spread of information regarding risk on the performance of communities under threat, or to estimate the economic costs and social benefits of making the investment in information technology and organizational training that would be necessary to achieve 'reliable performance' in extreme events. This paper will examine modes of increasing the capacity of inter-organizational systems to adapt to extreme events.

Theoretical background

The concept of adaptation in inter-organizational systems draws upon findings from four distinct research themes in public administration and organizational theory. First, it is informed by the broadly interdisciplinary literature on complex adaptive systems (Holland 1995; Axelrod 1997; Axelrod and Cohen 1999; Kauffman 1993; Prigogine and Stengers 1984). A key concept in this literature is self organization, or the capacity to reallocate resources and action to meet changing demands from the environment (Kauffman 1993). This capacity refers to change in behavior that is initiated by the actor, not imposed by any external force. Rather, the agent seeks change in order to achieve a better fit with its environment. Self organization has been observed in physics (Bak and Chen 1991), biology (Kauffman 1993) and public policy (Comfort 1999; Comfort and Sungu 2001). Extending this concept of self organization by a single agent to adaptation among a set of interacting organizations is critical to understanding the dynamics of response to extreme events.

Second, recent work on decision making under conditions of uncertainty offers a valuable perspective to adaptation in inter-organizational systems. Karl Weick (1995, 2001), a psychologist, and his colleague Kathleen Sutliffe (Weick and Sutliffe 2001) present the concept of sensemaking as a process of scanning the environment for information and using it to develop a plausible course of action in a difficult or shifting context. Gary Klein (1993) developed a more detailed model called recognition primed decision making based upon his observation of fire commanders directing operations in the dynamic context of a fire ground. Klein finds that fire commanders make decisions not on a basis of a rational review of alternative strategies, but upon recognition of situations they have seen before. They craft a strategy of action from a repertoire of previous events that are similar to the situation they are confronting. Rhona Flin (1995) confirms this process of naturalistic decision making in her observations of emergency operations chiefs performing under stressful conditions. Weick and Roberts (1996) move from observations regarding decision making by single operations chiefs to the interaction among members of a crew on an aircraft carrier. Their concept of "heedful interrelating" refers to a state of mindful attention among a group of actors that evolves from common training, intense communication, and a distinct culture derived from shared experience. The authors use this concept to explain the high reliability in performance that is achieved by ordinary human actors in the dangerous operating environment of an aircraft carrier. Each of these concepts offers insight into decision making in difficult, dynamic conditions, but none addresses this process in the context of a region-wide inter-organizational response system.

Third, research on uses of technology by social organizations documents the emergence of sociotechnical systems (Goodman and Sproull 1990; Gell-Mann 1994; Comfort 1994). A socio-technical system integrates humans, computers, and technical agents in an interactive system that transmits, receives, stores and acts upon information from the environment. The capacity to learn from incoming information in a dynamic environment alters significantly the operating context of organizations responding to threat. An inter-organizational response system is dependent upon access to information and the range and quality of the information available to operations personnel. This capacity can be enhanced by a technical infrastructure that establishes contact and communication with a wider range of sources of information and support to organizational personnel, but it can also be limited if the technical information infrastructure fails, or vital communications can not be made. It is the interaction between human actors and technical infrastructure that extends or limits the operating capacity of the response system.

Fourth, modes of adaptation in inter-organizational response systems depend upon the initial conditions of the participant organizations. Analyzing rapidly evolving response systems following earthquakes, I identified four types of adaptation (Comfort 1999) that may be applicable to inter-organizational systems emerging in response to other types of hazards, including terrorist attacks. This initial characterization gives a beginning classification of types of adaptation demonstrated by inter-organizational systems under differing technical, organizational and cultural conditions. Each type can be characterized by technical, organizational and cultural indicators. Technical indicators include measures of reliability for the technical structures, e.g. transportation, electrical power, communications. Organizational indicators include measures of organizational flexibility, e.g. adaptability to changing conditions, style of communication among members, leadership or lack thereof. Cultural indicators include measures of openness and innovation, e.g. willingness to accept new concepts or initiate new patterns of action. The emerging systems vary in terms of their characterization by these indicators, and interaction among the three sets of conditions limits the system's capacity for adaptation to a damaged environment. The response systems reflect these limits, defined largely by the initial conditions in which the damaging event occurred. The four types of adaptive systems identified in field studies of earthquake response systems, briefly, are: nonadaptive systems, emergent adaptive systems, operative adaptive systems and auto-adaptive systems (Comfort 1999).

Nonadaptive systems are systems that are low on technical structure, low on organizational flexibility and low on cultural openness to new information. They function under threat largely dependent upon outside assistance, but revert to previous status after the threatening event. Emergent adaptive systems are low on technical structure, medium on organizational flexibility, and medium on cultural openness to new concepts of operation and organization. These systems develop a mode of organization and action to cope with threat during disaster operations, but are unable to sustain collective action after the immediate threat passes.

Operative adaptive systems are those that are medium on technical structure, medium on organizational flexibility and medium on cultural openness to new information. These systems function well in response to threat, but prove unable to translate methods of response into new modes of sustained operation and threat reduction. Auto-adaptive systems are those systems that are high on technical structure, high on organizational flexibility, and high on cultural openness to new information. Such systems represent a rare achievement, but in practice, these systems prove effective in response to threat and are able to transfer lessons learned from prior experience into a sustained reduction of threat. For threats of unbounded uncertainty, such as terrorism, the preferred type of adaptation is an auto-adaptive system that is able to learn from incoming information, re-allocate its resources and attention, re-order its relationships with other entities, and act promptly to reduce the threat or respond to destructive acts.

While the concept of auto-adaptation fits the requirements for inter-organizational response to extreme events, the conditions needed to support its development in practice and the dynamics by which it evolves have had little attention in research. In order to apply this concept to a strategy of inter-organizational response in extreme events, its characteristics need to be developed more fully. Auto-adaptation by a single actor is a form of individual learning, but it moves to group learning when it occurs in an organization, and to broader collective learning when it occurs in an inter-organizational system. Auto-adaptation is a form of mutual adjustment among the component units of an organization and again, among the component organizations of an inter-organizational system. It is a means of managing change of different types at different rates among different units or agents that allows the formation of a coherent strategy of action for the inter-organizational system.

In addition to meeting the initial conditions stated above, an auto-adaptive system appears to move through five distinct phases in its response to extreme events. These phases are: 1) information search or scanning; 2) information exchange, or ‘heedful interrelating’ with other agents in the system; 3) sensemaking, or selection of a plausible strategy of action, given the situation and resources available; 4) adaptation, or action taken to implement that strategy; and 5) evaluation of actions taken and modification of succeeding actions on basis of observed results. In the next section, I will present brief vignettes of auto-adaptation in situations when the response system did function well, as well as brief vignettes when it did not.

Modes of adaptation to the 9/11 events

While the full record of damaged conditions and actions taken during the intense hours, days and weeks immediately following the 9/11 terrorist attacks is not yet complete, sufficient information regarding key aspects of the response is available to allow preliminary observations and interpretation. This analysis is based upon accounts of the events and actions taken from news reports, agency situation reports, and notes from interviews with key participants.[i] It is also important to set this analysis in administrative context. In terrorist incidents, two types of response operations are initiated simultaneously. The first is crisis management, or the effort to identify and pursue the perpetrators of the incident. Under the National Contingency Plan, the Department of Justice (DOJ) is designated as the lead agency for crisis management, and coordinates its work with other agencies involved in pursuit of individuals who may have engaged in illicit activity. These agencies include the Federal Bureau of Investigation (FBI), the Central Intelligence Agency (CIA), when international agents are involved; the Immigration and Naturalization Service (INS), which governs entry and exit of foreign nationals across US borders; and the Bureau of Alcohol, Tobacco and Firearms (ATF), which tracks the entry of illegal substances across US borders. These agencies operate within the bounds of security required for a criminal investigation.

The second type of response to a terrorist attack is consequence management, or the immediate mobilization of search and rescue operations to save lives of people harmed by the incident, as well as disaster assistance to the people who suffered losses from the incident, and recovery and reconstruction of the damaged communities. The Federal Emergency Management Agency (FEMA) has lead responsibility for consequence management, focusing first on lifesaving operations and second on assistance to the victims, recovery and reconstruction of the community. Under the Federal Response Plan, ten agencies in addition to FEMA play lead roles in disaster operations, with all twenty-eight federal agencies assigned responsibilities under twelve specified emergency support functions. The lead agencies include the Departments of Transportation (DOT), Defense (DOD), Health and Human Services (HHS), Housing and Urban Development (HUD), Agriculture (DOA), National Communications Service (NCS), Environmental Protection Agency (EPA), General Accounting Office (GAO), and the US Forest Service (USFS). The American Red Cross (ARC), a nonprofit organization, is designated as the lead agency for mass care. FEMA is responsible for information management as well as urban search and rescue operations (Federal Response Plan 1999).

This analysis deals only with consequence management operations, which are led by the FEMA in conjunction with other civilian federal and sub-national governments and agencies. While the interaction between the DOJ agencies and FEMA is critical to the overall operation of the disaster response system in response to a terrorist attack, the records of the agencies supervised by the DOJ are not open for public review as the criminal investigation is still on-going.

The initial conditions in which the incidents occurred shaped distinctively the emergence of the response systems at the World Trade Center and the Pentagon sites. At the World Trade Center, the physical devastation was catastrophic. The attacks caused not only the collapse of the 110-story twin towers, with an estimated 20,000 people in the buildings at the time of the attacks, but also the complete or partial loss of five smaller buildings in the immediate campus area, and heavy damage to twelve other buildings in the roughly six square block area in which the towers were located. In addition, the electrical power generation and distribution system for lower Manhattan was destroyed; the water distribution system, dependent upon electricity for pumping water, was disabled; gas pipelines were heavily damaged, and the telephone and telecommunications services were seriously disrupted.[ii] The technical infrastructure that enabled people to live and work in this densely populated, interdependent urban environment was decimated, and the site was dubbed appropriately "Ground Zero."

Organizationally, the New York Fire and Police Departments responded immediately to the event. In terms of professional experience and training, both departments had seasoned, well-trained and well-equipped personnel. Neither department, however, had confronted events as catastrophic as this. Both departments responded within their standard framework of operations for a major fire. But without an assessment of the interdependent effects of the collapse of the technical infrastructure needed to support their operations, the responders themselves became victims. The loss was greatest in the New York Fire Department, when 343 fire personnel were lost. This number included personnel who were in the buildings seeking to rescue others when the towers collapsed, as well as departmental leadership on duty when their Command Post, established in the ground floor of the North Tower, was destroyed.

Culturally, the emergency response departments of New York City have well-developed, coherent professional beliefs and values regarding their departmental performance. Less well developed, however, was their awareness of the need for information from other departments in order to craft an effective strategy of action for this extraordinarily difficult event. With little experience in suppressing fire in 110-story buildings, the Fire Department did not consider the possible collapse of the buildings themselves. Without an assessment of the structural damage to the building and its state of fragility, standard departmental procedures placed their own personnel at risk.

At the Pentagon site, the Boeing 767 struck a section of the building that had just been reinforced against possible attack. Consequently, the physical reinforcement of the building, including $10,000 windows and fire-resistant walls between sections of the building, limited the damage greatly. Fortunately, the advanced structural design of the building largely confined the damage to one section, facilitating response and enabling the occupants of the other sections of the building to leave unharmed. Organizationally, Pentagon forces were both a target of the attack and a responder to the event. With personnel trained in battlefield management, the Department of Defense was uniquely suited to respond to this event. Located in Arlington County, Virginia, the Pentagon site drew its first responders from the Arlington County Fire Department and the Fairfax County Search and Rescue Team. With familiarity developed from prior training and joint exercises, the local emergency response agencies moved quickly to joint operations with the Defense Department's Security Force, and together the two sets of agencies created an effective response system. This was an unusual situation, as it integrated a federal force directly with County emergency response teams, without the usual intervening state jurisdiction. The significantly lower death toll at the Pentagon site, 184 persons, documented both less devastating conditions and a smoother inter-organizational transition to response than at the World Trade Center.

Auto-adaptation in practice

Elements of auto-adaptation were evident in local response at both sites, but the difference in the magnitude of disaster at the two sites also affected the interaction between the local site response sub-systems and the wider national response. The response to the World Trade Center attacks involved a much larger loss of life, a far greater number of organizations, a significantly higher cost in damage, and a more profound impact on the economic, social and emotional state of New York City, the state and the nation. Responsible actors at both the Pentagon and World Trade Center sites requested assistance from FEMA, and FEMA personnel responded promptly to both sets of requests. The response to the Pentagon site was managed by a joint federal-local task force and was largely under control within four days. The response to the World Trade Center site was a much more complex operation that is still in progress. This analysis will review the five phases of a preliminary model of auto-adaptation against actual practice, focusing on the response to the World Trade Center site and the interactions among the participating jurisdictions as the more complex, dynamic set of operations.

<u>Information Search</u>

The interdependence among the response organizations' technical information infrastructure, their organizational procedures and capacity to assess accurately the risk to which they were exposed, and their willingness to explore alternative strategies in response to the extraordinary damage is clear. This interdependence is vividly demonstrated by the mixed signals, costly delays and painful misjudgments that exacerbated the loss of life in the 71 minutes that included the crash of United Flight #11 into the North Tower at 8:48 a.m., the second crash of American Airlines Flight #175 into the South Tower at 9:03 a.m., and the collapse of the South Tower at 9:59 a.m. The final collapse of the North Tower at 10:28 a.m. added a scant 29 minutes to potential evacuation time for the occupants of the North Tower.

In retrospect, it is difficult to portray the unimaginable horror that emergency personnel confronted as these events were unfolding. Information search was seriously limited, resulting in a severe lack of information as a basis for decision in this urgent, uncertain, swiftly moving context. The communications infrastructure was disabled. The Verizon cables in the base of the North Tower were destroyed, and telephone communication lines were disrupted. As people turned to cell phones, the number of calls increased by over 1000%, overloading the base stations and rendering them useless. Police and fire personnel turned to radio communications, but their call channels were also overloaded. In this extremely dangerous environment, thousands of people frantically sought safety. Fire personnel entered the towers seeking to suppress the fires or guide the occupants to safety, but without adequate communication, they lost contact with departmental leadership and had little or no information about the growing instability of the towers. Information search at the site level failed to provide a sufficiently timely assessment of this volatile set of conditions to support coordinated action. Departmental procedures developed for fires of lesser scale proved inadequate in this inferno.

Information exchange

The capacity for information exchange is directly related to the performance of information search processes. On scene at the World Trade Center collapse, information exchange in the first hours after the attack was limited by the same failure of communications infrastructure that hindered information search. Without information exchange, coordination between leadership of the response organizations and their personnel, as well as among organizations and jurisdictions, was delayed and disrupted. The need for a Joint Information Center among federal, state, municipal and borough operations was acute, but the extraordinary physical destruction in the immediate area of the WTC complex made it difficult to find space close to operations to establish a joint information center. Separate jurisdictions established separate information centers, asserting that they were joint, but in fact presenting different accounts of operations to news and agency personnel. Conflicting reports hindered cooperation and detracted from efforts to build trust and coordinate action among the agencies and jurisdictions in an extremely difficult, uncertain operations environment.

On the federal level, information exchange reached the level of near auto-adaptation for agencies engaged in consequence management. At FEMA Headquarters in Washington DC, senior personnel activated the Emergency Operations Center immediately upon seeing the second plane crash into the South Tower on the television news. Personnel from Health and Human Services began to mobilize the Disaster Medical Assistance Teams (DMAT) and Disaster Mortuary Teams (DMORT) to respond first to New York, and minutes later, to the Pentagon. Army Corps of Engineers personnel recognized that debris removal would prove a major problem for New York and planned ways in which they would offer their services to New York City personnel.

In Washington, DC and in the cities near New York, the physical information infrastructure remained intact. Communication lines were not damaged, and information was exchanged freely via telephone, fax, radio and e-mail. Daily conference calls between the Regional Operating Centers and FEMA Headquarters maintained an open, two-way exchange of information that informed decisions at both locations. Twice a day briefings at FEMA Headquarters kept both staff and leadership focused on actions planned and actions taken. In the intense first hours after the attacks, decisions were made and resources committed among agencies on the basis of verbal agreements. This informal process revealed the degree of common understanding among the senior personnel of the principal response agencies. It reflected a high degree of mutual respect, shared goals and trust among responsible personnel gained from working together in previous disaster operations. This kind of information exchange represented “heedful interrelating” among the personnel, with participants paying careful attention to the actions and needs of the other agencies in order to achieve coordinated action among all participants in response operations. Even members of Congress set aside partisan differences to show a unified approach to counter this sobering national threat.

Problems did arise, however, in integrating information from the consequence management set of operations with reports from crisis management operations to present a comprehensive profile of disaster operations to the President. At times, reports of the state of disaster operations were conflicting or information presented to the public was not carefully checked. The result was apparent confusion among agency personnel and the public, with the unfortunate outcome of missed opportunities for detection in the anthrax cases or conflicting statements made regarding the level of risk to which postal workers or others were exposed. The credibility of the information processes is cumulative, with the quality of information exchanged dependent upon the degree of care taken in information search.

Sensemaking

The ability to act in difficult, urgent situations depends upon sufficient understanding of the context to formulate a plausible strategy of action, given the existing constraints and available resources. This capacity depends, in turn, upon the preceding processes of information search and exchange. In coping with this seemingly incomprehensible event, few persons initially understood the danger to which they were exposed. Most painful were the accounts of security guards urging occupants of the South Tower to return to their desks, after the North Tower was struck. In an effort to maintain order and based upon inadequate information, responsible managers informed employees that they could safely remain in the building and return to work. Precious minutes were lost in evacuating the building, as employees followed instructions instead of checking the validity of the information against their own perceptions (*New York Times* September 12, 2001). The limitations of human cognitive capacity are nowhere more apparent than in the inability to absorb information that is startlingly divergent from one's previous experience (Cohen and Levinthal 1990). The potential collapse of the towers was not recognized by managers, individuals, or emergency personnel in time to implement immediately the strategy of evacuation that appears obvious only in hindsight.

At the federal level, away from the horror of burning buildings and failed infrastructure, sensemaking spurred action in anticipation of requests for assistance. For example, federal officials, recognizing the extraordinary extent of damage, pre-positioned mobile emergency response support (MERS) units to send communications equipment to New York to facilitate immediate response.[iii] From previous experience, senior officials recognized the type of assistance that would be needed to function in this demanding, urgent environment. They acted effectively to provide support to the on-scene managers, constructing meaning from a collage of prior events in disaster operations. The contrast in ability to make sense out of this seemingly incomprehensible situation reflected not only the difference in experience between senior emergency management personnel and on-site security guards, but also the long-recognized observation that human problem solving ability drops under stress (Miller 1967; Weick 1993; Comfort 1999; Flin 1996, 2001). In the actual environment of disaster, the demands of the situation often exceed human problem solving capacity.

Adaptation

Sensemaking represents a form of learning, the ability to construct meaning from perceptions that may be disparate or scattered, but that lead to recognition of a coherent strategy of action. The ensuing action constitutes a change from previous behavior that fits environmental demands more appropriately. Two incidents indicate adaptation of response units to urgent needs from the disaster environment. At the Pentagon site, local emergency response units from Arlington County and the FEMA-sponsored Urban Search and Rescue Team from Fairfax County responded immediately to the crash scene. Since the Department of Defense was the victim, the scene immediately became a federal disaster. Federal resources were made available to local managers, and the response system evolved essentially as a federal-local set of operations, with little involvement from the State of Virginia, despite formal requirements for state agencies to act as the intermediary between federal and local units. In this case, the experience and professional capacity of the local Arlington and Fairfax County responders, coupled with the immediacy of federal assistance, made formal intervention by state agencies, located in Richmond several hours away, virtually unnecessary.

The same situation prevailed in New York City, where federal agencies provided support directly to New York municipal agencies, without direct involvement of New York state agencies located in Albany two hours away. The urgency and scope of assistance required in response operations in New York City demanded federal resources, and prior relationships between federal and municipal officials established the trust and collaboration essential to coordinate actions under the stress of this uncertain disaster environment. Prior procedures proved inappropriate, given the size and scope of this disaster. Taking reasoned action to save lives, reduce risk, assist those who had been harmed and restore basic services in the damaged area meant adapting practice to this severely altered environment. Slowly, order emerged at both sites, but with significant adjustment of prior practices to meet the enormity of the tasks. In the process, it became clear that the role of state agencies in managing extreme events requires review.

Inter-organizational learning

The final phase in adaptation to a changed disaster environment includes evaluation of actions taken and modification of succeeding actions on the basis of observed results. This phase could initiate system-wide change as the action of one organization affects the performance of its near-neighbors in the response system, triggering a ripple of change throughout the interdependent set of organizations. It is too early to assess whether changes initiated by organizations as they modified prior practice in this event will remain in place. To the extent that they do, these changes will represent learning among organizations in a permanent alteration of conditions that lead to the disaster. A candidate for this type of permanent change among organizations responsible for public security is the newly formed Office of Homeland Security. This Office, as presently conceived, would integrate functions of crisis and consequence management in a unified approach to reduction of risk and response to terrorist or other types of threats. Although there is widespread recognition of the need to reduce risk of threats to public security, the precise mechanisms for bringing about this reduction are not clear.

At issue is the balance between governmental authority used to protect the public good and the rights of individuals to freedom from unwarranted breaches of their privacy. A secondary issue is interdependence among government agencies. Whether agencies currently operating under the Department of Justice would be limited in their functions of pursuing perpetrators of terrorist acts by sharing information more widely with other governmental agencies remains to be seen. Clearly mutual adaptation among the agencies will occur over time, but the direction, rate and intensity of this change will vary among the participant organizations and with the scope of the continuing threat. Equally important will be the evolution of the relationships among the jurisdictions in countering and responding to terrorist threats. Whether the emergence of direct federal-local relationships will continue or be replaced by wider, regional networks of preparedness and response will depend upon the interplay of threat and developing governmental capacity at sub-national levels. The lasting form of a response system for extreme events will certainly be intergovernmental, but the precise mix of federal-state-local participation will likely depend upon public investment in building an information infrastructure sufficiently advanced to manage the intense flow of information search, exchange and sensemaking among the respective levels of government needed to support coordinated action in risk reduction and response.

A preliminary model of auto-adaptation in emergency response

From this brief analysis, a beginning model of auto-adaptation in emergency response may be sketched. Auto-adaptation is a nonlinear process that depends upon early recognition of indicators for change. In contrast to linear models that have clear demarcations of authority and specific tasks for different levels of operation, nonlinear models have overlapping authorities and multiple points of entry into, or exit from, an operations field. Instead of a step-wise progression through categorical stages of change, the organization may proceed with a cumulative assessment of changing conditions that warrant reconsideration of risk and reformulation of strategies that shift responsibilities for action according to need and capacity. Identifying, measuring, and monitoring a set of critical conditions that place a community or region at risk become primary methods of providing decision support to practicing managers in terms of reducing their exposure to risk and determining the need for preventive action.

Auto-adaptation is primarily a learning strategy. It depends upon the development of a scalable knowledge base and information infrastructure to support inter-organizational operations among the multiple agents that make up the potential response system. While the exact form of this socio-technical infrastructure is not yet defined, it would likely have the following characteristics:

1. *Information search*. Search processes will be most effective if they are linked to current assessments of conditions and facilities vital to continuing operations in the community at risk. Establishing and maintaining the knowledge bases and updating the technical requirements to conduct rapid information search and aggregation functions to provide comprehensive views of the state of vulnerability for the community are the first steps in mobilizing that community's capacity to manage its own risk.

2. *Information exchange*. These processes are necessarily inter-organizational, and the boundaries of the information exchange will be defined, in part, by the state of technical advancement of the infrastructure that supports it. More important, the quality and effectiveness of the information exchange will be defined by the organizational processes of training, receptiveness to incoming information that may be inconsistent with prior assumptions, and willingness to share information regarding actual performance. Instead of following traditional jurisdictional boundaries, information exchange will more likely be defined by regions that share similar types of risk, or are bounded by functional interdependencies such as transportation systems or electrical power and water distribution systems.

3. *Sensemaking*. The capacity to interpret the signals and shifts in conditions of routine operations depends significantly upon the socio-technical infrastructure that has been established for information search and exchange processes. It also depends upon the cognitive capacity of those responsible for action. Understanding the limits of human cognitive capacity and using technical means of decision support to augment this capacity in extreme situations are fundamental to increasing the ability of an inter-organizational system of governmental agencies to take timely, informed action in response to risk. This function is likely most effective when performed on a regional scale. Municipal governments are too limited to manage extreme events with only their resources. State governments may be inadequately informed regarding the specific details of operations in local governmental jurisdictions. National governments may be too broad to provide the specificity in action needed for effective risk reduction and response over the range of local regions exposed to risk. Regional systems of risk reduction and response are likely to emerge in metropolitan areas as the most effective balance between size, capacity and specificity needed for effective action.

4. *Adaptation*. Particular forms of adaptation to manage extreme events are likely to continue to develop. The federal-local partnership proved effective in the 9/11 response at both the World Trade Center and Pentagon sites, but it is an expensive alternative. When costs are considered in assessing alternative forms of inter-organizational

response over the long term, increasing the capacity of regional networks may prove a more efficient, viable alternative. Most important will be fostering the dynamic of individual, organizational and inter-organizational learning that leads to lasting change.

5. *Auto-adaptation.* The conceptual model of auto-adaptation is a system of interacting units, each performing at its own rate but adjusting performance to that of its near-neighbors in response to incoming information from the environment. Thus, information entering the system becomes immediately accessible throughout the system in a synergistic adaptation to threat and reallocation of resources and responsibilities to meet that threat. It is a system of continuous learning, and fosters initiative and responsible action at all governmental levels, through mutual adjustment and reciprocal exchange of information and resources. It is guided by a common goal of public security for the community, region, state, and nation.

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Notes

[i]. The analysis of this case study draws heavily upon the daily news reports published by **The New York Times**, September 12 - October 6, 2001; situation reports prepared by the Department of

Health and Human Services and the Federal Emergency Management Agency, and semi-structured interviews with key operations personnel in the Federal Emergency Management Agency, the Department of Health and Human Services, and the US Army Corps of Engineers. The report is also informed by observations from professional researchers who were also engaged in studies of response to the World Trade Center-Pentagon Attacks, but who have not yet published their findings. To protect the confidentiality of the respondents, names will not be identified.

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Acknowledgements

I acknowledge, with thanks and appreciation, John R. Harrald and Joseph L. Barbera, Co-Principal Investigators of National Science Foundation Grant #CMS0139309, "Observing and Documenting the Inter-Organizational Response to the September 11 Attacks," for including me in their research team. This paper reports findings from research conducted under this grant. I also acknowledge the assistance of Michael Carrigan and Naim Kapuci, graduate student assistants at the Graduate School of Public and International Affairs, University of Pittsburgh, for their careful and diligent work in conducting the content analysis of the *New York Times* reports on this case. Further, I thank the public managers from the Federal Emergency Management Agency, the US Army Corps of Engineers, and the Department of Health and Human Services who gave their time and thoughtful observations to this research. For reasons of professional confidentiality, they are not named.

This paper has been submitted to *Publius* for consideration for publication on March 9, 2002.

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The International Emergency Management Society
9th Annual Conference Proceedings
University of Waterloo, Canada, May 14-17, 2002

INFORMATION SYSTEM INFRASTRUCTURE FOR A NATIONAL-SCALE EMERGENCY MANAGEMENT CENTER

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TUBITAK[1]

Keywords: Emergency management, resource management, crisis management, information systems, GIS.

Abstract

During the last decade of the 20th century, Turkey was shocked with numerous disasters. As a result, many efforts have been started to establish emergency management centers at various scales. This paper presents our views on the required information infrastructure of a national-scale emergency management center and the characteristics of a decision-support software required in such a center. The major responsibility of such a center will be to predict, track and minimize the effects of disasters, and manage the governmental resources in any part of the country.

Introduction

A disaster is a sudden, low-probability catastrophic event concentrated in time and space in which a society or a relatively self-sufficient subdivision of a society, undergoes severe danger and incurs such losses to its members and physical appurtenances that the social structure is disrupted and the fulfillment of all or some of the essential functions of the society is prevented [1].

Throughout time societies have dealt with natural and/or man-made disasters. For example, the Greco–Roman cities of Pompeii, Herculaneum and Stabiae were covered with and instantly preserved by volcanic ash up to 65 feet deep that resulted from the eruption of Mount Vesuvius in AD 79 [2]. The great fire of London in 1666 destroyed a large part of the city over 4 days including most of the civic buildings, a cathedral, 87 parish churches and about 13,000 homes [3].

Natural disasters kill an estimated 1 million people every decade and leave millions more homeless according to recent UN-IDNDR data. The economic damage from natural disasters has tripled in the last 30 years [4]. These make emergency management a crucial response mechanism against disasters. Emergency management is the discipline and profession of applying science, technology, planning, and management to deal with extreme events that can injure or kill large numbers of people, do extensive damage to property, and disrupt community life [5].

Establishing emergency management centers has been proved to be effective in all countries. The Carter Administration in USA pulled together various disaster response/emergency management programs and personnel previously scattered throughout the federal bureaucracy and created the Federal Emergency Management Agency (FEMA) in 1979 for comprehensive emergency

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management [8]. The Unified State System for Emergency Prevention and Elimination (USEPE) of Russian Federation provides communities' and the nation's prevention of, preparedness and response to and recovery from emergencies and disasters. [8].

During the last decade of the 20th century, Turkey was also shocked with numerous disasters. A series of major earthquakes in which the most severe one was the 7.4-richters Izmit earthquake (17th of August 1999, at 03.05 a.m.) that resulted in 15 thousand casualties in the largest industrial region of Turkey; floods in several major cities in south, west and north coasts that occurred after a rainfall of 600kg/m2 within a week in the region; mud flood in Isparta and Bartin cities are among the striking examples. After so many recent disasters, there has been subsequent development of state and local emergency management programs and centers along similar lines with international efforts.

This paper presents our views on the required information system infrastructure for establishing a national-scale emergency management center. We focus on the required software for providing decision support to the center personnel.

A National Center for Emergency Management

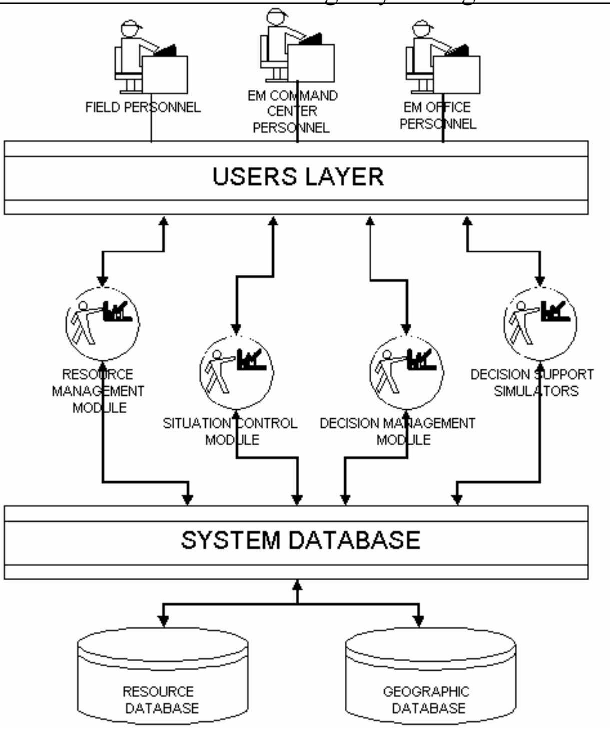
The proposed center consists of one emergency management command and control center, an emergency management office in each major governmental organization, such as ministries and general directorates, and several mobile emergency management offices that can quickly move to the crisis region to gather information and react to changing situations at real-time.

The following two observations are important in determining the responsibilities of the center and the functions it has to support. First, it has been argued that disasters are in fact local events. The local governmental body has traditionally had the first line of official public responsibility for first response to a disaster [11]. But municipal bodies tend to get much less exposure and have much less availability of resources compared with the central government. A national-scale emergency management center's basic responsibility should be to assist the local governmental bodies in all aspects of disaster response and recovery [12].

Second, if one looks across the range of threats we face, from earthquakes, to floods, to war, one will find there are common preparedness measures that we deal with in trying to prepare for those threats. These measures include evacuation, shelter, communications, direction and control, continuity of government, resource management, and law and order. It is the establishment of these measures that then becomes a foundation for all threats in addition to the unique preparedness aspects relevant to each individual threat. Thus, many emergency management capabilities are now operationally based on these functions, which are appropriate to a range of hazards [6]. The emergency management center software to be used in the center should be able to support the above-mentioned functions of the center.

The center also needs to have a sufficient number of qualified personnel to operate the existing emergency management center software. Each individual in the center should have a specialized function, abilities and responsibilities to manage. The actors can be classified as data collecting/entry personnel, decision makers, technical analyst experts, public relation experts and communication specialists.

Figure 1: General architecture of emergency management center software.



Emergency Management Center Software

Decent computers, large displays, scanners, fast printing equipment with high-volume capability as well as color printers and plotters will constitute the hardware infrastructure of the center. The center has connection with the local and mobile offices with telephone lines, dedicated communication lines, and/or the Internet. Satellite data communication means should also be considered for data exchange between the crisis region and command and control center.

Recent experience has demonstrated that investment in information technology may significantly increase the capacity to respond to disasters in a regional, national, or even international level. Computer-based decision support software to handle the disaster preparedness and response programs [9] have become an essential part of the emergency management centers. Such software help to coordinate, monitor, organize and distribute the required information in a timely and efficient manner appears to make it an ideal tool for strategic crisis management [10].

The general architecture of the software is shown in Figure 1. The emergency management center software should be composed of at least the following modules:

a. Resource Management Module

A resource is defined as anything that is owned by the central government and that may need to be moved to the crisis region or made available to the needy during the crisis time. Such resources may include, for example, fire-brigades, ambulances, doctors, medicine, food, etc. The goal of this module is to manage available resources in an efficient and effective manner. It provides a means for entering all kinds of resources under the authority of different governmental organizations into a central database. Thus it keeps an inventory of available resources with their actual geographical locations.

During and after a crisis, this module is used to display the current status of the resources on digital maps. The status may include the affected resources because of the crisis, needed resources in the crisis region as well as the distance of the resources from the crisis region and their amounts . It also provides various facilities to make spatial queries like "Calculate the number of ambulances in a neighborhood of 100 km of the affected region.", "Where can I find the required 1000 tents from the nearest locations within 24 hours?" Therefore it eases allocation of required resources and tracking of the allocated resources.

b. Situation Control Module

This module is used to store and serve the data related with the crisis and to view the up-to-date situation on digital maps after a crisis. It supplies the users in the command and control center with the information about the type, location, and the amount of damage in terms of effected regions and number of people.

The Resource Management and Situatıon Control modules use GIS system to help tracking the operation within the field and the allocation of the resources over digital maps.

c. Decision Support Simulators

A number of simulators for highly probable crisis and disaster situations like flood, earthquake, fire and wildfire and chemical material spills are also part of the system. They help to predict the possible effects of a certain disaster and the potentially risky regions around the affected region. These will be developed by experts by exploiting proven theories and made available to the experts in the command center. The analyst experts in the center will have the necessary skills to use the appropriate type of simulator and experiment with the parameters effecting the simulator and try out different scenarios. They will try to estimate the effects and results of the disasters such as possible threatened regions and the population.

A sample screen snapshot from a flood simulator is given in Figure 2.

d. Decision and Order Archiving and Tracking Module

This module will be used to store all the decisions made and orders given by the managers in the center and any information regarding the fulfillment status of them. All the decisions and orders and whether they have been carried out or not can be queried at once by using this module. An example of such an order would be "Send the below listed resources to the crisis region in 6 hours" and this order's status would be whether the corresponding office has yet taken an action or not. We assume that the receiver of the orders is responsible for reporting the status related to the given order.

After crisis, data collected using this module could be analyzed and evaluated in the sense of developing effective crisis management methods for different crisis types. The data entry personnel in the center organizes the incoming and outgoing data and updates the central databases when required.

e. Raw Data Archiving Module

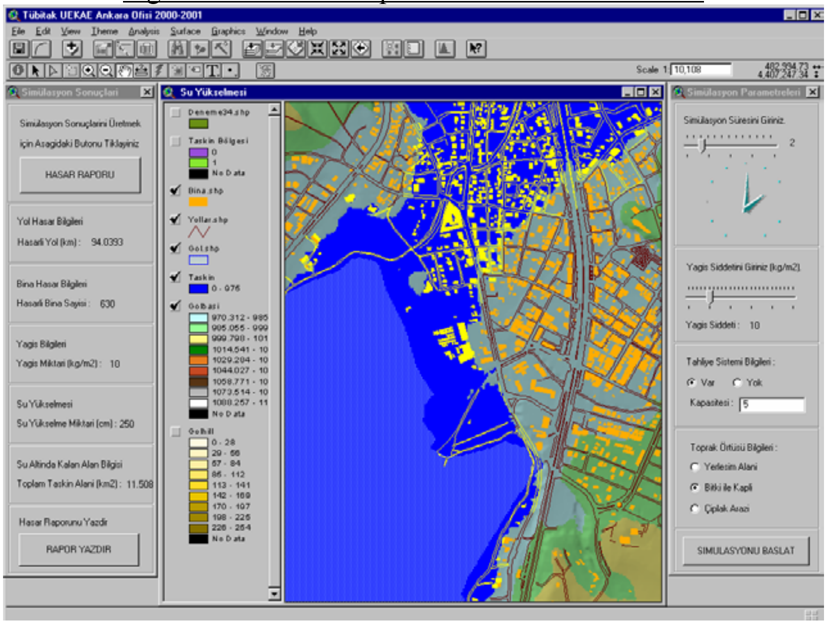
It is also used to archive all the raw reports coming from various sources. This may be formal or informal reports and other types of correspondence. For example, this module is used to record a mobile office's request to get some critical resources and their amount in the disaster region. All incoming raw data should be archived in some manner, and then be filtered, validated, and correlated (e.g., geographic and non-geographic data) by the data analyst personnel before updating the corresponding databases.

Database Support

As shown in Figure 1, a central data storage containing both geographical and non-geographical data lies underneath the information system. The geographic database will contain both large and small-scale administrative borders and units, transportation, topographic and cadastral digital maps of the country. The non-geographic database will contain any binary formatted data such as information about resources, correspondence, decisions, and orders and all the available demographic characteristics information about the country.

Data from various sources are fed into the center by various means; e-mail, fax, telephone, magnetic media, or other ways. They may contain formatted and unformatted text messages, database export files, Word or Excel files, voice and video files. The orthophoto images or commercial satellite images to obtain up-to-date information about the situation and to assess the damage will also be sent to the center from the field.

Figure 2: A screen snapshot of the flood simulator.



All offices whether permanent or mobile should be able to access remotely the databases in the center according to their authorization level. This will supply up-to-date data to the offices and also provide distributed updating of the central database. We have some concerns about the structure and initial population of the database. It is certain that each office organizes their data in a different way, keeps them in different formats, or uses different databases. Sometimes a similar resource is represented in completely different ways in different government offices. To match the central database design with the offices would make the database structure as well as the correlations of data among different offices complicated. On the other hand, defining a single common database structure to accommodate all the requirements from different offices is also inherently difficult. Using a different database structure than that of the offices will also require transferring and converting data using special adapters in order to update the central database.

Since sensible data will be exchanged with the offices, ensuring of the security and reliability of the communication media – whether Internet, dedicated network, telephone lines or satellites – is crucial. Furthermore, as excessive delays could negate the usefulness of the system, response time of the system should be kept minimal by choosing the appropriate server hardware and the network configuration.

Conclusion

Natural disasters cannot be prevented and will continue to strike. Due to increasing population and land development activities, the amount of property damage and cost of recovery after each disaster will continue to increase [13]. This paper addressed the establishment of a national-scale emergency management center with specialized software that will increase the efficiency of preparedness and response operations in natural and man-made disasters.

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SECTION 17:

MARITIME SAFETY

IS INTERNATIONAL MARITIME ORGANISATION'S FORMAL SAFETY ASSESSMENT APPROACH LEADING TO A MORE SYSTEMATIC IMPROVEMENT OF SHIPPING EMERGENCY MANAGEMENT?

Guillaume Chantelauve

BUREAU VERITAS[1]

Keywords: risk, marine, safety culture, decision making, regulation, proactive, safety management

Abstract:

Despite the technical progress achieved, the persistence with which maritime disasters recur is not acceptable. The recent shipping disasters of passenger vessels (Scandinavia Star, Estonia, etc.) and ecological disasters (Erika, etc.) have awoken the public opinion. The maritime community and industry are now converging to the same objectives of quality and safety under the auspices of the International Maritime Organisation (IMO), the United Nations Agency in charge of the commercial shipping regulation. The IMO and the whole maritime community are presently moving from a reactive to a proactive approach to safety and emergency response: reflecting the emerging recognition across the industry and its regulators of the risk management philosophy, efforts are undertaken to improve and effectively use risk based approaches in rule and decision making. This new approach developed within IMO is called Formal Safety Assessment (FSA) and includes the steps of hazard identification, risk analysis, evaluation of risk control options, cost/benefit analysis and recommendations for rule decision making.

This approach should eventually provide a more cost effective balance between prevention, protection and emergency measures accounting for technical and operational aspects. Of particular interest is the risk model established throughout FSA describing the distribution amongst the various causes, their interactions and the escalation barriers.

Both the change of approach in rule making and the global related perspectives are discussed as the backbone for an improved risk and disaster management in the maritime domain. The position of the regulatory framework in relation to emergency management will be examined. We will review the FSA approach and focus on its contribution to disaster management improvement. Finally, benefits and shortcomings will be highlighted.

Introduction

The importance of the risk management philosophy is progressing in the maritime industry and its regulator. One key feature of this philosophy is its "pro-activity". Peachey [1] defined the meaning of "Pro-active" as "planned action in anticipation of potential events or circumstances" and refined

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this meaning in the context of safety. This includes deciding upon a target risk level, identifying / implementing measures to achieve that risk level, and monitoring performance to ensure the target is achieved or exceeded.

Among all the safety approaches, two of them are especially emphasised as being "pro-active": the emergency management approach and the Formal Safety Assessment (FSA) approach. Although emergency management is a need for stakeholders close to the hazard and operational activities, FSA is the proactive approach with respect to regulation improvement. This approach, developed within the International Maritime Organisation (IMO), includes problem definition plus five steps: Step 1 - hazard identification, Step 2 - risk assessment, Step 3 - evaluation of risk control options, Step 4 - cost/benefit analysis and Step 5 - recommendations for rule decision making. FSA appears to be the backbone of the reactive to the proactive approach trend within the maritime community. Interim Guidelines for the Application of Formal Safety Assessment (FSA) to the IMO Rule-Making Process [2] – named hereafter the Interim Guidelines - were adopted by IMO technical committees in 1997. This paper will describe some of the key features of the crossed interactions and articulation between the risk assessment part (Step 1 to 3) of FSA and emergency management.

The first section of this paper will outline how the FSA approach enables to one capture and enhance operational issues, and especially emergency situations, with special attention on the modelling approach(es) used within FSA. This will be followed by a discussion of the FSA contribution to the improvement of emergency management and safety culture.

FSA capturing emergency issues

Preliminary remarks

IMO describes FSA [2] as "a rational and systematic process for assessing the risks associated with shipping activity and for evaluating the costs and benefits of IMO's options for reducing these risks." FSA should enable balance to be drawn between the various technical and operational issues, including the human element (and between safety and costs). The ability to address correctly these issues is highly dependant of the risk model and philosophy underlying FSA.

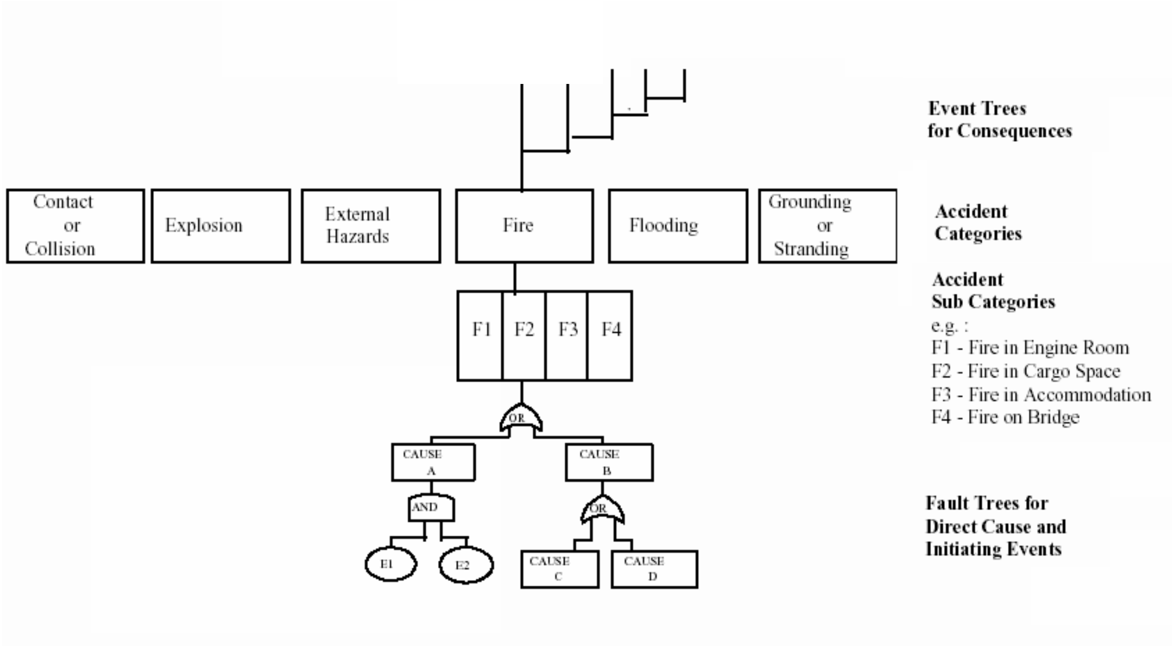
Boisson [3] has identified three approaches to explain accidents and enhance safety. The first approach, named the fatalistic approach, is an inheritance from the history of navigation itself. The accident is treated as the outcome of some act of God. Originally carried on by adventurers, the shipping trade uses expressions like "maritime perils", resulting from adventure, risk and good luck. The second approach, the deterministic one, that we would like to re-name the analytical one, rejects this idea of chance and fatalism but postulates that every event has a cause and that the same causes produce the same effect. This approach to safety has first focused on technical causes, then, as the causes of many accidents were identified as not purely technical but also strongly related to the operator, on human causes. The unsatisfactory nature of previous approaches has led to the emergence of new, total, global approaches mainly based on the theory of systems, recognising that beliefs, standards, values, objectives, data and models are of primary importance [4]. Describing the new approaches to regulation, Boisson classified FSA in the global approach trend to safety, and therefore recognises that FSA is able to deal with complex system issues. In particular the use of FSA should also enable one to assess the operational aspects, such as emergency situations, which are by nature unanticipated or infrequent in most systems.

Key aspects of FSA

The risk model

The risk model established throughout FSA step 2 is constituted by event trees and fault trees. In the Interim Guidelines the combination of these trees is referred to as the Risk Contribution Tree (RCT). See Figure 1. The goal of creating a Risk Contribution Tree is to provide an overview of where the main risk contributors are located in the risk model. Main risk contributors may exist as primary events in the fault trees of the risk model. They may also exist in the event trees of the risk model, as insufficient or missing escalation barriers.

Figure 2: Example of a Risk Contribution Tree [2]



Balance between prevention and protection

The FSA approach does not prioritise the measures to be applied in order to reduce risk, i.e. measures designed to reduce the probability of accidental events or measures designed to reduce the potential consequences of accidental events. Risk Control Measures, defined as a means of controlling a single element of risk, and subsequently Risk Control Options, defined as a combination of risk control measures, identified in FSA step 3, have a range of attributes. Category A attributes consider the two fundamental types of risk control that can be applied: preventive - preventive risk control is where the Risk Control Measure reduces the probability of the event; and, mitigating - mitigating risk control is where the Risk Control Measure reduces the severity of the outcome of the event or subsequent events. Thus, this dichotomy in the Interim Guidelines emphasises the balance between accident prevention and mitigation.

Escalation barriers

The measures designed to reduce the potential consequences of accidental events are sometimes known as “ defence in depth” or “barriers”. Among the range of attributes related to Risk Control Measures (and subsequently Risk Control Options), identified in FSA step 3, Category B attributes relate to the type of action required:

- Engineering: Engineering risk control involves including safety features (either built in or added on) within a design.
- Inherent: Inherent risk control is where at the highest level in the design process, choices are made that restrict the level of potential risk.
- Procedural: Procedural risk control is where the operators are relied upon to control the risk by behaving in accordance with defined procedures.

Category B attributes consider risk control at the technical, operational and organisation levels to ensure that training, quality systems and other organisational issues are addressed.

Human element

The maritime community is now recognising that the human element is one of the most important contributory aspects to the causation and avoidance of accidents. The Interim Guidelines state that: "Human element issues…should be systematically treated within the FSA framework, associating them directly with the occurrence of accidents, underlying causes or influences. Appropriate techniques for incorporating human factors should be used."

The International Association of Classification Societies (IACS) has given consideration on how to properly incorporate the human element into the FSA process. They proposed the use of Human Reliability Analysis (HRA) as a tool to properly incorporate the human element into the FSA process [5] in 1999. This draft Guidance provides a framework to systematically treat human element issues within the FSA framework, associating them directly with the occurrence of accidents, underlying causes or influences.

Conclusion

One of the important strengths of the risk model is that it portrays an overall picture of risk, in which both prevention and mitigation measures are incorporated and balanced accounting for the human element. The risk modelling is made with the aid of event trees, which have the advantage that they give an easy-to-understand illustration of the potential accident sequences, and with fault trees aimed at detailing initiating event causes and barrier failures within the event tree. This approach has been successfully applied in various trial applications (Helicopter Landing area on cruise ship, High Speed Craft, Bulk carrier, etc.). However, even if the objective is to ensure safety accounting for technical and operational factors, and if the described approach could be satisfactory, the objective will now be to take a closer look at the philosophical trend of FSA.

<u>Trends in FSA</u>

The Interim Guidelines mandate the adoption of a balanced approach between technical and operational factors reflecting their contribution to the safety of the overall system. Operational and emergency issues receive increased attention as integral parts of FSA. At the same time we have evidence from the Guidelines development, current discussions within IMO [6] and trial applications that the appropriation of FSA, under cultural inheritance and tools « recognition », has been an analytical interpretation of FSA. In the next section, we will identify some « trends and shortcoming » features of FSA when dealing with complex systems.

Risk model

The RCT would focus primarily on the operational tasks and conditions necessary for a successful scenario, or in other words the events related directly to the emergency situation. However on the basis of some practical trial applications of FSA, it is recognised that the events addressed first in the RCT are technical and human (considered as a technical component) and that "latent" conditions, i.e. poor design, failure due to poor construction, wastage, or operational factors, are addressed at a very low level. Fault and event trees using 'corrections' to account for the contribution made by the environment are often incapable of displaying and linking different types of causal information. Kristiansen and Soma [7] have outlined the fact that much weight is put on the task aspect and too little on the context, and proposed an alternative barrier model of evacuation which takes the life cycle of the system as a starting point.

Human element

In order to address the human element, the HRA approach is proposed. Bedier, Hollnagel and Pariès [8] have pointed out that the HRA approach has won substantial support despite fundamental weaknesses. Moreover, human reliability is envisaged as a strict transposition of technical reliability, operator being considered similar to technical component and as the source of problems rather than solutions. According to Hughes and White [9], the identification of why humans err and not just how they failed will lead to improved mitigation measures for regulators and seafarers alike.

Problem definition

FSA effectively starts with the "problem definition" aiming at defining the boundaries of the assessment and the problems to be addressed. The proposition to name this step "Step 0" has been rejected by IMO FSA Correspondence Group members. The IACS FSA training course [10] concentrates on the five step process, proposing detailed training modules for each step but no dedicated module addresses the "problem definition" step. As a consequence and even if this "step" is of primary importance when dealing with the analysis of a complex system, it has been under-focused and FSA is accepted/and trained as a five step process.

Moreover, within the problem definition is associated the concept of "generic model". As FSA results are intended to be used for rule development, they need to be valid for a variety of possible and typical designs or operations. Therefore, depending on the safety topic under consideration, a generic model, e.g. a system and its operation, under consideration is developed. The "generic model" concept should allow the use of FSA by attributing common features, characteristics and attributes to certain types of vessels operated under similar conditions. Once again this aspect is not emphasised and "generic model" has mostly been interpreted by "generic ship" and concerns concentrate too much on ship's hardware and not enough on operation. By limiting the "model" to the "ship" some important features are lost.

Risk Influence Diagram

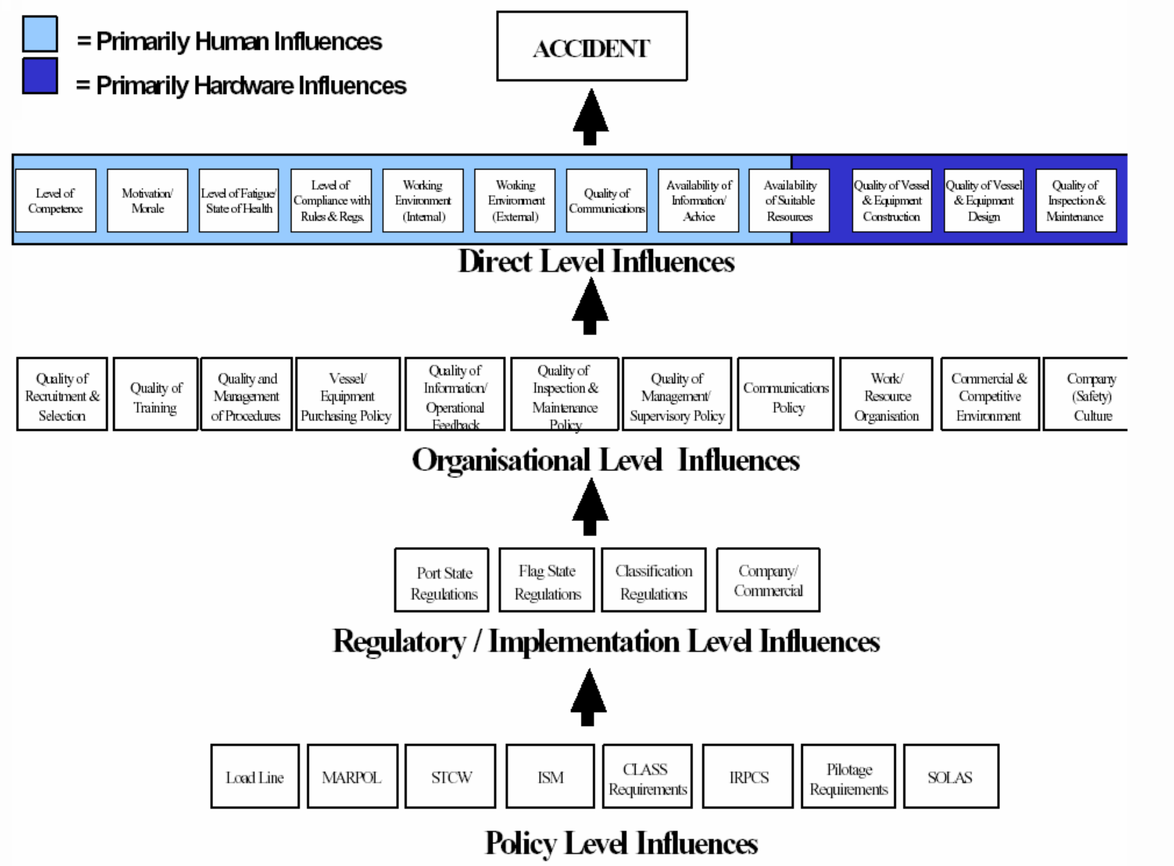
As a way of addressing some of the complex parameters, the Interim Guidelines make reference to the use of Regulatory Impact Diagrams (RID's). The RID is a method of modelling the network of influences on an event. These influences link failures at the operational level with their direct causes, and with the underlying influences. Basically, four levels of influences are addressed: a Direct Level (the direct causes of accidents, e.g. grounding, loss of hull integrity, etc.); an Organisational Level (the factors that influence the direct level); a Regulatory Level (the regulations and requirements that influence the shipping organisation); and a Policy Level (the Codes and Conventions and political structure that influences national regulators). See Figure 2. This tool can be an effective tool in the evaluation of Risk Control Measures and Risk Control Options, either by assisting in the identification of the type of regulations that may best influence safety, or in evaluating the effectiveness of proposed RCMs and RCOs. In 2001, the IMO FSA Correspondence Group [6] recommended to delete the Regulatory Impact Diagram from the Interim Guidelines.

The way forward

Established techniques are employed at each step of the FSA process. These include, for example: brainstorming, hazard identification techniques, HRA techniques, and event and fault tree analysis. However, because the FSA process is intended to assess complex issues and to be used for shipping in general rather than for any particular ship, additional techniques are also expressed, including in particular:

- Development of a generic model to describe the functions and features which characterise the problem under consideration; and
- Modelling of the regulator's influence over the underlying causes of accidents.

Figure 3: Example of Regulatory Influence Diagram [11]



These are the systemic aspects of FSA that should enable rule development accounting for its environment. In the conduct of a marine FSA, the interpretation and appropriation, even if FSA has been characterised as global, have been traditional analytical ones. It leads us to characterise this FSA as a FSA first generation, the analytical generation. The principle of this simple FSA is to search for causes accounting for technical and human components, the objectives being to eliminate or contain these causes. However, through this analytical appropriation, the analyst will lose some aspects of the problems and will accomplish the opposite of what is intended- namely a narrow vision of the problem and to propose mis-elaborated measures. This is the area where a FSA second generation recognising the relevance of "systemic" tools becomes complimentary to the traditional approach. Increasing emphasis on the non-analytical part of FSA should lead to greater attention to the environment and to better emergency management.

FSA and challenges

It seems accepted that the value and effectiveness of a rule can be assessed only within its environment and the complex socio-technical context. Boisson [3] argued in favour of a total approach to the safety issue and that an accident must not be regarded as an isolated phenomenon, the causes of which are sought to act on them, but as a result, among other factors, of a complex system comprising individual passengers, seafarers, shipowners, ships and maritime craft, infrastructures, navigational aids and the environment.

For the discussion above, there is real will to account for operational and emergency aspects within the FSA framework. We have identified a trend in FSA appropriation and characterised a FSA first generation based on an analytical approach, the risk model being built on a decomposition in tasks and basic events directly related to the emergency situation. This enables potential hazards to be considered before a serious accident occurs and provides input such as hazard identification, risk models and barriers to a risk based emergency management taking into account human error.

Nevertheless it appears that the global aspects of FSA have been under focused and that there is a need to emphasise these aspects. A first step towards this FSA second generation could be to go beyond the operator and technical component itself to take into account the influence of the environment. This step is expected to be proved more realistic and more promising as regards insights on safety, hence as regards indications to enhance safety and improve emergency management.

The new framework should ensure that the systemic tools are taken into consideration and used where needed and appropriate in the FSA process in order to meet the need of both the regulator and the operator. If the structure is correct and well used the questions "is the ship the best candidate for risk reduction", and "maybe IMO/IACS is the best place to take action" should be raised. By taking this approach, FSA would be likely to design safer ships as well as to be an initiating step towards an improved compliance and safety culture through the maritime community.

FSA impact on emergency issues

Introduction

A characterising feature of disasters and crises is that they are unpredictable. In order to reduce the effects of disasters, people in the emergency management organisation have to be trained in those situations they can expect to encounter. However, for the emergency management organisation it is impossible to think of every possible situation or event in advance. It is therefore important that the entire organisation can adapt flexibly and efficiently. In this context, the UK's Maritime and Coastguard Agency makes a distinction between emergency and crisis management. Emergency management has been defined as a situation where decisions and actions are based on documented emergency procedures. Crisis management differs from emergency management in that decisions and actions do not necessarily have to be documented emergency procedures and there may not be a predefined response, or if there are defined emergency responses those responses may have conflicting requirements.

Against this background, the application of FSA for rule development is expected to lead to safer ships and to an improved safety and emergency culture. We will now discuss how beneficial FSA could be for an emergency culture development.

From the reactive to the pro-active approach

The shipping industry is regulated under the umbrella of the IMO. Present rules are of a prescriptive nature and have been historically established from principles of naval architecture, marine engineering and other scientific principles. Limitations of the current regulatory regime have been recently highlighted: the regulations are of a prescriptive hardware nature; they are often driven by recent accidents therefore being reactive rather than proactive, etc. Kristiansen and Soma [7] have pointed out that: "The maritime transport has exhausted the traditional approaches in safety work and that new ones must be sought". FSA puts risk concept at the very heart of regulations and at the very beginning of the ship life cycle. Even if a safety culture cannot be imposed by regulations, but demands strong involvement by company management, FSA by will also bring about a thorough change in the dominant culture of shipping which is moving from a reactive to a proactive approach.

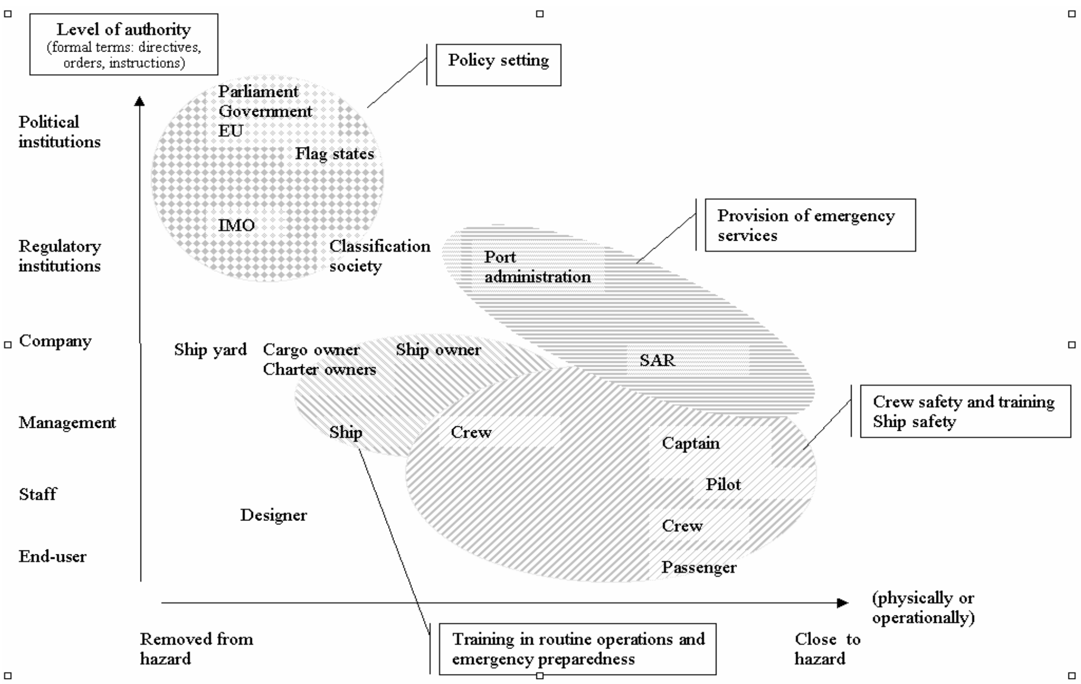
Stakeholder recognition

The use and need of crisis and emergency management approaches are widely spread within the maritime community. THEMES, an EU 5th FP Thematic Network for Safety Assessment of Waterborne Transport, recognises the importance of stakeholders. The starting point of this recognition is a description of stakeholder needs in respect to knowledge and information (and the extent to which these needs are shared with or common to other stakeholders), comparing needs with information availability, and analysing stakeholder interactions. An important deliverable [12] from the work so far has identified potential stakeholders and their related needs and decisions. The following have been identified as having emergency needs/decisions:

- Training in routine operations and emergency preparedness; and ISM compliance: Ship owners, Ship managers,
- Provision of emergency services: Port authorities, Bridge/Lock Controllers (inland navigation), Regional (waterway) authorities, Search and Rescue (SAR) organisations
- Crew safety and training; and ship safety: Pilot, Crew, Ship managers and owners

The next stage will categorise stakeholders according to their level of authority and degree of hazard exposure. A typology of decision domains, its implication on safety assessment and the interaction between decision domains and safety assessment approaches are foreseen. The results will especially indicate interaction between regulatory decisions and safety assessment approaches and the emergency management. See Figure 3.

Figure 4: Stakeholders and needs/decisions domains *(adapted from [13])*



Emergency preparedness improvement

As part of the safety culture encouraged by IMO, FSA could be used to develop new transparent, either prescriptive or performance based, regulations, which will directly impact both the ship safety level and the emergency preparedness.

FSA, in addition to providing a systematic method of developing risk based regulation, could serve as a starting point to the safety management system. IMO has stated the following objectives for the International Management Code for the Safe Operation of Ships and for Pollution Prevention (International Safety Management Code): "provide for safe practices in ship operation and a safe working environment; establish safeguards against all identified risks; and continuously improve the safety management skill of personnel ashore and aboard, including preparing for emergencies related both to safety and environmental protection".

FSA could serve as a safety management tool in the activities necessary to meet the objectives by supporting decision making regarding where safety investments are located best, e.g. in technical or operational modifications, or crew training to improve response in contingency. In other words, FSA could help targeting of emergency management resources and ensure that risks are correctly examined. Finally, since risk based regulation is often associated with performance, it may be a good opportunity to help the operators implement policies favouring personnel motivation and responsibility.

<u>Safety culture improvement</u>

The concept of culture appeared in literature on organisations in the 1980s. Culture has been described as a 'peeled onion' with a succession of different levels, starting from a centre consisting of core values and going to an outer layer with values, beliefs, norms and artefact. Moreover, Reason and al. have suggested the characteristics of an "advanced" safety culture [14]: Informed – managers know what is really going on and the workforce is willing to report their own errors and near misses. This relies greatly on trust. Wary – members of the organisation are ready for the unexpected. Just – there is a 'no blame' culture but with a clear line between the acceptable and unacceptable. Flexible – the organisation operates according to the needs of the current situation. Learning – it is willing to adapt and implement necessary reforms.

One means of "engineering" a safety culture can be via increased communication about the concept of risk. This requires an increased recognition of safety assessment methods to support decisions. FSA, by strengthening regulatory decision making, will allow the regulatory bodies to lead by example in promoting a safety culture. Encouraging risk concept/philosophy in this way will enable more effective practical application and is expected to contribute to an effective global cultural change in shipping safety, moving to a safety culture instead of a compliance culture.

Conclusions

The FSA approach combines risk and cost/benefit assessments, and is aimed at providing a rational and systematic risk-based approach balancing technical and operational issues to maritime safety regulation. This paper has discussed interaction between the FSA approach and emergency management. Within FSA, several aspects have been identified as improving the understanding of emergency operations. First, the risk model (RCT, a combination of event and fault trees) aims at providing an overview of where the main risk contributors are located in the risk model. Second, this risk model specifies that the main risk contributors may exist as primary events in the fault trees or as insufficient or missing escalation barriers in the event trees. Third, the potential measures to reduce risk can either be preventive, i.e. reducing the probability of an event, or mitigating, i.e. reducing the severity of the outcome. Fourth, the measures could address technical, operational, human and organisational aspects. Finally, the human element must be addressed.

However, we have pointed out that the appropriation of this approach to safety assessment and management has been an analytical one, and we have characterised this "1st FSA generation". Nevertheless, acknowledging the complex character of maritime safety and the fact that the 1st FSA generation is now mature, global and systemic tools should emerge. Such tools should be correctly incorporated, such as during the problem definition and the risk control option step, in order to account for complex features when developing new rules.

Moreover, FSA is expected to contribute significantly to the diffusion of a safety culture throughout the maritime community by making the regulations more transparent, developing a proactive approach towards safety rather than a reactive approach, increasing the understanding of user needs, focusing on areas of higher risks, explicating why and for what rules have been created, acknowledging that maritime safety is a complex issue, and leading by example.

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NEW TRAINING CONCEPTS IN MARITIME EDUCATION

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Keywords: simulation, distance learning, maritime education, training

Abstract

Approximately 80% of all navigational accidents at sea are due to human errors. Poor communication and co-operation between crewmembers and other ships seems to cause a significant part of these accidents. Improvement in communication and co-operation among crewmembers and other ships are one of the means for minimizing the number of accidents. This paper describes the development and evaluation of a simulator based training system where communication- and ship handling skills can be trained. A Search and Rescue scenario has been used in the evaluation. The system is coupled via the Internet so widely distributed trainees can take part in the training. A method for the debriefing of the trainees was tested and will be presented.

Introduction

The goal of the Nordunet2[2] project "MARITIME EDUCATION IN SHIP-HANDLING, COMMUNICATION AND CO-OPERATION THROUGH DISTRIBUTED NETWORKED SIMULATORS" is to give maritime students and professionals opportunities to train for real-world operational missions in an environment that is not constrained by cost or safety restrictions. Real-world exercises are costly and will often have restrictions in order not to endanger trainees; such restrictions, in turn, tend to limit the learning process of the participants.

There is agreement among experts that approximately 80% of all navigational accidents at sea are due to human errors. Poor communication and co-operation between crewmembers and other ships seem to cause a significant part of these accidents. To prevent navigational accidents, simulator based maritime Bridge Resource Management courses have been developed, focussing on inter-crew communication and co-operation in crisis situations. These courses are currently offered at a number of maritime education centres using high-realism bridge simulators [2, 3].

Traditionally, engineers supervising and controlling the engine room have been trained at separate institutions using engine room simulators. Recently, however, is has been realized that it would be beneficial to conduct combined Crew Resource Management courses involving the bridge crew as well as the engine room personnel.

Search and Rescue (SAR) operation is another area where the communication between ships has to be coordinated on the accident site in order to achieve the best result in a real-world situation. SAR

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[2] Nordunet2 is a research programme financed by the Nordic Council of Ministers and by the Nordic Governments.

exercises and education involving two or more countries can be carried out in a more cost effective manner.

Offshore operations may involve towing a production platform from the construction site onto the final position in, say, the North Sea. This operation requires the assistance of several tugboats where contributions from all tugboats have to be coordinated. The co-ordination of the operations of the tugboats has to be trained beforehand; and this requires, therefore, that busy tugboat captains have to meet at a simulation facility in order to train the operation.

To facilitate this type of education, physically separated simulators have been networked and course concepts for distributed simulation have been developed. (Pedagogical set-up, scenarios, tools supporting instructors, replay and debriefing). In order to be able to facilitate the development phase it was decided to interface only the Simflex ship simulator, which at the time of development was a stand-alone application. An additional reason for this decision was that the software of this simulator is under the full control of the Danish Maritime Institute [2].

Objectives

The overall objectives for the present project have been to develop course concepts and technologies supporting distributed networked simulation enabling education and training in ship-handling, communication and co-operation (e.g. crisis management in connection with SAR (Search and Rescue) operations) of geographically separated maritime students and teachers.)

These objectives can be further detailed into:

- Development of course concepts for distributed networked simulations (incl. pedagogical set-up, scenarios, instructor-, replay- and debriefing-tools).
- Development of generic network interfaces allowing real time distributed simulation (incl. communication).
- Evaluation of the final product

The concept will be scalable in the same way as e.g. SimFlex is scalable from a single PC running a Part Task training simulation to complete ship bridge environment (Full Mission training). This means that it shall be possible to use the concept to perform distance learning for a single navigational student using his own PC at home as well as distributed distance learning on fully integrated Full Mission simulators like e.g. DMI's Bridge "A" integrated with the Maersk's engine room simulator in Svendborg.

Another benefit is that the developed course concepts and technologies will provide the basis for a more flexible and cost effective use of the Nordic navigational teachers and make it possible to conduct cost effective and high quality education training in remote areas in the Nordic countries like e.g. Faeroe Islands, Iceland, Greenland etc.

The evaluation and demonstration of the final course concept has been carried out using Simflex simulators located at Danish Maritime Institute, Ålands Sjöfartsläroverk and Risø National Laboratory. The instructor was located at the Danish Maritime Institute.

Discussion of training concept

Simulator training contra classroom lectures

During normal classroom education, knowledge about Search and Rescue operations is transferred to the students as declarative knowledge. The students learn the right procedures, but they are not trained in a realistic environment.

In cognitive psychology [4, 5] there is a distinction between two different kinds of knowledge: *Procedural knowledge* and *declarative knowledge*. The former can be compared to "knowing how..." while the last is the formal knowledge about facts, rules, formulas etc.

Under normal conditions these two kinds of knowledge are retrieved fast and efficient from long-term memory, but under severe pressure of time and stress, as under a Search and Rescue Operation, procedural knowledge is retrieved significantly better than declarative knowledge. The access to declarative knowledge can even be totally blocked if the pressure or stress gets too high. It is therefore important, that knowledge that should be used under extreme conditions is of the type procedural knowledge. Declarative knowledge can be transformed into procedural knowledge by repetitive and intensive simulator training.

Simulator training contra in-services training:

The benefits of using simulation compared to in-service training in a real environment are mainly:

- The ability to provide risk-free training of hazardous scenarios.
- Low cost. Real SAR training would require 3 vessels, 3 crews, and oil consumption during the exercise, and the assistance from a radio station. Typical day charter of one vessel would be 2.000 EURO
- High degree of flexibility in choice of geographical location and date and time.
- The ability to fully control the scenario development by which the training transfer is optimized and required training time is minimized.

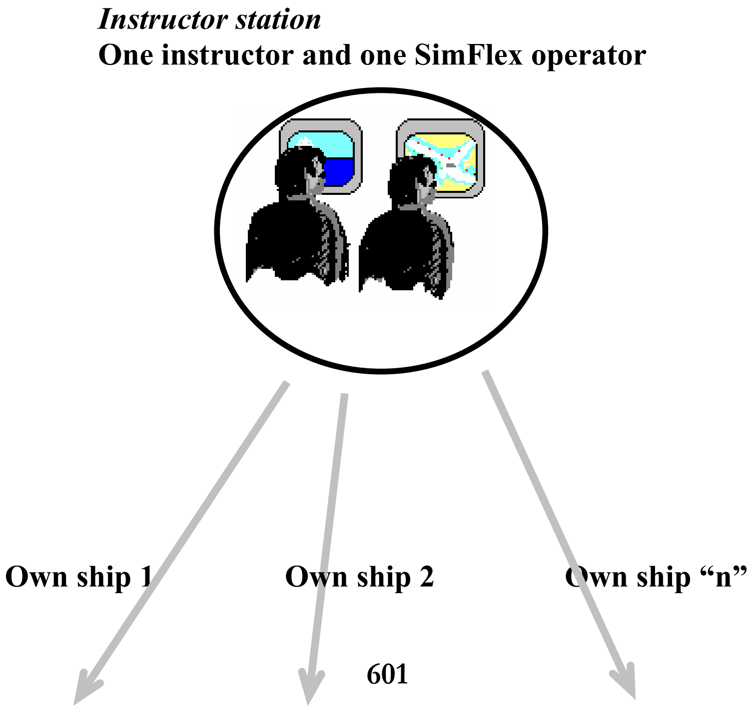
The above main advantages of using simulator based training results in reduced cost for training.

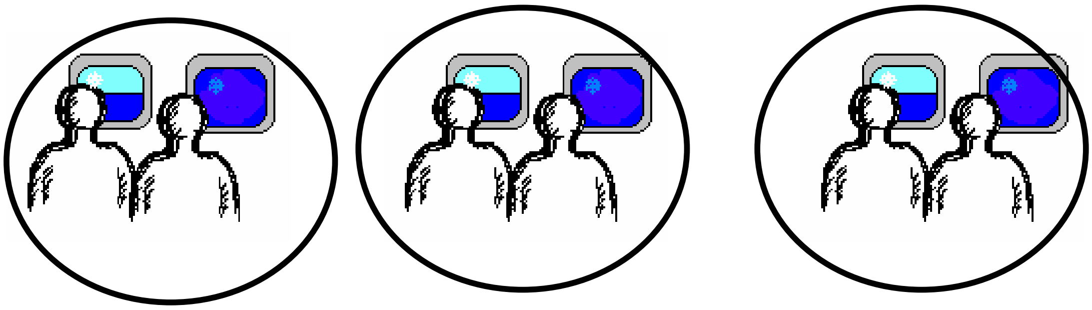
Course concepts for distributed networked simulations

Overall concept

The overall set-up for the distributed networked simulation is illustrated below. The simulators and the instructor station are geographically separated and connected through the Internet. A typical training scenario suited for distributed simulation training is e.g. Search and Rescue training and this scenario has been chosen for the concept demonstration and assessment.

Figure 1





The training concept for distributed simulation which has been developed under the Nordunet2 project comprises of the following phases/activities: in the following, emphasis has been put on the topics which are of special relevance to training of multiple co-operating teams at dispersed geographical locations using real time simulation technology.

- Preparation of detailed schedule
- Briefing of trainees
- Execution of training session
- Documentation and description
- Self evaluation by trainees
- Instructor controlled debriefing

Each activity in the training concept is explained in the following sections.

Preparation of detailed schedule

To ensure successful and effective planning in a distributed training environment timing is of extreme importance. Exact timing of the joined simulation must be planned and agreed in due time.

Briefing of trainees

Before the simulation each participant must be supplied with "Students Information", a booklet or E-Mail with all relevant information and documentation. The "Students Information" contains information about: Simulations plans, Time schedule, Ship Information, Exercise Information and checklists.

Execution of training session

The execution of the training session is controlled by the instructor on basis of a detailed scenario description (storyboard) along which the scenario develops.

Documentation and description

At the specified date and time all stations reports to the instructor station, using the embedded simulated VHF system. Under guidance of a navigational instructor, the simulation starts according to the scenario script.

During the whole exercise, the navigational instructor monitors all ships movement and communication. The navigational instructor acts as shore based radio station, broadcasting PAN messages (the PAN PAN message is the distress signal with a severity level just below the MAYDAY message), weather forecast, navigational warnings and other relevant radio communication.

The movements of the vessels are electronically recorded, and later available for replay during debriefing.

For each exercise a detailed script was made. The script describes position, speed and course of all vessels, date and time of simulation, weather conditions and current information. The scope of each exercise is described in the instructors material. In the following section a part of the description of a typical SAR exercise is showed.

<u>Script SAR 2</u>

Exercise area: Baltic west, Fehmarn Belt.
Vessels: Vessel no 1 “Erik Boye” is heading east.
Vessel no 2 “Sonja Grønborg ”is trawling east of Fehmarn.
Vessel no 3. “Mette Marit” is heading southeast.

Traffic vessels: The yacht “Seawolf” is heading SSE. Seawolf capsizes at 17.35.
Naval vessel “Søløven” is OSC and is heading WNW.
Other traffic vessels are sailing in the area, but they are not taking part in the SAR operation.

Plot:
17.45 hours LMT.
A small yacht reports, man over board to Lyngby Radio. A woman has reported that her husband has fallen overboard. She is not capable of maneuvering the boat by herself.
Lyngby Radio requests all ships in the area to assist in the rescue operation.
Naval vessel “Søløven” is appointed as OSC (On Scene Commander) by SOK. All vessels take part in a parallel track search.
The yacht “Seawolf” is capsized in position 54.31.1 N 011.25.1 E. One person is at the ships bottom.
MOB (Man Over Board) in position 54.32.4 N 011.27.5. One person is in the water.
In theory Erik Boye will be able to spot the man over board after 1 hour 15 minutes. Sonja Grønborg will be able to spot the yacht approximately 55 minutes after the vessel has started its search.

SAR Exercise No 2			
Exercise: SAR 2		Vessel: 1	Erik Boye: OVXO
Start Position	Course & Speed	Wind & Current	Special information
54°33.5 N 011°16.5 E	115° 9 knot	West 14 m/s, Current 0.3 knots East. Heavy rain showers.	16.45 LMT (ZT -1) 15 November 2001 Visibility les than 5 nm.
Your are on a voyage from Frederikshavn to Gedser Port with a cargo of logs. Please make your planning in Danish chart no 196 Femer Belt 2 hours ahead			
Exercise: SAR 2		Vessel: 2	Sonja Grønborg :OXLU
Start Position	Course & Speed	Wind & Current	Special information
54°29.0 N 011°20.0 E	090 ° 3 knot	West 14 m/s, Current 0.3 knots East. Heavy rain showers.	16.45 LMT (ZT -1) 15 November 2001 Visibility les than 5 nm.

Your are standing by awaiting orders where to unload your cargo of fresh fish. Please make your planning in Danish chart no 196 Femer Bælt 2 hours ahead			
Exercise: SAR 2		Vessel: 3	Mette Marit:GHLX
Start Position	Course & Speed	Wind & Current	Special information
54°36.5N 011°20.0 E	135° 5 knot	West 14 m/s, Current 0.3 knots East. Heavy rain showers.	16.45 LMT (ZT -1) 15 November 2001 Visibility les than 5 nm.
Your are standing by for orders, going slow ahead. Your next port of call will probably be Rostock. Please make your planning in Danish chart no 196 Femer Bælt 2 hours ahead			

Self evaluation by trainees and Instructor controlled debriefing

A very important part of any training session is to carry out a debriefing of the trainees. The system developed will in its final form only require that the trainees have access to a PC, the Internet and the Simflex software. It is not the intention that every trainee station must have an instructor present at the site where the training takes place. This gives on the other hand the problem in the debriefing phase, as only one central placed instructor is available. The solution adopted in the project was to use a WEB based questionnaire [6]. The goal of this questionnaire was to have the trainees to reflect over what had happened during the exercise. Did they write down important data, which were given over the VHF? Did they correctly report their findings during the exercise etc? They were allowed to use their logbook, which they were expected to update during the exercise. The answers were collected and the instructor had a few minutes to browse through the information. After that there was a "meeting" using channel 16 on the VHF, where the individual crews briefed the other crews of 5 good point and 5 weak point in their own handling of the scenario. This was followed by a short sessions where the instructor replayed the crews manoeuvres on the screen and commented on their ship handling and other points of interest.

Assessment of distributed training concepts

Three sites were used in the evaluation, two in Denmark and one at the Aaland Island. Each site had two PCs running the Simflex software. At each site two teams consisting of two navigational students were hired to participate in the evaluation. Each team started by carrying out an introduction exercise, which were used to familiarise the student with the interface to the Simflex simulator and to the manoeuvring characteristics of the ship they had to control through the interface. All teams at a certain site were given the same ship. The local exercise was followed by either a SAR (Search And Rescue) exercise or an exercise with approximately the same amount of communication. The final exercise SAR 2 were the same for all the teams

Team 1		Team 2
Introduction Exercise Local exercise		Introduction Exercise Local exercise
Exercise 1 Training Exercise		SAR 1 Training Exercise
SAR 2 Evaluation Exercise		SAR 2 Evaluation Exercise

Each team had access to two PC's running the Simflex simulator. The teams where allowed to distribute the workload among themselves. A typical distribution was that one person were responsible for controlling the ship, the other carried out the communication and navigational tasks

The interface to the simulator, the small icons in the bottom of the screen give access to expanded views of different instruments. In the exercises the students had the following instruments available: Self-steering instrument, Radar, Steering and speed controls, electronic map and a binocular. Different combination of these instruments can be shown on the screen. In the top of the screen are controls for walking around on the bridge and turning the head in different directions.

The VHF radio developed in the project is modelled after a Furuno model

The local exercise was carried out without connecting the three simulators. The task was first of all to familiarise the student to the simulators controls and the different instruments available on the bridge. A central instructor controlled the Exercise 1, SAR 1 and SAR 2, the exercises were distributed from the Danish Maritime Institute, where the servers for the distribution of the different VHF channels and ship positions were located. The instructor at DMI has the possibility to change parameters in the scenario such as the visibility, location of other ships, location of the capsized vessel (for the SAR scenario) etc.

The teams at each site was observed during the different exercises, see . The observer's role was not to act as local instructors, but only has the task to look at the behaviour of the students during the exercise and to report any relevant observation, which did not come out of the debriefing sessions.

The schedule for each session was as follows:

Telephone meeting and starting up all computers
Instructor launching the exercise
Students fill in checklists
All students reporting by VHF to the instructor
Simulation starts
Simulation stops
Students fill out debriefing questionnaires
Questionnaires are returned to the instructor
Students making self evaluation
The main instructor prepares evaluation of all students
Erik Boye team briefing all other teams on own performances via VHF
Sonja Grønborg team briefing all other teams on own performances via VHF
Mette Marit team briefing all other teams on own performances via VHF
The instructor briefs all teams on their performances via VHF and replay

The last exercise SAR2 was followed by a questionnaire where the students evaluated the overall concept.

Analysis of the final questionnaire

The questionnaire filled out after the completion of all the exercises, was on the other hand aimed at the overall evaluation of the Nordunet2 concept developed. The questions in this questionnaire can be summarized in a number of heading concerning:

- Performance of equipment
- The execution of the exercise
- Learning experience during the exercise
- Expected benefits having access to the tool used in the exercises

The answers in the overall questionnaire have been collapsed in the above shown categories.

Performance of equipment

Table 1 summarizes the user satisfaction with the exercise setup; basically there is a high satisfaction with the performance of the tools and the set-up of the exercises. Looking through the comments received it seems that even with some annoying break downs of the radar in some exercises the students were able to carry out the mission with the remaining instruments

Table 1: Performance of equipment; questions 1 - 3 in the questionnaire		
Very Poor	0	0%
Poor	1	6%
Average	5	28%
Good	11	60%
Very Good	1	6%

The execution of the exercise

A very important step in any exercise is the debriefing phase were the students with the help of the instructor have to reflect on their on behavior and on any other observations they have had during the exercise.

Table 2: Debriefing; question 4 in the questionnaire		
Very Unimportant	0	0%
Unimportant	1	17%
Neutral	0	0%
Important	2	33%
Very Important	3	50%

The big challenge in this project was to setup a system where relevant feedback to the trainees was given. As can be seen from table 2 there are agreement among the trainees that debriefing is important Normally instructors are present both during and after the exercise, as can be seen from table 3 a majority of the trainees do not think that it is important to have an instructor nearby.

Table 3: Physical presence of instructor during and after exercise, question 5-6		
Very Unimportant	1	8%
Unimportant	7	60%
Neutral	1	8%
Important	1	8%
Very Important	2	16%

This could be due to the answers in table 4, where the trainees were satisfied with the debriefing they received.

Table 4: Quality of debriefing, question 7-8		
Very Poor	0	0%
Poor	0	0%
Average	6	50%
Good	6	50%
Very Good	0	0%

Learning experience during the exercise

The trainees were asked to indicate if they felt that the exercise had improved their understanding about the different aspects of participating in Search and Rescue operations. There were here a difference between the answers from the students running the exercise at Aaland and the students carrying out the exercises at DMI and Risø. The students at Aaland had already in their syllabus been going through the SAR material, where the students from Svendborg will go through this material during the current semester. This may explain why the students from Aaland declare that they only had little or no improvement during the filling out of the debriefing questionnaire.

Table 5: Learning experience, question 9-11		
No Improvement	2	11%
Little Improvement	3	17%
Some Improvement	9	50%
Much Improvement	3	17%
A Lot of Improvement	1	5%

Table 5 shows that the majority of the trainees experienced some improvement in their knowledge of SAR operations.

Expected benefits having access to the tool used in the exercises

The trainees were asked to indicate the relevance of having access to a simulator tool as Simflex.

Table 6: Expected outcome using simulator based training, question 12		
No Improvement	0	0%
Little Improvement	0	0%
Some Improvement	2	33%
Much Improvement	2	33%
A Lot of Improvement	2	33%

As can be seen from Table 6, trainees will expect that their education will benefit from access to Simflex. From the free text part of the questionnaire we got the following answer
"It would be optimal if it was possible to conduct exercises as these from your computer at home to a server at school/ in Lyngby or other place". Which nicely summarise Table 6.

Observers comments

A number of observation and comments not picked up by the questionnaire were observed.

- The teams were able to divide the tasks among themselves so one students were responsible for the steering and lookout of the ship whereas the other were carrying out the planning and communication (VHF). One team commentated after the exercises that their task sharing had not been optimal. The students changed roles between the two exercises.

- It was mentioned that normal training in communication were very predictable as they had "standard" answers from the syllabus, whereas the students in the exercises carried out had to judge the current situation and then formulate their answers/questions on the spot.
- There were only observed very few communication errors.

Conclusion

The evaluation of the Nordunet2 project "Maritime Education through Distributed Networked Simulators" shows that even with a limited amount of test subjects used in the evaluation there is a high degree of satisfaction with the developed product.

The main problem foreseen for the project was the debriefing phase, which without direct observation by a skilled instructor could lead to negative training transfer. The solution used in the project with a debriefing questionnaire, followed by a self-evaluation, turned out to be satisfactory both from the trainees' point of view as from the instructors view. This can be seen from the responses to the overall evaluation questionnaire as well as that trainees have experienced an improvement of their overall knowledge of SAR operations.

Acknowledgement

The research was done in the frame of the Nordunet2 [7] initiative supported by the Nordic Council of Ministers and by the Nordic Governments.

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Biography

Steen Weber got his PhD in reactor physics in 1974. Since 1990 he is a member of the System Analysis Department. He is a Senior Scientist at Risø. He has been local project leader of projects in which various knowledge-based systems were developed. His main research interests are in the development, implementation and evaluation of human-computer interfaces.

Hans H. K. Andersen got a M. Sc. in psychology in 1991 from Aarhus University, Denmark and received his Ph.D. in 1997 from Roskilde University, Denmark. He joined the research staff at the System Analysis Department at Risø National Laboratory in 1992. His research focuses on Human-Machine Interaction within the areas of team situation awareness, usability evaluation methodology, user requirements elicitation and human visual behaviour.

SECTION 18:

COMMUNITY VULNERABILITY RISK ANALYSIS

The International Emergency Management Society
9th Annual Conference Proceedings
University of Waterloo, Canada, May 14-17, 2002

ASSESSMENT OF THE CAPABILITY OF LOCAL GOVERNMENT FOR THE VISUALISATION OF COMMUNITY VULNERABILITY

Norm Free

Shire of Yarra Ranges[1]

Keywords: Local Government, Community, Vulnerability

Abstract

Information available to officers of Local Government and regional authorities on community risk associated with hazards such as landslide at a particular location is typically limited to an assessment of the risk of the hazard eventuating. However, community vulnerability to these hazards is related to many aspects of a specific location. Factors include the proximity to the source of the hazard, proximity to the propagation path of the hazard, demographics (population density, age, income, ethnicity, education etc), value of land and improvements, and post-incident availability of essential services and support (a destroyed bridge may isolate an otherwise unaffected community from essential services) and continuity of utilities such as gas, electricity water etc. Information on these further variables is often available to Council, but not in an integrated form immediately useful for community education and hazard mitigation. The Thredbo Landslide (New South Wales, 1997. 18 people dead) has prompted many responsible authorities in Australia to commission geotechnical landslide risk assessments, typically resulting in classification maps (eg. high, medium & low risk). While these classifications provide a useful planning tool, they do not necessarily represent the true community risk. For example, a high value, high density residential development located on stable ground (low risk) downhill from a high-risk area may represent a far greater overall community risk. This project develops a framework to validate geotechnical risk assessments using Geographic Information System (GIS) and visualisation technology to integrate existing landslide probability assessments with social, infrastructure and economic measures to provide a visualisation of community vulnerability to landslide. The resultant information tool will then be evaluated for practicality and usefulness in community education, mitigation of landslip and other hazards.

Introduction

Landslides in Australia are attributable for at least 83 deaths and property damage involving over 200 buildings in the order of $30 million (AUS) present day dollars since 1842. Major incidents to receive international media and community attention occurred at a ski resort in 1997 at Thredbo, New South Wales, involving the displacement of 2,000 cubic metres of liquefied soil resulting in 18 deaths and a cliff collapse in 1996 at Gracetown, New South Wales, resulting in nine deaths. (Emergency Management Australia Reducing the Community Impact of Landslides 2001)

The Shire of Yarra Ranges is a municipality located on the eastern metropolitan fringe of the Capital City of Melbourne in Victoria, Australia. With an area of almost 2,500 square kilometres

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the Shire is the largest of any metropolitan or fringe Council in the State. The Shire has a population currently estimated to be 141,170 people.

In terms of population it is the seventh largest municipality in the metropolitan area and the eighth largest in the State of Victoria in terms of population.

The Shire has an extensive history of landslides. The types of landslides that occur in the Shire include falling boulders, debris flows, slow long-term earth movements, small landslides up to the size of a residential block and large landslides involving entire hillsides. Some landslides move relatively frequently whereas others have not moved for hundreds, perhaps thousands of years. Landslides can be caused by both natural and artificial causes. Heavy rainfall has triggered many landslides in the Shire, such as those that occurred in 1863, 1891, 1928,1934, 1958, 1992, 1994 and 1996. Many landslides often occur then re-occur in the same location; therefore sites where landslides have previously occurred have a higher risk of future landslide.

The largest recorded landslip occurred at Montrose (at the base of the Dandenong Ranges) in July, 1891, and involved the displacement of approximately 30,000 cubic metres of earth and rock causing damage over 1.4 kilometres and was estimated to have travelled at a speed up to 40 kilometres an hour. Two horses were killed, a house destroyed and a lady was trapped but quickly pulled from the debris with minor injuries. In 1992 a significant shift at an active landslip in Blackwood Avenue, Warburton, resulted in permanent closure of the road, evacuation of a number of houses and ultimately the demolition of some houses in that area. (Coffey Partners International Pty Ltd Emergency Response Procedures for Landslides within the Shire of Yarra Ranges M2964/2-AG dated 19 June 2000)

It has been estimated that as a direct result of heavy rainfall in August, 1996, four significant landslips resulted in disaster funding claims to the order of $500,000. In 1998/99 the Shire obtained the services of engineers to conduct a geotechnical survey of the municipality with a view to devising an Erosion Management Overlay for inclusion into the new Planning Scheme and the Shire's Geographic Information System.

The following table describes the risk categories and criteria designated under the Erosion Management Overlay:

Table 1: risk categories and criteria designated under the Erosion Management Overlay

Ex	Exempt	Flat land, unlikely to be any instability, no impacts
L	Low	Landslip unlikely even though the land is gently sloping
MO	Medium Risk	Construction requires compliance with guidelines
M1	Medium Risk	Construction requires compliance with guidelines
M2	Medium Risk	Slopes>20% require a mandatory planning permit and site specific geo-technical assessment
H	High Risk	At risk of landslip without any development. A planning permit can only be issued where a geo-technical investigation shows risk is acceptable. There may be circumstances where a planning permit cannot be issued.

There are approximately 55,000 rateable properties within the Shire of Yarra Ranges. The survey identified 434 properties in the High Risk category and 5,556 properties in the M2 Medium Risk category. This translates to approximately 11% of total properties.

Given the large percentage of properties affected within the municipality, considerable resources were directed at ensuring extensive community consultation was undertaken. Other than an initial influx of general inquiries from property owners requesting access to static mapping information in their particular areas, there has been little response to the information program. Council Officers are now questioning whether there might be a general lack of appreciation of community vulnerability arising from the use of static risk maps.

The information on community risk associated with hazards such as landslide and fire at a particular location, which is available to officers of Local Government and regional authorities, is typically limited to an assessment of the risk of the hazard eventuating. However, community vulnerability to these hazards is a function of many aspects of the location. These include proximity to the source of the hazard, proximity to the propagation path of the hazard, demographics, engineering and other lifelines and the environment.

From an emergency planning perspective the information gained by this survey for the Erosion Management Overlay was limited in that it focussed on the risk of landslip for a given geographic location but it did not provide information indicating the direction of a landslip or debris flow. Emergency planning for landslip would be greatly enhanced if the current information could be modelled to provide an insight as to the impact of an event. Such a tool would be useful in determining the vulnerability of the community by identifying the number of properties affected, the disruption caused by loss of infrastructure such as roads, gas, water, sewerage, electricity, etc. It would also assist in the identification of risk to specific buildings deemed through the nature of their occupancy to be more vulnerable, for example kindergartens, schools, aged person accommodation, hospitals etc.

The Shire's Geographic Information System (GIS) currently captures information relating to rateable properties, topography, satellite imagery and various planning overlays however current resources were insufficient to undertake this project. The Shire also lacked specialist geotechnical knowledge regarding landslip.

In acknowledging the need for expertise and in keeping with its collaborative approach to emergency management, the Shire commenced dialogue with the Royal Melbourne Institute of Technology (RMIT) and the Australian Geological Survey Organisation (AGSO). A joint application was then made to the federal government body, Emergency Management Australia (EMA), to assist in joint funding to assess of the capability of local government for the visualisation of community vulnerability.

The project has been managed by a panel consisting of the research supervisor, Mr Norm Free, Executive Officer Emergency and Safety Planning, Shire of Yarra Ranges, and Matt Hayne, Geoscience Australia. A researcher, David Fraser, a Senior Lecturer, has been appointed and is directly supervised by Dr Ron Grenfell of the Department of Geospatial Science, RMIT University. The researcher has consulted with members of the panel on a formal and informal basis and other members of their organisations on an as-needs basis.

Role of Local Government in Emergency Management

Local government has a moral and legal responsibility of duty of care to its citizens. Legislative controls are put in place to ensure that local government meets its obligations in this area. In Victoria, Australia, the Emergency Management Act 1986 requires that each municipal council forms a Municipal Emergency Management Planning Committee (MEMPC) for the purpose of formulating, monitoring and reviewing a Municipal Emergency Management Plan (MEMP) in relation to the prevention of, response to and recovery from emergencies within the municipality.

The Shire of Yarra Ranges Community Risk Based Emergency Management Plan has been modelled against the Australian and New Zealand Standards for Risk Management AS/NZS 4360:1999 and the Victoria State Emergency Service Community Emergency Risk Management Model (Risk Management and Municipal Emergency Management Planning 1998 p.vi), creating a transparent process and auditable trail in recording the identification, analysis, evaluation and treatment and decision making. This process relies on community consultation and the Shire has made the completed plan will be available to the community. With the integration of 'risk management' into Municipal Emergency Management Plans, (MEMP) the Shire of Yarra Ranges fulfils the recently revised funding requirement under the Commonwealth/State Natural Disaster Relief Arrangements.

Under the Australian and New Zealand Standards for Risk Management AS/NZS 4360:1999, risks are analysed through qualitative measures of likelihood and consequence and then prioritised according to a risk analysis matrix. In many cases it is possible to reduce the likelihood or impact of a risk by adopting various strategies ranging from physical engineering mitigation works to community awareness campaigns. The aim of any mitigation strategy is ultimately to reduce or eliminate the likelihood of an event occurring. If it is not possible to eliminate the possibility of an event occurring then efforts need to be directed at reducing the impact of an event. This structured and rigorous risk management process rated landslip as a high priority.

Topography and history of landslip in the Shire of Yarra Ranges

The Shire of Yarra Ranges can be divided into three zones, the undulating country to the west with suburban development, the forested hills to the east and the valley of the Yarra River, which runs east to west and is surrounded by farmlands. There are four major water reserves in the mountainous areas which supply drinking water for the Shire and metropolitan Melbourne: the Silvan Reservoir in the Dandenong Ranges, Maroondah Reservoir above Healesville, the smaller O'Shannassy Reservoir north-east of Warburton and the Upper Yarra Reservoir further east again. The majority of the suburban areas are found in the western part of the Shire around Mooroolbark, Montrose and Lilydale. The Dandenong Ranges are moderately populated, especially, the Belgrave-Upwey area. Even though much of these hills are heavily wooded approximately one third of the Dandenong Ranges is given over to forest parks, the remainder being zoned for residential or agricultural purposes. Forested mountainous areas also stretch from the surrounds of Healesville in the north-central part of the Shire across almost the entire eastern section. This forms part of the Great Dividing Range. The highest point is Snowy Hill at 1380m above sea level and is located at the northern most point of the Shire. The other major geographical feature of the Shire is the Yarra River, which flows along the eastern part of the Shire and runs through the Melbourne CBD into Port Phillip Bay.

There are 1116 kilometres of sealed roads and 838 kilometres of unsealed roads crossing the Shire. Approximately 60 road bridges providing major links to townships throughout the Shire. Many of the bridges carry essential services such as water and communication cables. Electricity is supplied to all residences with natural gas covering the majority of residences. Council has recognised that the physical diversity of the Shire, in particular the mountainous terrain and large floodplains, also creates challenges in developing and maintaining the infrastructure and in servicing the residents to the desired levels.

Origin of the Project and the Partnership Approach

The value of networking amongst emergency management and associated professionals cannot be underestimated. The annual conferences of the International Emergency Management Society (TIEMS) are based on the strengths and advantages of providing an opportunity for professionals to gather and debate theories and provide insights as to practical application of emergency management.

The concept for this project was born from informal networking of professionals following the Australian Disaster Information Network (AusDIN) workshop conducted at the Australian Emergency Management Institute at Mt. Macedon Victoria, in 2000. The Institute is the education and training centre managed by Emergency Management Australia a Commonwealth (National) body established in 1974 as the Natural Disasters Organisation (NDO) to absorb the functions of the existing Directorate of Civil Defence, coordinate Commonwealth physical assistance to States and Territories in the event of disaster, and assist them to improve disaster management capabilities. Since then the organisation has provided assistance in numerous major counter-disaster operations such as the Cyclone Tracy (which decimated the Northern Territory Capital City of Darwin) in December 1974, the 1983 "Ash Wednesday" Bushfires in Victoria and South Australia, 1986, Cyclone Winifred in Northern Queensland, the 1990 "Great Floods" in central NSW and southern Queensland, the 1993 north-eastern Victorian floods and the 1994 NSW bushfires. In 1993 NDO changed its name to Emergency Management Australia (EMA) and currently performs emergency management functions in relation to natural, human-caused and technological hazards. (Emergency Management Australia website www.ema.gov.au)

Geoscience Australia was first established in 1946 as the Bureau of Mineral Resources, Geology and Geophysics (BMR) with its main aim to perform the systematic geological and geophysical mapping of Australia. It then shifted focus in 1978 to develop a geological understanding of the Australian continent and its offshore areas and subsequently moved towards strategic research. During the 1980s BMR gained expertise in remote sensing and groundwater investigations and commenced nuclear monitoring and geohazard assessment, by building on its activities in earthquake monitoring.

BMR became the Australian Geological Survey Organisation (Geoscience Australia) in 1992 and provided much of the geoscience information that underpinned exploration and development work for petroleum and minerals in Australia. A review carried out in Geoscience Australia's infancy concluded that geoscience was relevant to society by providing information essential for economic prosperity and for the proper use of resources to protect the local and global economy. The change of name to AGSO – Geoscience Australia in August 2001, and to Geoscience Australia in November 2001, is recognition that the agency's work is vital in a wide range of contexts. (Geoscience Australia website www.agso.gov.au)

RMIT is a university with a global focus in Melbourne, Victoria, with three main campuses and offers many qualifications in collaboration with more than 190 partner institutions around the world including a student exchange program with the University of Waterloo. It is a member of the Australian Technology Network (ATN), a coalition of five leading Australian universities across the country and part of the Global University Alliance (GUA), a partnership of ten international universities, dedicated to providing students across the globe with accessible education using the latest interactive web and data-based technologies.

The RMIT University Geospatial Science Initiative (RMIT GSI) - an initiative of RMIT University's Department of Land Information - aims to create business and strategic partnerships, ensure the commercial application of the university's best R&D in the geospatial sciences, and grow the geospatial science industry in Victoria and nationally. RMIT University's Department of Land Information is recognised nationally for supporting leading edge R&D in specialist areas including technology convergence, remote sensing and geographic information systems, information modelling, satellite positioning, measurement and mapping sciences, multimedia, visualisation, the World Wide Web applications and sustainable development. (RMIT University website www.rmit.vic.gov.au)

Project Aim

The primary aim of this project is to assess the capability of local government to produce an effective visualisation of community vulnerability from currently available data, modelling techniques and technology, suitable for community education and hazard mitigation. The project will develop a methodology for integrating currently available data, models and techniques for this purpose and will then assess the effectiveness and limitations of the resultant visualisation. Geographic Information System (GIS) and visualisation technology will be utilised to integrate existing landslide probability assessments with social, infrastructure and economic measures to provide a visualisation of community vulnerability to landslide. The resultant information tool will then be evaluated for practicality and usefulness in community education and hazard mitigation.

Project Objectives

The project's objectives are to deliver the following:

- A methodology for Local Government to integrate currently available data, models and techniques for community vulnerability visualisation
- An assessment of the adequacy of currently available data, models and techniques for visualisation of community vulnerability, together with an assessment of the likely improvements from wider knowledge and information sharing
- Identification of hazards originating from land owned by other agencies, eg Department of Natural Resources and Environment, other municipalities, that impact on vulnerable elements of the Shire of Yarra Ranges thus requiring a collaborative approach to mitigation
- Increased awareness of community vulnerability to landslide by the Yarra Ranges community
- Incorporation of the information into all facets of emergency Management within the Shire of Yarra Ranges including planning, preparation, response and recovery
- A case study in the Shire of Yarra Ranges as an example of the degree to which an authority with significant need for such an information product is able to do so with generally available resources and organisational arrangements. The case study will be packaged in a form suitable for dissemination through the World Wide Web.

Project Methodology

Review literature on community vulnerability landslide modelling, and visualisation. Considerable research has been conducted utilising resources of the University, EMA (which is reputed as having the most extensive emergency management library in the Southern Hemisphere) and Geoscience Australia.

Review suitability and availability of existing data, models and technology identified as relevant following the literature review. The Shire currently possesses a mature Geographic Information System (GIS) to support Council's mapping and information needs. An initial review of the data suggests that there is a clear deficiency in information relating to the specific location of utility infrastructure relating to electrical and gas utilities. The AGSO Cities Project, which assesses the effects on urban communities of a range of natural hazards, incorporates examples of some of the models currently being reviewed.

Consult with Council and AGSO officers to develop a model of community vulnerability to landslide. The model will be a function of proximity to the source of the hazard, proximity to the propagation path of the hazard, demographics (population density, age, income, ethnicity, education etc), value of land and improvements, post-incident availability of essential services and support, and other variables identified in previous steps. Two levels of vulnerability were established. Primarily the community, infrastructure and environment directly in the path or immediately adjacent to the debris flow and secondly to those elements not directly impacted upon but vulnerable as a result of the damage and disruption caused by the landslide which would include people isolated by the damage to roads or from the loss of engineering and other lifelines.

Knowledge of the level of vulnerability to an event becomes a crucial element in reducing its impact. If one considers vulnerability as the relationship between susceptibility and resilience then by reducing susceptibility (such as ensuring physical distance of community to a risk) and increasing resilience (by educating a community on the existence of a risk and how to respond appropriately) one can effectively decrease the level of vulnerability to which that community is exposed.

Select an appropriate case study site with guidance from Yarra Ranges Shire Officers. The choice of the case study site was based on needs of both the Shire Officers and the researcher and included the need to select a relatively small geographical area with preferably a well known active landslide that had been studied by a geotechnical engineer to provide expert advice as to the anticipated debris flow in the event of a catastrophic failure. The project model could then be tested to ascertain whether it provided information consistent with that predicted by the geotechnical engineer. Other factors were also considered relating to the location and proximity of a variety of vulnerable elements to the site.

In October 1992 an active landslip in Blackwood Avenue, Warburton (located in the eastern region of the Shire), moved significantly resulting in the evacuation of houses in the immediate area and the permanent closing of the road. Historical information indicates that this landslip has been in existence for, perhaps, thousands of years and was almost certainly well established prior to European settlement in the Warburton area. The earliest recorded movement of the landslip occurred in the early 1950's. The landslip has moved every decade since then and is expected to continue moving. It is believed that total movements in the order of 20 to 30 metres have occurred since the landslip formed (based on the present slope profile and the assumed pre-landslip profile).

The Blackwood Avenue landslip lies on the north bank of the Yarra River at Warburton. The toe of the landslip is at the edge of the river. Cumulative movements up to about 1.5 metres have been measured on the Blackwood Avenue landslip in the last seven years. Concern has been expressed that this landslip may fail catastrophically, blocking the river, and this could lead to flooding of the Warburton area. The landslip covers approximately 6 hectares. It is irregular in shape and has a maximum length of about 320 metres and a maximum width of about 230 metres. Currently there are no occupied buildings on the landslip. Four houses were on the site until the early 1990's. They have since been demolished or permanently vacated. Four houses lie in close proximity to the edges of the landslip.

No evidence has been found to suggest the landslip may have blocked the Yarra River in the geological past, let alone in more recent times. The available evidence indicates the landslip is "slowly shuffling" along, most likely in response to heavy rainfall and that substantial movements causing the river to totally block are unlikely to occur. Irrespective, given the narrowness of the river and the uncertainties regarding the behaviour of any landslip and the events that could take place in a major storm/flood event, the consequences of the landslip blocking the river need to be considered.

In the opinion of the geotechnical engineers engaged to assess the landslip, in the very unlikely event of a total blockage of the river, the resulting landslip dam is likely to be made up of loose debris, which would erode quickly, particularly if over topped by the river. If the unexpected happens and the dam is not rapidly eroded, flooding will occur. This will, in turn, primarily affect infrastructure, such as the bridge spanning the Yarra River (shown above), which carries the main Highway through the township. This will result in the isolation of services such as the hospital and the volunteer fire brigade and loss of engineering and other support lifelines. (Coffey Partners International Pty Ltd Emergency Response Procedures for Landslides within the Shire of Yarra Ranges M2964/2-AG dated 19 June 2000)

Obtain and integrate relevant models and data in a GIS environment, developing general integration methodology. A number of relevant models are still being explored including those incorporated by AGSO in its Cities Project, which assesses the effects on urban communities of a range of natural hazards.

Four broad data sets are currently being collated and/or considered for inclusion in this project. Each set has been categorised into a general and more specific groupings.

SET 1 - Hazard identification: Awareness Level 1 – general includes land cover, streams, flood plain, slope gradient. Level 2 – specific includes geology, mantel of soil and rock fragments, bare soil, erosion gullies, forest cover and groundwater regime.
SET 2 - Areas prone to instability in the Shire: Awareness Level 1 – general includes broad geographic areas such as the rolling slopes of Mooroolbark, Silvan, Wandin Yallock, Forest Hill and Wandin East; Kalorama and the western and north-western slopes of Mt. Dandenong. Level 2 – specific includes land fill, soil creep, batter slopes, seepage.

SET 3 - Critical facilities analysis Level 1 – general includes **e**xisting development, key economic centres. Level 2 – specific includes hospitals, emergency services, retirement villages, government offices. Level 3 – detailed includes roads, gas lines, electricity lines, water mains, telecommunications, public transport. This data set will also be considered to include an inventory incorporating details such as facility name, type, street address, town, owner, contact name and title, contact telephone number and emergency service district.
SET 4 - Environmental analysis Level 1 – general including **e**nvironmentally sensitive locations, areas subject to primary environmental impact, areas subject to secondary environmental impact. Level 2 – specific includes structural vulnerability, operational vulnerability, societal vulnerability. Level 3 – detailed includes critical facilities hazard risk areas, natural hazards risk areas, population (*housing*) density, location of hazardous or toxic sites, cleared sites, natural drainage interference, assembly areas for population.

Create alternative visualisations of community vulnerability. To date the following visualisations have been created:

- Warburton satellite image
- Blackwood Avenue landslide
- Topographic map of the Blackwood Avenue Case study Area
- The Yarra River and Bridge at the Blackwood Avenue study site
- Digital Elevation Model of Blackwood Avenue Environment
- Site of the Blackwood Avenue landslide
- Possible flooding extent after the landslide shown with public buildings (buffered)
- Buildings on low lying land
- Steep slopes in relation to buildings
- Steep Slopes on terrain model
- Steep slopes in relation to road locations

Evaluate information products through focus groups consisting of community members and council officers. Stakeholders, including the community, other land owners and other stakeholders, who have been identified as vulnerable to the impact of a landslide in the selected site such as a local school and an aged care facility, are currently being canvassed as to their needs with a view to conducting a public meeting. This forum will provide an opportunity to demonstrate the various visualisation models and obtain feedback as to the relevance and effectiveness of the visualisations. The forum will also provide an opportunity to gauge support for community involvement in a system to monitor the landslip.

Evaluation of the project. The project will be evaluated in achieving its objectives and its effectiveness by:

- surveying the community and stakeholders regarding the visualisation in meeting their needs.

- survey of Shire of Yarra Ranges Officers from the Emergency and Safety Planning, Planning, Building Surveyor and GIS areas as to the suitability of the model to meet individual needs.
- survey of other municipalities regarding the model.
- survey of RMIT and AGSO stakeholders.
- Overall assessment for broader application by Emergency Management Australia.

Conclusion

Although this project is still in progress a number of significant factors are worthy of note:

- The opportunities derived from informal networking at emergency management forums to initiate collaborative inter-agency projects
- The appreciation for community involvement in emergency management projects
- The acknowledgment of State and Federal Agencies of the need for tools to assist emergency management practitioners and the community in reducing vulnerability
- An acknowledgment of the advantages to be gained through the application of computer technology to aid emergency practitioners
- The opportunity for effective practical advances in emergency management through the collaborative efforts of practitioners and academics.

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Acknowledgments

I would like to thank the researcher, David Fraser, Senor Lecturer, RMIT University, for his involvement in the project and for providing information intrinsic to the details of the project in this paper.

I would also like to thank Dr Ron Grenfell RMIT University, Matt Hayne AGSO and Rob Taylor-Pike of Emergency Management Australia for their involvement and valued contribution.

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REDUCING THE GAPS BETWEEN PRESCRIPTION AND PRACTICE BY ANALYSIS AND SHARING OF EXPERIENCE

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Keywords: Procedure of delegation, communication, sharing of knowledge

Abstract

Two important aspects of the safety of chemical plants are the design of safe systems and the definition of procedures and prescriptions to run the different processes of the plant.

Along the life of the plant, technology and organizations change, people adapt their behavior to their perceptions and experience, but procedures and prescriptions often remain the sole reference. This tends to create a gap between prescription and practice.

This gap is difficult to assess during routine operations as everything runs smoothly, but when an incident occurs, it may become a risk factor because some people trust the procedures when identifying the problem and finding a solution, while the real state of the process may be inappropriate for these actions. We have studied this problem in a chemical plant near Grenoble (France), using an analysis method based on the formalization and sharing of individual experiences. It has been possible to identify the gaps between prescription and practice, to reinforce the dialog between stakeholders, and to reach a common acceptation of the prescriptions taking into account their initial justifications and some relevant suggestions proposed by operators.

Introduction

A chemical plant is characterized by the complexity and the diversity of its systems and processes, the multiplicity of the stakeholders (interns and subcontractors) and the variety of its products and activities. The risks related to each industrial activity are inherent to installations, products used, organization and processes. Procedures and prescriptions are relevant tools to control installations, complex systems and processes. They constitute the primary safety mechanism by providing a technical and procedural framework to guide the actors in their decisions and actions.

> *"Procedures will be applied by people at the good moment. They have requirements and expectations that result in part from their experience, formation, personality and from the technical and social tradition from where they come. From one system, one industry, one population to another, differences are big. Then, it is important to avoid the phenomenon of rejection, doubts and misunderstanding that can start from a wrong adaptation of procedures to the people to whom they are intended. It is difficult or even illusory to design procedures without the effective participation of the final*

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> *users. The human factor has his requirements as regards the form and the content of the procedure".* [Translated from Nicolet 1990]

Inside a plant, nothing is static; systems, people and organizations change with time, evolution of technology and accumulated experience, and it is important to harmonize the procedures to this changing environment.

> *"Procedures are not only understood like the use of instructions but also as the result and the creator of a complex interaction process whose stakes relate to the culture of the company and its evolution".* [Translated from Minzoni-Deroche 1997]

This means that we have to assess what are the gaps between the prescription (procedures) and the real practice, and how to reach a consensus among stakeholders on the adaptation of the procedures, to reduce these gaps.

In this perspective, we have used a methodology based on the sharing of experiences [wybo 2001] that focuses on human and organizational factors.

The objective of this method is to highlight the know-how of stakeholders and to make them aware of the importance of a pro-active approach (participation, motivation) in the research of harmonization in the definition and evolution of procedures.

The «procedure of delegation»

A chemical plant is composed of different units: production, storage, maintenance, etc. These units need to be well maintained to avoid accidents and to keep the system safe. Consequently, it is necessary to check the components, products, and processes and to carry out the repairing task as soon as a problem has been identified.

In this context, the chemical plant in which the study has been made has designed a specific procedure called "procedure of delegation" that describes the prescriptions to apply on that site.

This procedure includes the request for works, the organization, the follow-up and the closing of a maintenance operation. The production and maintenance units are the primary stakeholders in this process. In many cases, a subcontractor is given a delegation to carry out the task.

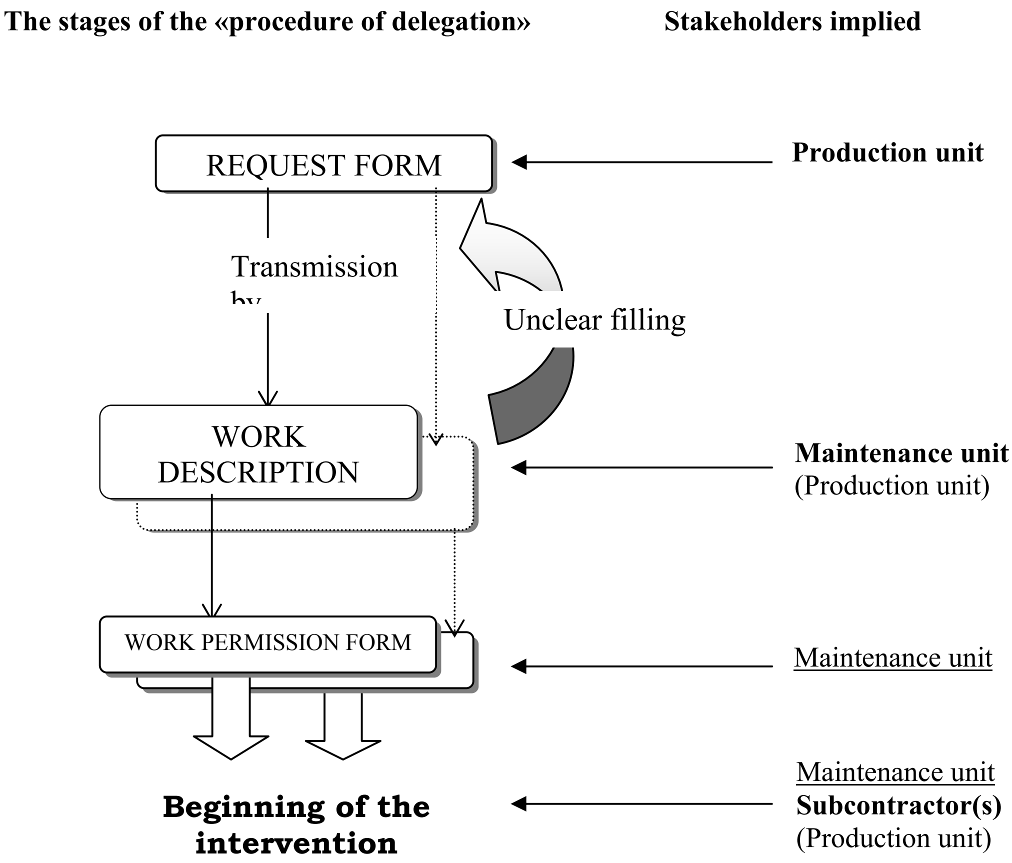
Three documents are used to organize this process:

- The request form, which is at the origin of the «procedure of delegation». A problem is identified by the production unit, which creates a request to solve the problem. This request form is transmitted for information to the maintenance unit. It is the first stage of the process.
- The work description form. The maintenance creates it after determining precisely the nature and the description of the works. Several forms can be issued from one request form.
- The work permission form that describes the work, the means to use, the existing risks, the protections and – if needed - the subcontractor company chosen to carry out the task. There is one work permission form for each work description form.

The figure 1 shows that several outsourcing companies may intervene in the procedure of delegation, which implies an increased number of stakeholders in the process. Although the procedure defines their roles, some gaps may appear between prescription and practice, caused by a lack of information, poor coordination and "dissonances" between stakeholders and ignorance of their specific constraints of parties.

> *The term "dissonance" (discord) corresponds to the differences of opinion, disagreements and tensions, which exist between two networks of stakeholders" and constitute risk factors.* [Translated from Kervern 1998]

Figure 1: Main documents and stakeholders involved in the «procedure of delegation»



This point raises four central themes/questions:

Lack of co-operation between stakeholders

The outsourcing, the increasing number of stakeholders, and the use of new technology, lead to a decreasing flow of tacit exchanges of information and knowledge between stakeholders, in support to formal exchanges, represented by standardized forms, invitation to tender, contracts, etc.
Each stakeholder thus remains trapped within his framework of work, the dialogue tends to be reduced, and a corporate safety culture is therefore more difficult to build.

> *The cooperation activities depend on framework's organizations and communication tools placed at the disposal of the agents to synchronize themselves mentally (construction of a shared representation) and temporally (in the action).* [Translated from Amalberti[a] 2001]

Perception of stakeholders

The procedure specifies what are the rules to follow at the time of the organization of a maintenance operation but it gives a freedom of interpretation with regards to the identification of problems, the estimation of the emergency level, the comprehension of the work to be done, the filling and circulation of documents.

> *The quality of technical documents…can be a factor of formidable complexity when it's wrongly written.* [Translated from Amalberti[b] 1991]

In these domains, malfunctions appear in the ways to achieve tasks. This creates gaps between the prescriptions (what is written in the documents), and the practice (what is understood from their contents).

Example: filling the request form. This task requires a clear identification of the problem and a good wording of the text in order to make the document well understood by the maintenance unit that has to organize the work. But sometimes, the document is not clear enough, which creates misunderstanding and delay in the procedure. This could be solved by organizing the dialogue between stakeholders.

> *Collective activities, where the actor's task depends on the results of other actors over whom he has no control, also constitute an example of the weakening of the prescription-event linkage.* [Schlenker 1994]

There are also the transmission paths of documents, which are not always appropriate and so, relevant information may not be transmitted. This reveals a part of the ignorance of the stakeholders as regards to their respective constraints and difficulties.

> *The irreparable gap existing between prescription and practice result from the insuperable difficulty to lock up inside a total forecast, the whole situations that can be met when running a complex system.* [Translated from Verot 1999]

But, even if it is not possible to prescribe everything inside a procedure, it is important to consider the professionalism and the behavior of people so that the documents are correctly filled out and their contents fit the needs of concerned people. This can be achieved in a framework of trust and mutual respect, by a strong knowledge of the work and by the competence of people.

The loss of knowledge

Knowledge management is the result of a corporate work and the sharing of information among all stakeholders involved in the process (from the operators up to the top management).

> Knowledge management is about people and processes they use to share information and build knowledge. *[Hanley 1999]*

The aim is to favor the circulation of information between the different units, following a network approach more than a hierarchical one. But the major difficulty remains in the collection of information.

> Knowledge creating depends on the tacit knowledge of individuals and groups, and on the knowledge links and alliance that they and the organization have developed internally and externally with other partners. *[Choo 1998]*

The stakeholders don't know inevitably the constraints and the difficulties of everyone because they don't have enough opportunities to discuss and share their experiences among them. Consequently, the information that could be exploited remains tacit and unknown by the organization.

Risks associated with the loss of knowledge

To achieve some very technical operations or in contact with dangerous fluids (like mercury), subcontractors need to have specific skills in the domain, and a precise follow-up of their activity must be ensured by the maintenance unit.

Nevertheless, these specific skills are not always checked, which can cause injuries to staff and damage to processes. For each task, stakeholders must be informed and trained to face the risks. Providing information about the risks related to the tasks cannot be avoided and checking the availability of this knowledge in the choice of subcontracting companies should be a priority.

People from the chemical plant and from the subcontractor company have to share their knowledge and experience, in order to develop organizational learning. This point is a matter for prevention activities inside the plant and for organizing the training of subcontractors.

Methodology: Formalization and sharing of individual experiences

Most of the times, the sharing of experience consists in collecting information concerning an accident from all stakeholders involved in a process or an organization. Generally, there is no more implication of people in the processing of this information, except from sanctions or changes in procedures. In order to reduce this frustration that reduces the willingness of people to comment incidents, our approach is to present to the stakeholders the importance of their participation, their perception and their competence in the management of incidents and other activities.

The aim of the method is to favor exchanges, group work and sharing of knowledge, implicating stakeholders in the analysis of the activity, in order to develop a corporate language and culture. This method, entitled "*the positive experience reflection method*" [Colardelle 2000], was designed to build the complete representation of the development of an incident, accident or crisis.

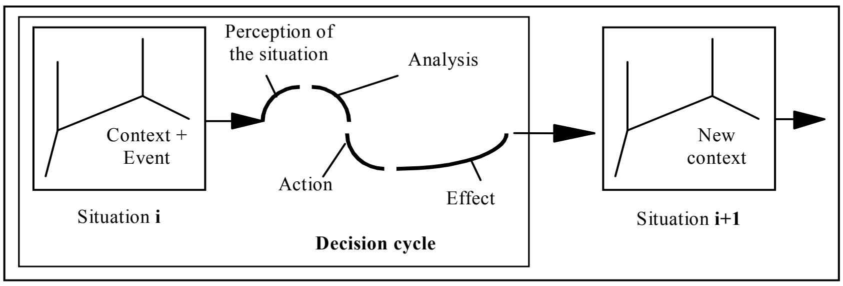
> *Experience reflection is a management method in which people having participated in the management of an action, analyze the development of the situation, learn lessons and apply decisions to avoid problems in the future.* [Colardelle 2000]

This method has been adapted for application to the study of procedures. It is composed of three phases: collection of information, formalization of experience and sharing of knowledge.

Collection of information

The procedure of delegation includes many actors. The main objective of this phase is to identify the stakeholders directly concerned with the procedure of delegation and to collect their experience through anonymous interviews. This dialog provides a good understanding of their perception of the tasks and enlightens the difficulties and constraints of their work. Then discussion is focused on alternatives that they can propose to improve the procedure, and on their justifications for these improvements. This part of the interview gives access to their know-how, experience and tacit knowledge.

Figure 2: Decision cycle [Colardelle, 2000]



Formalization of experience

After the interviews, all the data collected must be merged and formalized, to obtain a clear and simple display of the dynamics of the application of the procedure, represented by a series of events and decision cycles (fig. 2).

Each cycle is formed of 4 phases:
- Situation: context and event,
- Analysis of the situation by the stakeholder,
- Action (done according to the analysis)
- Effects of the action.

The procedure of delegation is composed of different documents to fill out and to transmit to the relevant parties. The representation as decision cycles contributes to clarify the sender, the receiver and the contents of the document, at each step of the progress of the activity described by the procedure:
- The document
- The stakeholders
- The transmission paths of documents,
- Suggested alternatives to malfunctions and improvements

Once this clarification is made for each stakeholder, it is easier to show, understand and discuss about the gaps and the malfunctions that occurred.

Sharing of individual experiences

Once the whole procedure of delegation has been formalized as a series of decision cycles, our approach is to bring together all the actors interviewed and to present them the final document, during a "*mirror effect meeting*" [Colardelle 2000].

Each stakeholder is provided with a document that gives him a global view of the collective experience, collected through the individual interviews. The aim of this phase is to validate the knowledge resulting from the experience of the group, to make the stakeholders aware of the tasks and constraints met by every of them, to identify the gaps between practice and procedure and to try to reduce them.

During this meeting, all stakeholders have the opportunity to exchange, share and communicate on the different matters. The objective is to create a dynamics of learning, based on mutual respect and the use of a common language, in order to build a consensus between stakeholders and to share knowledge. The aim is to reach a collective appropriation of the procedure of delegation and to develop a safety culture inside the plant by organizing reflection on safety management issues.

> *It is necessary to discuss the technical finds, to organize a proceeding about advantages and disadvantages for adopting them, integrating them somehow in the tradition of the company or the job.* [Translated from Dejours 1995]

Contributions of the sharing of experience in reducing the gaps

The method gives a detailed representation of the procedure. Thus, it is possible to improve the knowledge of the organizational, technical and human aspects of the procedure of delegation. Furthermore, this process highlights forces and weakness of the procedure, by describing real practices, identifying problems, and designing a more effective procedure, approved by all parties.

The role played by the representation of knowledge

The representation of experience as a set of decision cycles enables to reduce differences in opinions among parties. It gives access to the "intimacy" of a procedure, by the understanding of difficulties and specific constraints met by everyone, at each step of the application of the procedure.

> *Members of an organization must have a clear view of their role and responsibility in the operation…and must achieve a new culture which consists of finding valid information, making informed choices and checking the implementation of their decisions for recovering and reducing errors.* [Translated from Moingeon 1995]

The knowledge gained from malfunctions is a source of improvement for the organization. This approach contributes to agree on a "collective truth" about the real application of procedures, which is more complete in terms of human and organizational aspects.

Promoting a group work

The federative aspect of the method enables to involve stakeholders and to modify their behavior thanks to a better comprehension of their constraints. Bringing together all the stakeholders and supporting the cross relations between the different units is a way to improve comprehension and knowledge of the real situations and to support progress in efficiency and safety.

> *It is essential to be able to observe and understand from inside, with the help of the stakeholders themselves, in which forms and which costs (psychological, sociological, political and economical), a whole organizational community (the whole stakeholders of a system), manage the obligation to complete the tasks successfully, very often difficult, in a good reliability.* [Translated from Bourrier 2001]

During this study, we have observed that the stakeholders felt motivated to participate to the procedure and to belong to a group in which the objective is working better together. Group work gives a collective view and understanding that could not be perceived by only one person.

> "*A good management of information is a condition necessary for the organizational learning.*"[Translated from Moingeon 1995]

Promote a consensus

The objective of this study is to study the best conditions to harmonize prescriptions and actions undertaken in the plant. Promoting a sharing of knowledge enables each stakeholder to know the whole procedure and to transmit his/her opinions and suggestions concerning the operations. The objective is to reach a consensus, an "objective truth" accepted by everybody, which recognizes and takes into account the individual achievements of stakeholders. This rewarding and pro-active approach demonstrates its efficiency in motivating stakeholders to participate and involving them in the search for performance improvements while respecting prescriptions.

Subcontractors training

The maintenance unit is aware of the importance of checking the specific skills of subcontractors, to train them to the tasks to be done and to face the risks of operations. Indeed, before starting a maintenance operation, the maintenance unit explains the work to be done to the management of the subcontractor company, which transmits this information to their staff. These explanations are given outside the context, which can create misunderstandings and loss of information. That is why the maintenance unit has to be careful about the training of subcontractors.

The application of this method has been perceived very positively because it succeeds to achieve two major objectives: design and apply an effective procedure approved by everybody, and reinforce the sharing of knowledge between stakeholders.

Conclusion

The sharing of experiences is a powerful tool as regards to the collection and analysis of information. This case study shows that the methodology used is operational to support comprehension and improve knowledge about the application of the procedure of delegation. It is perceived as:

- A working method which gives access to the dynamics of the procedure of delegation
- A means to identify and reduce the gaps between practice and prescription, as regard to comprehension and transmission of documents, identification and management of problems.
- A unifying element among the stakeholders: improvement of the cross relations between units, strengthening of cooperation among people
- A way to reach a consensus accepted by everybody, which values individual suggestions.
- A reinforcement of communications and sharing of knowledge among parties.
- A better training and supervision of subcontractor companies.

This study shows that procedures and prescriptions have to be adapted to the actions and decisions of the people who apply them, who are confronted with difficulties in their application, who suffer injuries and blame, but who also develop appropriate solutions. Learning from these experiences and sharing knowledge among stakeholders is a key aspect in keeping a balance between the need for a strong corporate memory and the development of outsourcing.

> *Procedures remain the primary mechanisms for maintaining the corporate memory work force. The loss of corporate memory can be devastating without comprehensive and accurate procedures and mature processes* [Work group 1997]

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AN ASSESSMENT OF DISASTER VULNERABILITY:

Fifteen Tenets About a Crucial and Complicated Concept

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Keywords: Vulnerability, Hazards, Disaster, Emergency Management

Abstract:

The following paper reviews the research literature on disaster vulnerability and provides 15 tenets about this important concept. Findings are taken mainly from sociologists, but also include various disciplines such as geography, engineering, anthropology, political science, economics, public administration, social work, public health, urban planning, environmental science, etc. The purpose of identifying these tenets is to uncover what is known about vulnerability, and stress the centrality of this concept for academics and practitioners pursuing disaster reduction.

Introduction

Scholars interested in disaster studies are currently calling for a holistic and even revolutionary shift in paradigms (see Mileti 1999, 35; Geis 1999). The need to rethink traditional theoretical perspectives and entrenched policy approaches stems from a recognition that we are not doing all that is possible to reduce the frequency and severity of disaster. Ironically, however, attention still focuses on hazards while insufficient recognition is given to vulnerability. The failure to appreciate the importance of this concept is limiting our understanding of disaster phenomena as well as our ability to prevent or manage the adverse effects of mass emergencies.

With the above in mind, the following paper reviews relevant research literature. Findings have been taken mainly from sociologists, but also include various disciplines such as geography, engineering, anthropology, political science, public administration, economics, social work, public health, urban planning, environmental science, etc. The paper proposes and discusses 15 tenets about the concept of vulnerability. The purpose of identifying these tenets is to uncover what is known about vulnerability, and stress the centrality of this concept for academics and practitioners interested in disaster reduction.

Tenet 1: We have control over vulnerability - not natural hazards

Throughout history, humans have traditionally viewed disasters as acts of God (Drabek 1991, 3). The problem with this conceptualization is that it ignored the natural processes of the physical environment. With this added knowledge, people later equated disasters to natural hazards such as earthquakes and hurricanes. While this overcame the weaknesses of the previous perspective, it was also flawed in that it ignored the human component of disaster (O'Keefe, Westgate and Wisner

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1976). For example, a tornado that touches down in a vacant field is only a natural hazard. When a tornado interacts with a social system that has not taken measures for mitigation or preparedness, a disaster may result. But this is not all. Some disasters, such as a hazardous materials spill or terrorist attack have human instead of natural causes. Another problem with the natural hazard paradigm is that it resulted in a technocratic approach to disaster reduction. Efforts were aimed at controlling nature, which often resulted in repetitive losses and frustration. Taking this into account, social scientists, particularly sociologists, have recently come to recognize that disasters are not just natural phenomena. Instead, there is a social cause for mass emergencies; disasters are also non-routine social problems (Kreps and Drabek 1996). The first proposition of vulnerability, therefore, is that we mainly have control over this "social" aspect of disasters. In contrast, humans have less control over natural hazards. Thus, as Cannon illustrates (1993) so well, "a hazard need not a disaster make." For this reason, academics and practitioners need to focus attention on understanding and reducing disaster vulnerabilities rather than just focusing on hazards.

Tenet 2: We may be vulnerable to many different types of hazards

While attention needs to be shifted towards vulnerability, this does not imply that hazards are unimportant. A second and major point to be made is that people can be vulnerable to a plethora of hazards (Merriman and Browitt 1993; Perrow 1999; Falkenrath, Newman and Thayer 1998). For instance, we may be vulnerable to natural hazard agents such as earthquakes, hurricanes, tornadoes, volcanoes, floods, tsunamis and wild fires. We may also be vulnerable to severe winter storms, excessive temperature fluctuations, landslides, and other extreme natural phenomena. In addition to being vulnerable to natural hazards, we may be vulnerable to biological and environmental hazards. This may include the spread of aids, small pox and other infectious diseases. Vulnerability to global warming and other forms of environmental degradation is also possible. Technological hazards also exhibit a relation to vulnerability. This may include vulnerability to airplane crashes, train derailments, hazardous materials spills, dam failures, power losses to electric grids, nuclear plant accidents, industrial explosions and computer malfunctions. Finally, we may be vulnerable to civil type disasters such as mass shootings, riots and terrorist incidents. Thus, it is possible to be vulnerable to many different types of hazard agents.

Tenet 3: Vulnerability occurs at the interface of the physical and social/organizational environments

Although it is possible to categorize our vulnerability in terms of many different hazards, doing so runs the risk of oversimplifying the complexities of vulnerability and disasters. In other words, we are likely to be vulnerable to a combination of several different types of hazards at the same time (e.g. natech disasters such as the combination of earthquakes and hazardous materials spills). Moreover, vulnerability may emanate from the physical environment based on the hazards and geography of that area. It may exist in the built environment due to the construction of edifices, dams, roads and bridges, water systems, phone lines and other infrastructure. And it may also be based on human activity and the nature of our social, political, economic and other institutions. However, vulnerability is more a function of each of these environments together, rather than being a result of any single environment alone. Vulnerability is therefore most likely to be present at the intersection of the natural, built, social/organizational environments (Mileti 1999; Burton, Kates and White 1993; Cutter 1993; Liverman 1990).

Tenet 4: Vulnerability is determined by both the positive and negative features of the physical and social/organizational environments

Vulnerability is not only complex due to its overlapping relationship with different environments, but it is complicated further due to the positive and negative features of those distinct but overlapping realms. On the one hand, there are many negative features of the physical, built and social/organizational environments that augment vulnerability. This may include being located in on a dangerous hillside, living in a poorly constructed home, or having certain attitudes that downplay the potential for disaster. These we may label as liabilities. On the other hand, there are also positive features in the aforementioned environments that actually reduce vulnerability. For instance, a certain location may be less vulnerable to technological disaster if it is situated far from an airport, an industrial center or a hazardous materials transportation route. Buildings may be less vulnerable to structural failure based on certain engineering practices. Or, heavy furniture and water heaters can be tied down to reduce vulnerability to certain hazards such as earthquakes. These we may label as capabilities (see Anderson and Woodrow 1998). In reality, the vulnerability of any given area is determined by both the liabilities and the capabilities of the environments at play in that location. Hence, a specific low-lying area may not be vulnerable to earthquakes but may be vulnerable to episodes of flooding. A building that is less vulnerable to high winds may be vulnerable to a terrorist attack involving biological weapons. Communities that are less vulnerable to a disaster in terms of preparedness measures (as they are better able to respond) may not have done enough to prevent them in the first place. These liabilities and capabilities may not always work at cross-purposes however. The combination of certain environmental features may produce a situation where liabilities are low and capabilities are high. For example, it is possible to locate a building in a safer area and construct it in a way as to withstand many different hazards. Or, a society may do much to reduce the probability of disaster through mitigation efforts while still maintaining an adequate state of readiness to respond. In most cases, though, both liabilities and capabilities influence the degree of vulnerability in a convoluted fashion.

Tenet 5: Vulnerability is the product of many variables

The positive and negative features of the distinct but overlapping environments include many variables that influence the level of vulnerability (see Alexander 1993). The geography of an area may increase or reduce vulnerability in terms of proximity to hazards. Building design and construction plays a role in whether the occupants are vulnerable or protected. Political values determine what hazards will be addressed and those we accept (e.g. giving priority to environmental hazards vs. terrorism or vice versa). Economic preferences and practices may reduce vulnerability, ignore it altogether or actually increase it. Psychological processes may encourage a community to pursue safe development or undertake activities with no regard for the outcome. Technology may lead to a disaster if it is used improperly, or it may help us in our efforts to prevent and respond to these deadly, destructive and disruptive events. Attention given to planning, training and exercises determines the effectiveness or ineffectiveness of important disaster functions such as emergency response, damage assessment, donations management, and debris removal. Family structure may facilitate emergency response or inhibit recovery. Education may promote preventive actions or inhibit emergency operations if it is based on inaccurate assumptions. Other variables, including zoning laws, building code inspections, insurance coverage, scientific research, networking of emergency managers, language barriers, computers, cooperation of first responders, the media and demographic trends, also impact vulnerability. In short, there are many variables that interact to produce the degree of vulnerability.

Tenet 6: The variables of vulnerability exhibit distinct patterns

In spite of the fact numerous factors produce vulnerability, there are identifiable patterns of interaction (McEntire 2001). These include cultural attitudes and practices, development processes, and institutional arrangements. First, culture may influence vulnerability. Beliefs about the causes or controllability of disaster have an impact upon what steps an individual or community takes to address vulnerability. Vulnerability is also influenced by daily activities at home or at work. The development of economies and urban areas likewise influence the degree of vulnerability. Economic growth may facilitate spending on emergency management while a highly unequal distribution of resources may augment the vulnerability of certain individuals and groups. Urban planning that takes disasters into account may limit the concentration of people and property or make people and property more vulnerable. A final pattern deals with institutions. For instance, we may build response institutions through planning, training and exercises only, thereby ignoring the importance and need for prevention. Or, we can organize ourselves in such a way as to promote prevention activities and facilitate responses when necessary. Therefore, the patterns of culture, development and institutions may help us to understand the causes of vulnerability.

Tenet 7: The variables and patterns of vulnerability influence the degree of risk, susceptibility, resistance and resilience

The variables and patterns that influence the level of vulnerability may be placed under the categories of risk, susceptibility, resistance and resilience (see Blaikie et. al. 1994; Dow and Downing 1994; Timmerman 1981). Risk indicates potential for adverse impact, and is often associated with location, construction and technology. Susceptibility implies proneness to being affected by a disaster due to social, cultural, political, economic, psychological and organizational variables. Resistance suggests the ability of structures to withstand the forces of powerful agents in order to minimize damage and destruction. Resilience includes the individual and community ability to respond and recover based on preparedness and other measures. Welchgartner's review (2001) of the literature illustrates that risk, susceptibility, resistance and resilience are frequently mentioned in definitions of vulnerability.

Table 1

		Environments	
		Physical (including natural, built, technological)	Social/Organizational (including cultural, political psychological, economic)
Environmental Attributes	Liabilities	*Risk*	*Susceptibility*
		VULNERABILITY	
	Capabilities	*Resistance*	*Resilience*

Adapted from McEntire, D.A. (2001).

Tenet 8: The categories of vulnerability are not mutually exclusive but interact in complicated ways

It should be noted that risk, susceptibility, resistance and resilience are not mutually exclusive or exempt from interaction (McEntire 2001). This is to say that the lines of demarcation among the positive and negative attributes of both the physical and social/organizational environments are fuzzy and fluid, never exempt from interaction. In other words, each category of vulnerability may influence, or is influenced by each other category. For instance, risk may be increased if resistance is lowered, while resilience may be decreased if susceptibility is heightened. At the same time, risk and susceptibility (as well as resistance and resilience) often interact in mutually reinforcing ways (e.g. the social, cultural, political, technological and economic environments may encourage people to locate in dangerous areas while a lower degree of resistance may make response and recovery more problematic). Furthermore, risk could jeopardize resilience, and resistance and susceptibility may have an inverse relationship. Thus, there are complex and interdependent relationships among risk, susceptibility, resistance and resilience.

Tenet 9: Vulnerability changes continuously

Vulnerability is not static. In other words, any particular degree of vulnerability does not remain constant over time (Lewis 1999). Instead, vulnerability is dynamic and may fluctuate minute-by-minute, day-by-day, and over months and years. For instance, the arrival of an inebriated employee will augment the vulnerability at a manufacturing plant dramatically in spite of an otherwise safe and productive work crew. The transportation of hazardous materials makes some communities more vulnerable than they were the previous day. Immigration patterns over the past few years to the South and West have had an adverse impact on vulnerability to hurricanes and earthquakes. The ongoing expansion of communities as well as the methods and materials used for construction also determine vulnerability. Cultural misunderstanding, mistakes in public policy, the unfair treatment of minorities and global poverty augment our current vulnerability to terrorist attacks. A new Airbus 380 is being built in Europe that will hold between 555 and 800 people. The plane is schedule to fly around 2004. Can we fathom the potential impact if this plane crashes due to adverse weather, pilot error or mechanical malfunction? These and other examples illustrate that vulnerability may change quickly and is altered constantly.

Tenet 10: We must assess vulnerability periodically

Because vulnerability is in a constant state of flux, it is necessary to evaluate vulnerability periodically. The growth of communities, arrival of new businesses, and building of new critical facilities and infrastructure make repetitive assessment necessary. While small changes in a community may not be readily apparent, they will have significant impact upon vulnerability over time. Thus, it is extremely important that hazard and vulnerability analyses and emergency operations plans be revisited at least once each year. Mitigation strategies, planning, training, exercises and other emergency management activities must take into account changes in the degree of vulnerability in any given assessment period.

Tenet 11: We can and should reduce many types of vulnerabilities

Without a doubt, we must not delay in recognizing and reducing vulnerabilities (weichselgartner 2001). Evidence increasingly suggests that disasters are becoming more frequent and intense (mileti 1999). While it is true that there is some debate as to whether the number of natural hazards is rising or not, there is less disagreement that technological and other man-made disasters are occurring more often (waugh 2000). However, one thing is indisputable: we are becoming more vulnerable to a variety of hazards (mileti 1999; lewis 1999; merriman and browitt 1993). For this reason, attention and resources should be increasingly directed towards the reduction of disaster vulnerabilities.

Tenet 12: We cannot and should not try to eliminate all types of vulnerabilities

While much can be done to reduce vulnerability, it is imperative to remember that it is impossible to eliminate all types of vulnerabilities. Attempting to eliminate vulnerability assumes omniscience and omnipotence, jeopardizes freedoms and requires excessive expenses. Humans are not all knowing, and they do not have control over mother nature (and each other at times). In addition, we must admit that there is no hazard-free area. What is more, the regulations imposed on society would hurt liberties, and the resources needed to produce an "invulnerable society" could limit economic productivity and lead to poverty. In addition, there are benefits from things that increase risk and susceptibility (e.g. farming in a flood plain is advantageous due to the presence of rich and fertile soils). Finally, the infrequency and sometimes-unpredictable nature of disaster makes prevention and preparedness difficult from a political standpoint. Thus, we must concede that it is not wise or possible to eradicate all types of vulnerability.

Tenet 13: Everyone plays a role in reducing vulnerability

Although we cannot eliminate vulnerability, everyone can take steps to reduce it. In the academic realm, scholars from a wide variety of disciplines provide important information about vulnerability (see Merriman and Browitt 1993). For instance, geographers attempt to reduce vulnerabilities by recommending the use or non-use of certain locations or structural mitigation devices (Maddrell 1993). Meteorologists attempt to reduce vulnerabilities by giving advance notice of possible weather disturbances (Slater et. al. 1993). Engineers attempt to reduce vulnerabilities by building structures that are able to withstand and resist strain (Hodgson and Whaites 1993; Norton and Chantry 1993). Anthropologists attempt to reduce vulnerabilities by exposing constraining attitudes and risky behavior (Oliver-Smith and Hoffman 1999). Economists may help to reduce future vulnerabilities by discussing the important role of insurance in the recovery phase of disaster (Dlugolecki 1993). Sociologists attempt to reduce vulnerabilities by illustrating what individuals and groups are most susceptible to disaster (Enarson and Morrow 1998; Peacock et. al. 1997). Psychologists attempt to reduce vulnerabilities by exposing how people process risk, or by helping victims and responders understand their emotions and overcome post-traumatic stress disorder (Phifer 1990). Epidemiologists and others in the medical field attempt to reduce vulnerabilities by exploring those factors that increase disease, injury and death, or by building the capacities of those who respond to the victims' emergency and long term health care needs (Shoaf and others 1998; Noji 1997; Auf der Hiede 1989). Political Scientists attempt to reduce vulnerabilities by showing what government policies are ineffective or even dangerous (McEntire 1999). And scholars of Emergency Management attempt to reduce vulnerability through discussions about how various preparedness measures (such as community education, planning, training and exercising) improve the performance of emergency functions (such as warning, evacuation, search and rescue, mass care, mass casualty, sheltering, public information, damage assessment, and debris management) for the protection of people (Drabek and Hoetmer 1991; Britton 1986).

Practitioners and citizens also play an important role in the reduction of vulnerability (McEntire, forthcoming). In regards to the public sector, it is the politicians that give priority to disaster policies and enact relevant pieces of legislation. Department leaders play a significant role in the implementation of disaster regulations while emergency management organizations build the prevention and preparedness capacities of the community, state or nation. The private sector likewise helps to reduce vulnerability. The goal of corporations to increase profits may jeopardize the safety of employees, nearby residents and the community as a whole. Nonetheless, the private sector is involved in a variety of functions (e.g. consulting, business continuity, insurance, debris removal, hazardous materials clean up, etc.) that have a bearing on vulnerability. The non-profit sector works diligently with vulnerable groups either to improve their capacities to care for themselves or by helping them to recover once a disaster occurs (thereby reducing future vulnerability). The public, private and non-profit sectors cannot resolve the vulnerability problem alone however. The values and activities of individual citizens also determine the level of vulnerability. Citizen Emergency Response Teams, volunteers, and emergent groups also determine levels of vulnerability. Therefore, everyone must take responsibility for the reduction of liabilities and the building of capacities.

Tenet 14: We can address vulnerability through each phase of emergency management

Vulnerability can be reduced through mitigation, preparedness, response and recovery activities and operations. This concept is related to mitigation in that hazard/vulnerability mapping, the appropriate location of settlements, the use of structural mitigation devices, sturdy construction techniques and environmental protection reduce vulnerability. Furthermore, infrastructure engineering, retrofitted buildings, a slower pace of (or controlled) urbanization, a reversal of social marginalization, the changing of cultural attitudes, political will to do something about disasters, a reduction of poverty, early warning systems, the careful use of technology, the anchoring of heavy furniture and equipment, the strengthening of the infrastructure, and the careful use and maintenance of hazard containing devices such as dams may also reduce vulnerability.

Vulnerability is related to preparedness in that it notes how local emergency planning committees, community education, insurance coverage, and the availability of disaster related resources reduce liabilities and build capacities. It is also related to preparedness in that vulnerabilities may be created or minimized through planning, training and exercising for specific emergencies and disasters (such as hazardous materials spills, school shootings, hurricanes, etc.) or for important post-disaster functions (such as dispatch operations, emergency medical care/tactical EMS, search and rescue, public information, continuity of government, EOC operations, media relations, debris management, etc.). Preparedness and planning measures are strong determinants of whether a community will reduce its future vulnerability during disaster recovery operations. Insufficient or inappropriate steps taken for preparation may therefore increase the vulnerability of communities to disaster (Weichselgartner 2001; Britton 1986).

Vulnerability is likewise related to a more efficient, effective and appropriate form of disaster response in that it increases the capacities of responders by delegating authority to the local level, avoiding overly stringent bureaucratic operating procedures, encouraging self-reliance among the affected population, improving decision making in crisis situations, and discouraging the creation of dependency through well-intentioned but sometimes ineffective and counter-productive relief operations. Vulnerability also shows relation to this functional area because, as Britton (1986) and Weichselgartner (2001) suggest, the failure to effectively perform emergency operations functions (e.g. flood forecasting, evacuation, incident management, logistics, sheltering, resource management, etc.) increases the inability of people to cope with disasters that cannot be prevented. In addition, failure to take necessary safety precautions during search and rescue, damage assessment and debris removal increases the vulnerability of emergency workers to secondary hazards.

Vulnerability is related to recovery because disaster relief is intricately related to local capacity building. For instance, disaster assistance may - depending upon how it is distributed and received - encourage dependency or reduce one's vulnerability to future disaster. Vulnerability also links reconstruction, relocation and redevelopment back to mitigation for the reduction of future vulnerabilities. Furthermore, the handling of debris could lead to environmental degradation or other problems, which may create future disasters. Moreover, this concept also includes the emotional vulnerability of people by helping them to cope with and bounce back from disaster losses.

Vulnerability therefore helps us to address disasters in a holistic and integrated manner. Such an approach is imperative if we are to take a more proactive approach towards mitigation. Nonetheless, a fundamental part of disaster vulnerability is the inability to prepare, respond or recover effectively. Vulnerability consequently has an important relation to each phase of emergency management.

Tenet 15: We must pay special attention to those individuals, groups and nations that are most vulnerable

As emphasis and activities shift towards vulnerability, it will be imperative to focus on those that are most vulnerable. Research has repeatedly illustrated that some people are more vulnerable to disaster than others. This may include women, children, the elderly, the disabled, and the poor (Fothergill et. al. 1999; Enarson and Morrow 1998; Fothergill 1996; Rahimi 1993; Eldar 1992). Minority groups are also more likely to be vulnerable to disaster (Peacock et. al. 1997). In addition, developing nations, which may lack knowledge, technology and material resources, rank among those most vulnerable (Lewis 1999). Although responsibility for vulnerability reduction should never be taken away from those that are vulnerable, steps can and should be taken to assist individuals, groups and nations reduce their vulnerability. Political values, partnering, education, technology transfers, development priorities can all be adapted to help those who are most vulnerable.

Conclusion

This review of the research literature suggests that vulnerability should be the focal point of our academic and practical efforts to reduce disaster. Focusing on vulnerabilities, instead of hazards, would shift emergency management from a reactive field to a proactive profession. It would allow us to recognize what we cannot control and help us to concentrate on those areas which we can control. In addition, the concept of vulnerability appears to provide a holistic approach in that it is related to all of the hazards, variables, actors, phases and disciplines of disasters. With the above 15 tenets in mind, perhaps it may be wise to rename our approach for the reduction of the quantity and quality of disasters. One possible label is "vulnerability management" (McEntire, forthcoming). This implies that we endeavor to assess liabilities and capabilities, reduce risk and susceptibility, and raise resistance and resilience. At a minimum, implementing vulnerability management would require:

- a better understanding of vulnerability as it relates to development and disasters (through contributions by all disciplines),
- continued assessments of community liabilities and capabilities
- citizen and decision maker education about vulnerability and disasters,
- stronger disaster prevention and emergency management institutions,
- altered attitudes about disasters and development,
- holistic politics (focusing on all triggering agents, phases, actors and variables),
- the use of carrots and sticks (e.g. incentives, legislation, and enforcement),
- increased but cautious reliance on technology,
- environmental protection,
- poverty reduction,
- additional coordination among citizens and the public, private and non-profit sectors,
- and, individual and community empowerment and responsibility.

Regardless if vulnerability management is accepted as a new paradigm and policy guide, it is certainly apparent that more attention needs to be directed towards the disaster problem. It is therefore hoped that this paper has helped to generate new ideas and initiatives for this purpose. To the extent it has not, more research should be conducted on ways to reduce disaster vulnerability.

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Author Biography

David A. McEntire is the Coordinator of the Emergency Administration and Planning Program in the Department of Public Administration at the University of North Texas. Dr. McEntire has researched disasters in Peru, the Dominican Republic and in the United States. Research interests include the concept of vulnerability, disaster reduction, response coordination, and emergency management. Dr. McEntire recently published an International City Management Association *IQ Report* on terrorism, and is currently developing an Instructor Guide on disaster response operations and management for the Higher Education Program in the Federal Emergency Management Agency.

PROFESSIONAL COMMUNICATIONS

Address of Mr. Pieter van Vollenhoven,
Chairman of ITSA, The International Transportation Safety Association to
The International Emergency Management Society,
May 14 to May 17, 2002, Waterloo, Ontario

2002-04-29

Mr. Jack Harrald, President,
The International Emergency Management Society,
9th Annual International Conference,
Univeristy of Waterloo,
Waterloo, Ontario,
Canada, N2L 3G1.

Dear Dr. Harrald,

Re.: Independent accident investigation: every citizen's right, society's duty.

Please accept this as a short address to your conference as an indication of our interest in cooperation between our organizations. Unfortunately, other preexisting commitments prevent me from joining your conference; but certainly in spirit I am with you in your deliberations.

Every time a major accident occurs a public demand is heard for an independent investigation into the causes of the accident and to prevent reoccurrence of similar accidents.

I believe that the public has the right to such investigations because such investigations are the only way to establish exactly what happened. They help alleviate public concerns that may have arisen in the aftermath of the accident.

Independent investigations can help victims and their families come to terms with their suffering; they can teach us lessons for the future and they can make our actions transparent. In fact you could say that they help our democracy to function properly.

Parties involved in accident investigation began to realize that inquiries based in criminal law which mainly attempt to find out who was to blame for an accident was not the right instrument to find out just what exactly had happened. If lessons were to be learned for the future and steps were to be taken to prevent the similar accidents from happening again and again, another type of investigation was needed.

It is not a question whether independent investigations are needed, but rather how independent they really are in practice. Governments have come to realize that if they carried out such investigations themselves, they invited criticisms about impartiality and conflicts of interest. Since governmental inspectors are involved in drafting regulations and monitoring compliance, they could be seen as both judge and jury. The only way of stopping this criticism was to set up independent safety boards.

Independent investigations can be of great significance to society. Only if the people have the right to them, *and a right that is anchored in law*, can there be a guarantee that truly independent invesitgations can and will be carried out.

I have been working in this area for over 25 years. I have advocated this concept for modes of the transportation industry. Over the past decade more and more countries are following the example of the grandfather of this development – the National Transportation Safety Board of the USA, founded in 1967.

Recently, after some major disasters in the Netherlands, the concept found its way to other sectors as well such as defense, industry, natural disasters, health and environment and major occurrences involving explosions, fires, collapse of buildings and structures.

In the Netherlands, it now has been recognized that independent investigations can be a valuable tool in general:

- to reveal the causes of an accident,
- to learn from accidents, and
- to restore the public confidence.

It has lead to the establishment of a new board in the Netherlands: a Safety Investigation Board for all sectors.

This new board will address safety issues in an integral manner. It will conduct multidisciplinary investigations into all relevant issues, including both the immediate and underlying causes, and the events before, during and after the event. This means we will focus on fire fighting, rescue and emergency aspects as equivalent to accident precursors and causes.

To fulfill its mission, a Safety Board must be legally and functionally independent. A Safety Board does not allocate blame or reliability. Its methodology and procedures must therefore be separated from criminal law inquiries and influences of governmental and industrial interests. It has its own methodology and must maintain the highest quality to guarantee its credibility and objectivity.

It therefore also needs the support from other organizations. Safety boards cannot cover all expertise and specialist disciplines in-house. Safety Boards must take part in an information infrastructure and must have experts available on call,

In this respect it is of great importance to be here at the 9th Annual TIEMS (The International Emergency Management Society conference to convey to you the message of the very real importance of independent investigations. It offers both organizations the opportunity to exchange information, to combine efforts, to exchange experiences and findings and to develop a common body of knowledge.

I hope this expression of our interest will be just the first of a series of contacts leading to a fruitful cooperation between our organizations.

Yours sincerely (dictated)

Mr. Pieter van Vollenhoven, Chairman,
ITSA, The International Transportation Safety Association.

TIEMS: ITS EVOLUTION AND CHALLENGES

K. Harald Drager

A/S QUASAR Consultants[1]

1. Abstract

This paper briefly describes the origins of TIEMS, and of its progress over the years in providing a forum for interactive discussion by experts in emergency management. The Society's current strengths and weaknesses are detailed and have been used to determine what is needed to ensure the continued development of the Society to the benefit of the participants and the international emergency management community.

Set in the context of the needs of the international emergency management community, a vision for the future is provided, and a proposed plan and time schedule for achieving the objective of developing TIEMS into one of the leading contributors to the international emergency management community.

2. Background

In the early nineties, The Society for Computer Simulation (SCS) provided a forum for discussing and promoting simulation techniques in Emergency Management during their annual multi conferences. During their 1992 conference in Orlando, at their session on simulation, organised by Jim Sullivan, I presented a paper on the simulation of evacuation processes from offshore platforms. About 50* participants attended, of which the majority were Americans, with a few Europeans. We were a lively and interactive group, and I was pleased to be offered the opportunity of presenting a further paper at the following year's conference to be held in Washington D.C. At the time I decided that although SCS made a useful contribution to emergency management simulation, it was not the ideal vehicle for promoting emergency management in a global perspective.

3. Establishment of TIEMS

During the preparatory phase for the 1993 conference, I suggested to Jim Sullivan that, in addition to the SCS, there was a need for a uniform international society to provide a forum for the presentation and exchange of emergency management ideas, and based on global needs. I proposed the name, The International Emergency Management and Engineering Society (TIEMES), and suggested forming a selective group during the Washington conference.

Jim Sullivan subsequently promoted the idea to a number of participants, and we met in the margins of the conference. The Society was thus formed, mission statement and by-laws agreed. At the end of the SCS conference we held our inaugural meeting at which Jim Sullivan was elected President and I was elected International Vice President. We decided that our first conference should be at Fort Lauderdale in Florida in 1994.

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4. The first years

TIEMES' first conference in Florida attracted about 100* participants from America, Europe and Asia, and some commercial exhibitors. It was widely considered to be a successful beginning for the Society. The theme was, "Bridging the Gap between Theory and Practice: Research and Applications", and the papers were subsequently published. Suleyman Tufekci, the Society's treasurer, also became the first editor of our newsletter, "Carpe Diem", and copies were distributed at the conference.

The Society succeeded in establishing cooperative links with the IEEE System, Man, and Cybernetics Society, the Operations research Society of America (ORSA), the Institute of Industrial Engineers (IIE), the Association of the European operational Research Societies (EURO), the National Institute for Urban Search and Rescue, The University of Florida, the EUREKA Program for Research and Development in Europe, the Directorate-General XIII (Telecommunication, Information Market and Exploitation of Research) and III (Industry) of the Commission of the European Communities.

Although we were still in the embryonic stages of developing the Society, the participants in Florida were highly complimentary about the content and outcome of the conference. There was considerable enthusiasm for our next annual conference to be held in Nice, France, where the theme would be, "Globalisation of Emergency Management and Engineering: National and International Issues concerning Research and Applications".

In Nice, approximately 120* participants attended. A new Board was elected under the Presidency of Jean Luc Wybo. The Society's name was changed to The International Emergency Management Society (TIEMS).

Our first meeting as TIEMS was the 1996 conference in Montreal, Canada, under the theme, "International Issues concerning Research and Application". Approximately 60* participants attended.

The next conferences were as follows:

- In 1997 in Copenhagen Denmark under the theme: National and International Issues concerning Research and Applications. The conference organizer was Verner Andersen, and some 60* participants were present
- In 1998 in Washington D.C. under the theme: Disaster and Emergency Management, International Challenges for the next Decade. The conference organizer was John R. Harrald, and some 120* participants were present.
- In 1999 in Delft, The Netherlands under the theme: Contingency, Emergency, Crisis, and Disaster management, defining the Agenda for the Third Millennium. The conference organizer was Giampiero E. G. Beroggi, and some 80* participants were present.
- In 2000 in Orlando, Florida under the theme: Contingency, Emergency, Crisis, and Disaster Management; defining the Agenda for the Third Millennium. The conference organizers were Suleyman Tufekci and Kathleen M. Kowalski, and some 60* participants were present.
- In 2001 in Oslo, Norway under the theme: Towards Cooperation and Global Harmonization. The conference organizer was K. Harald Drager, and some 200 participants were present.

* Approximation of numbers based on memory.

5. The present situation of the society

TIEMS is arranging its 9th international conference this year in Waterloo, Canada. Organised by Ross Newkirk, the theme is, "Facing the Realities of the Third Millennium". At last year's conference I was given the mandate to propose an international development plan for TIEMS, and to set out a vision for the society in a global context. Therefore, a special plenary session will be devoted to discussion on the future of the society.

This issue has become increasingly important following the events of last year. The terrorist attack on the USA on 11th September 2001 has changed the world. It highlighted the need to be ready and adaptable to deal with new challenges and circumstances. And so it must be with this Society. It is imperative that we remain in close touch with international developments through increased cooperation and participation. Indeed, we have the skills, experience, innovation and potential to become one of the leading contributors to Global Emergency Management.

Our future development should be determined in the context of our current strengths and weaknesses:

<u>The strength of TIEMS</u>

- TIEMS is a true international society. Participants from 28 countries attended the conference in Oslo last year
- The papers presented at the TIEMS conferences are of high quality, and many of these have been accepted for publication in several recognized international publications
- Participants represent a unique blend of expertise and experience, covering a broad spectrum of emergency management, including natural hazards and man-made disasters
- TIEMS provide an annual global meeting place for emergency management specialists that enables interactive and lively discussions during the conferences and associated social events/programmes
- The Society has survived in an increasing competitive environment, where other international organisations are competing for participants

<u>The weaknesses of TIEMS</u>

- There are too few attending practitioners and representatives of the authorities, international organisations, industry and exhibitors at the annual conferences
- TIEMS has a weak economic base, resulting in too much reliance on voluntary contributions
- No activity programme other than an annual conference is offered
- No formal membership is offered, and the Society has no structured policy regarding sponsors
- The mission statement and by-laws are not up-to-date and need to be revised in line with the development of international emergency management community
- The Internet home page of the Society is under-utilised

The inherent strengths of the Society have enabled us to survive in an increasingly competitive environment. By addressing our weaknesses we can generically develop the Society into a globally recognised organisation with credibility and the capability of meeting the current and future needs of the international emergency management community.

6. The international emergency management community

The international emergency management community can be categorized into a number of different users, providers and financers:

- National emergency management organisations
- Public authorities
- International organisations dealing with emergency management
- Humanitarian organisations with need for emergency management

- Industry providing emergency management software and hardware systems and equipment
- International and national emergency management societies
- Emergency management practitioners
- Universities offering courses and doing emergency management research
- International institutions that may finance emergency management projects
- Any other affiliated or interested groups

The aforementioned categories have different needs. However, there is one common requirement, a meeting place for the exchange of ideas and appraisal of new and innovative developments within emergency management.

To determine the challenges TIEMS faces in meeting these needs, preliminary research of the different groups has been undertaken. Summarised below, this market research should be an ongoing task as part of a future development plan.

<u>National emergency management organisations</u>

Some countries have organised their public emergency management activities in separate institutions, such as the United States Federal Emergency Management Agency (FEMA). Founded in 1979, its main mission is "to reduce loss of life and property and protect our nation's critical infrastructure from all types of hazards through a comprehensive, risk-based, emergency management program of mitigation, preparedness, response and recovery". FEMA is an independent US federal agency with more than 2600 full time employees (Washington, regional and area offices etc.). In addition, FEMA has nearly 4000 standby disaster assistance employees. FEMA often works in partnership with other organisations.

After the September 11th - terrorist attack, the US Government established the Office of Homeland Security (responsible for overall coordination and policymaking) with the purpose of shaping a national strategy and coordinating efforts between all related bureaus. The Office of Homeland Security has close connections to The White House, civilian agencies and the intelligence community. Homeland Security oversees Aviation security, Command, Control and Communication (C3), Detection & Prevention, First Response (inclusive of FEMA), Emergency Management (inclusive of FEMA), Energy Security, Perimeter Security, Bio/Chem & Nuclear/Radiation Security, Water and Agricultural Security and other fields, such as Maritime Security etc.

<u>Public authorities</u>

Most countries maintain a traditional sector approach in their organisational structure within respective public authority administrations. The responsibility to cope with prevention is delegated according to a silo based approach between several ministries and directorates according to the nature of the threat, such as natural disasters (earthquakes, hurricanes, cyclones, volcanic eruptions, floods, wood fires, landslide, avalanche, etc) or man-made disasters (e.g. explosions, transport disasters in aviation, maritime, rail or road traffic, fires in hotels, restaurants, etc). This practice is often found in the organised public safety boards charged with the responsibility to investigate disasters and promote recommendations to prevent further accidents. General national or multi-modal safety boards in the transport field are still limited to less than ten countries.

<u>International organisations dealing with emergency management</u>

Two organisations, which play a major role:

- *United Nations*: In 1997, the United Nations, as part of the Secretary-General's programme for reform, established The Coordination of Humanitarian Affairs (OCHA). This succeeded the Department of Humanitarian Affairs (DHA) that had responded to 416 natural disasters from 1992 through 1997. OCHA's headquarters staff (137) is divided between New York and Geneva in Switzerland, and has a core annual budget of $ 42.4 million. The number of field staff is 51.

Coordinators function are focused in three core areas: policy development and coordination; advocacy of humanitarian issues with political organs; and coordination of humanitarian emergency response on the ground. OCHA discharges its coordination function primarily through the Inter-Agency Standing Committee (IASC). OCHA currently maintains field coordination arrangements in 16 countries and one geographical region. Among information tools administered by OCHA, is the Humanitarian Early Warning Systems (HEWS), which identifies crises with humanitarian implications. HEWS is supported by an extensive database of information for more than 100 countries. Another tool is the Integrated Regional Information Network (IRIN). Based in Nairobi, it distributes daily reports to more than 50 countries.

In addition, the UN Secretariat for the International Strategy for Disaster Reduction (UN/ISDR) plays an important role as an inter-agency task force for the implementation of the strategy concerning disaster reduction. The Task Force is composed of several representatives from organisations and geographical regions and has four working groups.

- *NATO/Partnership for peace council*: The European Atlantic Partnership Council (EAPC) consists of 46 member states; 19 NATO countries and 27 Partnership for Peace Countries (PFP). The EAPC has decided to establish a European Atlantic Disaster Response Control Centre (EADRCC), which has been mandated to deal with two major emergencies simultaneously and coordinate the request, mobilisation and deployment of the EAPC response to a request for assistance from a stricken country. This could include both EAPC national assets and European Atlantic Disaster Response Unit (EADRU).

  The EADRCC will deal with natural and industrial disasters as well as chemical, biological and radiological (CBR) attacks. The focus will be on protection of the population and civilian and humanitarian support. The EADRCC program will be discussed and concluded on the EAPC meeting in Prague in November 2002.

  This program could lead to a development of a disaster response network comprising all EAPC member states.

Humanitarian organisations with need for emergency management

One internationally recognized organisation:

- *Red Cross:* The International Federation of the Red Cross and Red Crescent Societies consists of a secretariat (230 persons with one division for Disaster Management and Coordination) in Geneva (Switzerland) and several field offices around the world. The ICRC (800 headquarters staffs) has permanent delegations in about 70 countries and has conducted operations in about 80 countries with about 10 000 field staff. In addition to the traditional Red Cross organisation, several other international and national non-governmental organisations participate in the humanitarian emergency assistance in several places throughout the world.

Industry providing emergency management software and hardware systems and equipment

One major international industrial organisation, delivering a holistic approach to hardware and software emergency management systems:

- *Silicon Graphics Inc (SGI):* SGI was incorporated in 1982, and has its main office in Mountain View, California. SGI has 4700 employees and is present in 50 countries. The company's turnover in 2001 was US$ 1.9 billion.

SGI's solutions to government areas and defence are focused on three disciplines: visual simulation, geographic information systems, and decision support. SGI's traditional strengths in high-performance graphics systems, scalable high-performance compute capability, and large-scale data storage are the ideal ingredients for the modern, 21st century military operating in a digital battlefield. Information dominance is the goal of SGI's solutions – understanding the situation and providing an environment for rapid, confident decision making.

SGI decision support centres offer the capability to efficiently and seamlessly deal with huge quantities of information, maps, imagery, GIS data, video, audio, and weather. The wide field of view offered by SGI's large format of high-resolution displays provides the ultimate in situation awareness. SGI's Reality Centre solutions support government and defence users worldwide with decision-support solutions in:

- Command and control
- Disaster and crisis response
- Mission operations
- Briefing and presentation centres

SGI has installed more than 400 Reality Centre facilities worldwide and can provide design, development, engineering, software, integration, installation, delivery, operations, and maintenance engineering for decision-support systems.

<u>International and national emergency management societies</u>

As one example, The International Institute of Risk and Safety Management, established in 1975 in the UK, has more than 5 500 members in over 50 countries throughout the world. The institute's main objective is to advance public education in accident prevention and occupational health. Membership is based on a personal basis, from students to professionals in the safety management field.

<u>Emergency management practitioners</u>

Practitioners organised in special organisations can be categorised into four major groups: 1) Humanitarian relief organisations - International Red Cross, Friends (Quakers) Disaster Service, The Salvation Army, Medicines sans Frontiers, Save the Children, and several others 2) Professional groups - manufacturers/producers of highly relevant equipment in preparedness or disaster reduction, engineers, fire fighters, disaster and emergency medical personnel, geologists, psychologist etc. 3) Resource personnel with special skills - planning, local community organising, training specialists, on-spot emergency work etc. 4) Volunteers - radio amateurs, women groups, local emergency groups etc. Collectively, there are several hundreds of organisations and players in these groups, constituting a very complex picture.

<u>Universities offering courses and doing emergency management research</u>

Research programme and projects and academic courses in emergency management are growing disciplines, which are integrated in the schedules of several universities throughout the world. Usually, the themes reflect the risk profile in their respective region or country. Topics within the emergency management area can now be found at several universities, especially in USA and Canada, Great Britain, The Netherlands, India and Australia. In addition to academic studies, several universities and other institutions offer learning programmes and courses in emergency proficiencies.

<u>International institutions that may finance emergency management projects</u>

Two financial organisations supporting emergency management projects:

- *World Bank/International Finance Corporation (IFC):* Since its foundation in 1956, the IFC has committed more than $ 29 billion of its funds and has arranged $ 19.2 billion in syndications and underwriting for 2446 companies in 136 development countries. IFC coordinates its activities with the other institutions in the World Bank Group – the International Bank for Reconstruction and Development, the International Development Association, and the Multilateral Investment Guarantee Agency – but is legally and financially independent. Its 174 member countries provide its share capital and collectively determine its policy.

  Since the 11th September 2001 attack on USA, it is expected that emergency management will become part of their agenda. Both World Bank/IFC personnel and emergency management personnel in the development countries should be target groups for TIEMS.

- *The European Union*: Within the European Union, the responsibility for emergency management is divided between several Directorate-Generals governed by the European Commission. However, the main responsibility for activities concerning external development aid rest with the new EuropeAid Co-operation Office (ECHO), formally established on 1. January 2001. But this new body has no responsibility for humanitarian activities or security policies inside the European Union. This is devolved to the Directorate-General for Justice and Home Affairs. The new Police Unit – EUROPOL – is playing an important role in fighting terrorism and international crime. The EU Unit Humanitarian Security (HS) has as its mission to provide an independent technical reference, offering measurement resources for validation of methods and data in applications related to among others natural hazards. HS is serving several DGs and the EuropeAid Co-operation Office. Another important body is The Institute for the Protection and the Security of the Citizen (IPSC), which has as its mission to provide research-based, system-oriented support to EU policies so as to protect the citizen against economic and technological risk, including, amongst others, potential damage caused by natural disasters or human activities. IPSC came into being on 1st September 2001, and is located at ISPRA in Italy.

The above gives a snapshot of the variety of emergency management community. It would also indicate that TIEMS could provide a suitable forum for groups and individuals where interactive discussion and state of the art information technology would be on offer. Combined with activity programmes that add real value, TIEMS would become an attractive proposition for many groups within the international emergency management community.

7. Current and future challenges

Preliminary analysis would indicate that there is a considerable need for an international emergency management meeting and market place. TIEMS currently appeals to only a small segment of the market, struggles with a weak economy, and has no clear and unified vision for the future.

I have therefore in the following concentrated on key areas of weakness, and propose an action plan and schedule that I believe is necessary for the generic development of TIEMS.

The proposed plan of action is not definitive, but is of course a proposal, and will be subject to further discussion and improvements agreed by TIEMS Board of Directors and TIEMS supporters/members.

Improvement of TIEMS economy

A sound economic base is essential for the further growth and development of TIEMS, and should be one of the top priorities. Annual conferences alone cannot provide sufficient income and other sources should be investigated.

A membership programme has been proposed by Kathleen Kowalski, and this will be one step in the right direction. However, we should also investigate the possibility of attracting sponsors. The benefits to a sponsor would be promotion in TIEMS' publications and Internet home page, in addition to exposure at annual conferences.

Partnership with other organisation(s)

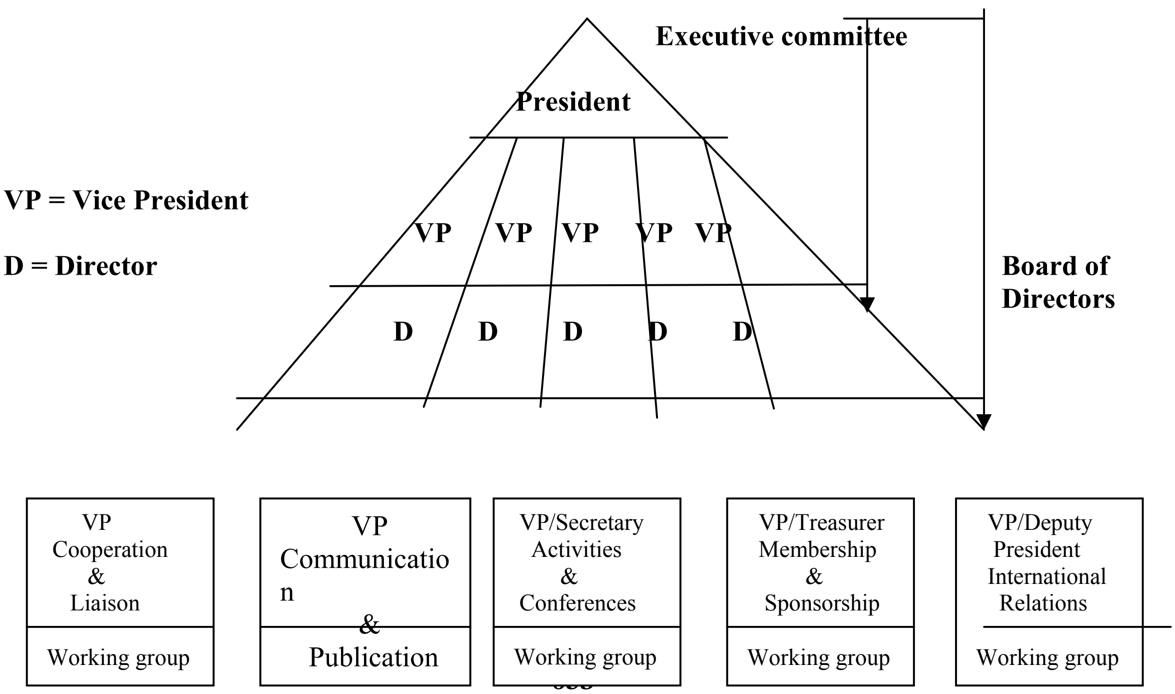
The effectiveness of TIEMS and its capability to develop is restricted by its current economic base, and limited by the number of man-hours that are voluntarily offered each year by various individuals. Broadening and strengthening our relationship with multi-national organisations and their associated funding sources might be one way of alleviating this problem. It will be important to maintain the very special character that constitutes TIEMS, but closer cooperation with other groups will require us to be flexible in our approach and tailoring our strategy and aims accordingly. This will need to be explored further in the coming year, including determining what would constitute the most suitable of the international emergency organisations for cooperation.

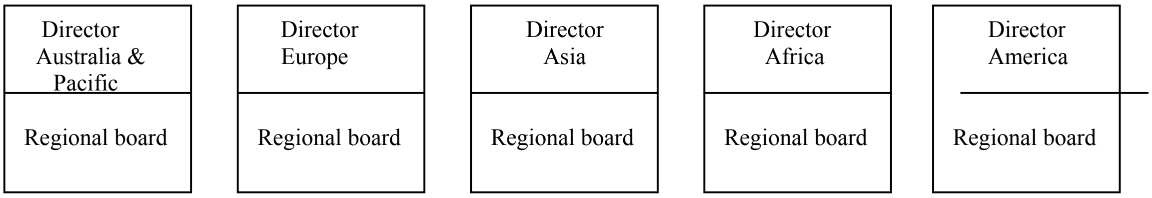
Further globalisation of TIEMS

In addition to a sound economic base, a dedicated and focussed leadership is vital for success. This means clearly defining the work tasks and ensuring equitable delegated responsibility to the Board of Directors. It will also require the establishment of permanent and ad hoc working groups for the spreading of workload and stimulation of ideas.

Ultimately, a global organisational infrastructure should be established, consisting of Regional and National chapters as the fundamental elements to strengthen and add value to the central core organisation.

A TIEMS organisation might be constructed as follows:





<u>Proposed Strategic Program and Action Plan</u>

TIEMS should ideally develop a long-term strategy covering a 5 year period, inclusive of a clearly defined mission statement and related intermediate term targets and activity. But this can only be achieved if all participants/members collectively contribute to the process. Further work on this issue should be undertaken by a working group under the responsibility of the Vice President to the Secretariat with the aim of producing draft proposals for consideration by the Board of Directors at the next international conference. A recommendation would then subsequently be presented to the Annual Assembly in 2003 for confirmation.

<u>Global, Regional and National Conferences</u>

A global and decentralised TIEMS will necessitate a review of the annual conference programme. In the first instance, the establishment of Regional and National groups is likely to result in localised conferences, and probably on an annual basis. The attractive spin-off would be more comprehensive recruitment for a global conference.

I therefore propose that Regional/National conferences be held annually, and global conferences every other year. The global conference should then alternate to the different regions/nations including the Australian Pacific Region which to date has been largely ignored.

This conference programme should lead to more participants because of more advanced planning and awareness.

The global conferences should continue to last for 4 days, while the regional/local conferences should be shorter, e.g. 1, 2 or 3 days, subject to the views of members and expectation of the numbers of participants attending.

<u>Internet Home Page Activity</u>

Most serious international and national emergency institutions, organisations, associations and institutions with emergency management as a sector activity, such as universities, book companies, consultancy institutions, newspapers, journals, etc, have established their own internet home pages to promote and inform about their activity, such as TIEMS. But unlike TIEMS, most of these Internet home pages are regularly updated. Many of these institutions utilise the Internet as one of their most important communication channels, using frequent updating to attract and retain thousands of interested readers. At present, Internet gives users throughout the world access to several different type of information:

- databases of disasters
- preventive real time information (weather forecast/ warnings, etc)
- organisational information, (history, policy, programme, activity, publications)
- academic schedules
- articles/papers
- membership information

- trade union activities
- methods and tools
- statistical information

Some of the homepages offer an open forum for discussion, like The Virtual Forum, created by the Emergency Information Infrastructure Partnership, which offers information and tools from academia, business, government, and volunteers.

Recognition should be made of Michael Bittle's considerable voluntary effort in designing, hosting and updating TIEMS' present home page, as and when information is received.

Consequently, TIEMS currently publishes fairly conventional, conference focussed communication via www.tiems.org. The potential for improvement is considerable.

8. Recommendations

The above vision and proposals for development of TIEMS requires thorough discussion both within the Board of Directors and at a plenary session of the Waterloo conference. In this context, participants should be mindful of the fact that expeditious decisions are necessary for the future development of TIEMS to be undertaken.

Therefore I propose a two years plan of action and time schedule for the revision and development process as follows:

Issues to be raised at the coming TIEMS annual meeting

- Agree on revision of the by-laws and mission statement
- Extend the board to eleven Directors
- Elect the President who will have the overall responsibility for TIEMS development
- Elect the Vice Presidents and determine responsibilities
- Appoint Regional Directors
- Agree the membership programme as proposed by Kathleen Kowalski
- Elect working groups responsible for:
    - TIEMS activity programme, revision of by-laws and mission statement
    - Cooperation and Liaison action plan
    - Communication and publication strategy
    - Membership and sponsorship strategy
    - Regional/National development programme
- Agree on permanent secretarial services to the society
- Agree conference programme and responsibilities

Time schedule

- All working groups to serve a two year term
- All working groups to detail their progress on TIEMS home page

9. Acknowledgement

I am grateful for the significant contribution from Sverre Roed-Larsen who carried out research to summarise the international emergency management community and helped determine the strategic programme, action plan, Internet home page activity and relevant references.

10. Conclusions

A review of the Emergency Management Community, and set in the context of the events of the last year, confirms the view that TIEMS has a significant role to play. Increased discussion, planning and action on an international scale between the various individuals and organisations can only benefit the community as a whole, and TIEMS as a Society. Individually, we will each benefit from more widespread contact and access to alternative knowledge and skills.

It is clear that intrinsically we have the core skills, experience and potential to develop TIEMS into a credible worldwide organisation. Providing we work together, it is possible to provide an infrastructure and activity programme within a reasonable timescale, and that will be an attractive proposition to all those involved in Emergency Management.

11. References

Examples only – universities, libraries, training schools, business companies, journals etc. are excluded

ABBR.	NAME	WEB-ADDRESS
International organisations		
OCHA	UN Office for the Coordination of Humanitarian Affairs	www.reliefweb.int/
ISDR	International Strategy for Disaster Reduction	www.unisdr.org/
IAEM	International Association of Emergency Managers	www.iaem.com/
DERA	The Disaster Preparedness and Emergency Response Association, International	www.disasters.org/dera/
ESRA	European Safety and Reliability Association	www.esrahomepage.org
ESReDA	European Safety, Reliability & Data Association	www.vtt.fi/aut/tau/network/esreda/esr_home.htm
EAAP	European Association for Aviation Psychology	www.eaap.net/
LACDE	Local Authorities Confronting Disasters & Emergencies	www.ulai.org.il/_aced.htm
RAPA	The Risk Assessment and Policy Association	www.piercelaw.edu/tfield/rapa.htm
IIRSM	The International Institute of Risk and Safety Management	www.iirsm.org
IFRC	International Federation of Red Cross and Red Cross Crescent Societes	www.ifrc.org
IRCD	International Research Committee on Disasters/ISO	Sociweb.tamu.edu/ircd/
National Emergency organisations		
FEMA	US Federal Emergency Management Agency	www.fema.gov/
NTSB	US National Transportation Safety Board	www.ntsb.org/
NEMA	The National Emergency Management Association	www.nemaweb.org/
FAA	US Federal Aviation Administration	www.faa.gov/
EMA	Emergency Management Australia	www.ema.gov.au/
EPC	Emergency Preparedness Canada	www.epc-pcc.gc.ca/
ARC	American Red Cross	www.redcross.org/services/disaster
Others – such as Information centres etc.		
EPIX	Information Preparedness Information exchange	Epix.hazard.net/
CRID	The Regional Disaster Information Centre for Latin America and the Caribbean	www.crid.or.cr
ADRC	The Asian Disaster Reduction Centre	www.adrc.or.jp

	Disaster Warning Network	www.disasterwarning.com/
	Global Disaster Watch	www.angelfire.com/on/predictions/
	The s Natural Hazards Research and Applications Information Centre	www.colorado.edu/hazards/intro.html
	Relief	www.reliefweb.int/
GDIN	Global Disaster Management Network	www.gdin.org/
EIIP	The Emergency Information Infrastructure Partnership	www.emforum.org/
IPW	Injury Prevention Web	www.injurypreventionweb.org

12. Biography

K. Harald Drager is the Managing director of A/S QUASAR Consultants, established in 1983, and having delivered software solutions internationally for emergency and risk management. He has a master's degree in control engineering from the Norwegian Technical University in 1966 and a master's degree from Purdue University in industrial engineering in 1973.

His specialisations are international business development, emergency and risk management, chemical hazard communication and project management. He is doing consultancy work amongst others for the World Bank/International Finance Corporation and NATO, and has been project manager of several international research and development projects for software development in risk and emergency management.

He was active in establishing TIEMS in 1993, and has been the International Vice President of TIEMS since its inauguration.

He has published numerous papers on emergency and risk management.

PREVENTION - THE FIFTH AND MOST IMPORTANT PHASE IN EMERGENCY MANAGEMENT

Michael E. Martinet, C.E.M.

Office of Disaster Management - Area G[1]

Key Words: disasters, flood, construction, mitigation, planning, construction, building

Abstract

The FIVE? Phases of Emergency Management explores the element of human complicity that often worsens the loss of life and property damage nominally caused by natural disasters. Mr. Martinet presents a case study of the Johnstown Flood (1889), showing how human activities set the stage for one of the greatest U.S. disasters in terms of loss of life.

He shows that the human interference leading up to the Johnstown tragedy was not the exception but rather the rule. He cites similar contributions to the losses in the Galveston Hurricane of 1900, the San Francisco Earthquake and Fire and other modern disasters.

He develops the argument that actions (or inactions) that at the time seemed quite unimportant played a critical role to greatly facilitate loss of life and property damage from a natural and inevitable cycle of nature.

Mr. Martinet then turns to his years of experience in the construction industry to show with startling photographs how the built infrastructure is deteriorating far more rapidly than most emergency managers and disaster planners can possibly know.
He argues that current mitigation programs cannot begin to address the magnitude of the real problem facing society. This presentation is directed to emergency managers, building officials, community development planners and elected officials. This is a call to re-examine some of the fundamental assumptions upon which disaster planners base the planning process.

Introduction

We are all familiar with the traditional four phases of emergency management: mitigation, preparedness, response and recovery. I believe that there is a fifth phase that we need to recognize and deal with if we are ever to begin to reduce the impact of natural and technologic disasters. But before I describe this fifth phase, I want to tell you about a disaster that happened over 100 years ago. It has been described as a natural disaster. But see if you would still call it a natural disaster when I am through.

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The Scenario

Johnstown - Pennsylvania - Thursday May 30, 1889 - Memorial Day weekend - and rain was in the air...A rain storm had come from Kansas and Nebraska and moved east. All along the storm's path there had been heavy rain, roads were washed out, and trains delayed. The U.S. Signal Service (forerunner of the NWS) had telegraphed warnings for severe local storms. When the storm hit the portion of Pennsylvania near Johnstown, an estimated 6 to 8 inches of rain fell in 24 hours. Some places in the mountains 10 inches of rain fell.

Johnstown Pennsylvania is sited at the confluence of Stony Creek River and the Conemaugh River at slightly over 1100 feet above sea level. Johnstown was built on a level flood plain and in their natural state the two rivers are 60 to 80 yards wide. Flooding was a relatively common occurrence. The first recorded flood was in 1808. Flooding followed in 1820, 1847, 1875, 1880, 85, 87 and 1888.

As the area grew, trees were cut for timber and the watershed on the hills was being stripped off. The river channels were narrowed to make room for new buildings, and to make bridge building easier. Some in Johnstown thought that the river would merely dig deeper channels. But the river beds were nearly all solid rock.

The little Conemaugh River originates at a height of about 2300 feet above sea level and drops about 1100 feet as it flows to Johnstown, with a drainage area of some 60 square miles.

Roughly 14 miles upstream from Johnstown, at an altitude of slightly over 1500 feet above sea level was the **Three Mile Dam**, also known as the **Old Reservoir**. Originally its top was 72 feet above the valley floor. It was 930 feet long. In 1889, water in the dam was normally 6 or 7 feet below the top of the dam, which covered 450 acres, and was 60 feet deep. The estimated weight of the water was 20 million tons.

The original dam was commissioned by the state of Pennsylvania in 1836, to provide a steady supply of water for a canal. The dam was built to the standards that had been used for hundreds of years. It was earth fill construction with a clay liner to prevent water seepage. To avoid erosion of the dam, a spillway was cut into the solid rock that adjoined one end of the dam. At the bottom center of the dam were 5 cast iron pipes 2 feet in diameter to control the height of the water.

So far so good.

In 1875 a Congressman Reilly bought the property. The only thing that he did, was to remove the cast iron culvert pipes and sell them for scrap. In 1879, the South Fork Fishing and Hunting Club was formed and purchased the dam and surrounding countryside. The club began renovations on the dam. The holes where the five culvert pipes had been were filled in with whatever was at hand, rocks, trees, hay, mud and some quantity of horse manure.

In 1880, a local Johnstown businessman who was concerned with the safety of the dam sent an engineer to evaluate the dam's condition after the renovation. The engineer noted the removal of the drainage culverts, and poor repair techniques, which resulted in a leak cutting into the embankment. The report was sent to the dam's owners, who rejected it as having no merit whatsoever. In addition to these two problems noted in the report, the new owners had made some other changes. In order to provide a wider road across the top of the dam, so carriages could pass each other, the dam had been lowered one to three feet. But the height of the spillway was not changed, so the relative safety margin between the crest of the spillway and the crest of the dam was reduced.

The club also added a screen of iron rods to prevent the stocked fish in the lake from going over the spillway. This only slightly reduced the flow of water, but it now created a trap for debris when the water was running fast over the spillway. Additionally, the dam sagged slightly in the middle. The middle of the dam may have been one to four feet lower than the ends of the dam. The center of the dam should have been the highest and strongest, but the reverse was true. Before the South Fork Fishing and Hunting Club bought the dam, the water level had been maintained at about 40 feet. But the Club raised the water level to nearly 60 feet, almost to the top of the dam.

In the 1880's there were many scares that the dam would fail. The first came on June 10th, 1881, when a flash flood caused a rumor that the dam was going to fail. On this occasion, a group of local men went to the dam and inspected it. The local paper reported that all seemed to be well with the dam, and that the water was still two feet from the top of the dam. And in any event, the paper mused, there was plenty of land between the dam and the town for the water to spread out. This was the first of many such scares for the residents of Johnstown. All of which proved to be just "cries of wolf." But on Friday May 31st, the previous night's rain had begun to raise the level of the rivers at about a foot per hour. By ten o'clock in the morning, water filled most of the basements in town.

In years previous, local municipal ordinances had fixed the width of the Stony Creek River at 175 feet, and the little Conemaugh River at 110 feet. But below the conjunction of the two rivers, the river was only 200 feet wide. 85 feet of river had simply been legislated right out of existence.

That morning, Johnstown locals had gathered near the rail yards to watch the rivers rise. Every indication was that the wooden bridge above the railroad station was going to wash out, and it promised to be a grand spectacle. Between noon and 1 o'clock, a telegraph message came into the East Conemaugh dispatcher's tower: "South Fork Dam is liable to break. Notify the people of Johnstown. Prepare for the worst." A few minutes later the message arrived in Johnstown. The freight agent glanced at it, but did not read it. He later said that he had heard these warnings before. The two men in the station who did read it laughed out loud. Two more warnings were sent from the dam to Johnstown, and both were ignored. Observers at the dam estimated that the water was rising an inch every ten minutes. The dam was three miles long, up to a mile wide in places, and 60 feet deep.

Shortly after 3:00 p.m., the dam broke and over 2,200 people perished.

Would you still call this a *natural* disaster?

In Johnstown and at the dam, over the years, people had made almost every mistake possible to guarantee that disaster would happen. But was this an unusual event? Not really. In most American disasters human complicity has played a significant role in creating what are termed "natural" disasters." Certainly, the forces of nature create conditions that precipitate disastrous loss of life and property. But almost always, the human involvement is a major contributor to the losses of life and property from so-called "natural disasters."

In the Galveston hurricane of 1900 that killed over 6,000 people, the citizens of Galveston received not even 1 warning about the approaching storm, even though the weather forecasters in Florida and Washington, D.C. knew of its existence. But they also "knew" that a hurricane **could not** move from the Carib0bean as far west as Texas. Cuban weather forecasters, who better understood the serious threat, attempted to make notification. But at the request of the Weather service, the Cubans were denied access to the telegraph cables, which in the aftermath of the Spanish American War, were still controlled by the U.S. Military.

The huge losses from fire in San Francisco in1906, were in part a result of an inadequate fire main system. Even though Fire Chief Dennis T. Sullivan, made a study of the system and requested funds for making badly needed improvements to the system, the City council did not want to spend the money. For decades, we here in California minimized and even attempted to completely deny the existence of earthquake faults. It was not until 1938 that the first "official" map of known faults was published by the State Division of Mines and Geology.

In July 1944 in Hartford Connecticut, the Big Top of the Ringling Brothers, Barnum and Bailey Circus caught fire and burned, killing 165 persons, mostly women and children. Spectators at the scene were amazed at how fast the big top burned. As usual, the previous spring, the tent had been waterproofed, with a mixture of paraffin and white gasoline.

The Oakland Hills fire of 1993 demonstrates the losses possible when homes are built in the urban-wild land interface without respect for the inherent dangers involved.

Local governments across the country regularly permit, and even participate in land development in high-risk areas without sufficient safeguards to prevent catastrophic losses when the inevitable dangerous cycles of nature occur.

But this presentation is not about history and events past. This presentation is a clear and unambiguous look into future disasters. Very rarely are damages from disasters solely the result of a single catastrophic event or failure. Almost always, the structural fatalities of any system are the result of a series of seemingly random and disconnected micro-failures. Let me give you a small example of what I mean.

A man has an important job interview at 10 o'clock. He gets up in plenty of time, and even allows himself an extra 45 minutes for what is normally a 25 minute trip by car. This morning however, his spouse accidentally leaves the empty coffee pot on and it cracks. But our hero needs a cup of coffee, and so he gets the old drip coffee maker down from the cupboard. He waits a few extra minutes for the coffee to be ready, but still has plenty of time. He hurriedly leaves the house and goes into the garage, locking the house behind himself, when he realizes that he left his car key in the kitchen. But being a good emergency planner, he has a back up. He keeps a spare house key in the garage. But suddenly he remembers that he gave it to a friend a few days ago, when the friend was returning a borrowed tool. His cushion of time is narrowing, but he is resourceful. He goes next door to his elderly neighbors, who seldom drives any more, and keeps his car well maintained to borrow the car for this emergency. Unfortunately, his neighbor tells him, the starter is broken, and the mechanic is coming today to repair it. But his advance planning has still left him enough time to take the bus. The neighbor reminds him that the bus drivers are on strike. He calls for a cab, but the dispatcher tells him that it will be an hour before he can send him a cab, because of the transit strike. He uses the neighbors phone to call his appointment to cancel.[2]

What caused this man to miss his important appointment?

Human failure: forgetting the coffee pot, locking himself out of the house?
Mechanical failure: broken starter motor?
Environmental failure: transit strike and taxi overload?
System design: he can lock the house door without the key?
Procedures: warming up coffee in glass pot, not giving himself even more time?

Had any one of these relatively minor and disconnected incidents not happened, the man would have presumably made his appointment. This same sort of chain of failures can often be seen in so called natural disasters, or as we like to call them, acts of God. The term "act of God" assigns blame to the Divine, and coincidently expunges humans of any guilt associated with causing the disaster or contributing to the consequent damage.

Certainly there are massive climatologic, seismic, and technologic events that precipitate floods, strong winds, earth movements, explosions, fires and other events. But upon close examination, the damage caused during these events almost always has some roots of human contribution, some elements of human action that either enabled the disaster in the first place, or exacerbated it.

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[2] Perrow, Charles, Normal Accidents, 5

We continue to build homes on flood plains, on top of unstable ground, at the bottom of a hill of unstable ground, adjacent to and even directly over earthquake faults, and close to every conceivable source of natural and man made disaster possible. We then act amazed that homes are destroyed as a result of an act of nature that we knew was inevitable, and then we quickly declare it to be an act of God.

So far we have looked at the broader view of disasters, and their human components. But there is deeper aspect of this issue. Not only can big mistakes and obvious errors contribute to disasters, but small hidden faults can contribute to failures with the same degree of magnitude.

To examine this theory in some detail, I am going to talk about a field that I know quite well, and in which I have many years of actual experience.

I grew up in a family of builders, including my father, my grandfather, and uncles. For over twenty-five years I have held a general contractors license in California. I worked as a carpenter, superintendent, and estimator in the construction industry.

I'm going to tell you about the real world of tract home construction, and how it directly affects what we do as emergency managers. And this is not just a California problem, it is a problem across the country.

How are tract houses built?

Tract homes are built mostly by professional developers and managers, with a lot of help from amateurs. Let me explain.

Developers buy a piece of raw land, and hire planners and architects to design a community of homes. The planners layout the streets and lots. On some projects, they will include parks and open space areas. What they don't do is to analyze the long-term consequences of building in a particular area relative to natural or technological hazards that may exist in that area. The decision to build has already been made by the developer.

Architects and planners normally do not address anything more than the minimum issues of drainage and seismic risk. Their job is to create a community of homes that will sell quickly and bring the greatest economic return to the developer. They have no vested interest in creating safe and strong homes, beyond the minimal requirements of the building code.

Soils engineers are commonly used, because soil properties will affect how the foundation is built. But the foundation may be the last part of the house to be engineered.

When an architect and engineer design a large commercial or industrial building, they must do a structural analysis based upon the design of the building. Individual parts of the structure, such as the steel framing or concrete columns and walls may need to be increased in size or strength depending upon the engineering analysis. The analysis is a series of mathematical calculations that are based upon the known characteristics of a particular construction material and how it performs under certain stresses.

In single-family homes, and two story apartment construction, when conventional wood framing construction techniques are used, and the openings in the walls for the windows and doors do not exceed certain limits, an engineering analysis may not be required. A competent carpenter will know the rules of thumb to produce a strong building.

However the operative phrase is "competent carpenter" Construction is hard work, and housing is some of the hardest physically, and production schedules are very tight. Non-union labor is common and "Piece work" is a typical practice. Piece work, is where a worker is paid by each piece that he produces, rather than by an hourly wage. The faster a carpenter can frame a house, the more money he can make. There is relatively little incentive for doing quality work.

It is not uncommon for so called carpenters to only be able to do a few limited but very repetitive tasks. Many carpenters cannot read blueprints, and do not understand the basic physics of wood frame construction.

When I worked as an assistant superintendent on a tract of homes, there were over a hundred carpenters who worked on the project at one time or another. But only three of these carpenters could have built the entire house from start to finish. They were the layout man, the roof cutter and the stair cutter. Only these three people could read and understand blue prints and to the mathematical calculations necessary to layout the positions of the walls, and build roofs and stairs, the two most mentally demanding chores in home construction. Most of the other so-called carpenters would just follow the lead of these three and nail together the components that they cut and marked.

One of the most basic elements in building construction is called a shear panel. A shear panel is what gives a wooden frame its ability to resist seismic forces and the force of high winds.
Use folding box example

Properly applied, shear panels are absolutely essential for a building to be able to resist the forces of earthquakes and high winds. Some type of plywood or manufactured wood wafer board is the most common material for shear strength. However, in homes with large openings for doors, windows or garage doors or where there is a second story above the garage, moment resisting steel frames are also very effective. Moment resisting steel frames are heavy structural steel beams that will resist damage from earthquakes. Properly nailed gypsum wall board can also be used to provide a small part of the shear value in a structure.

Wood-frame structure.

Another potential weakness in the process is the use of "engineered components" Engineered components are structural elements that are carefully designed by registered engineers and mass produced to speed up the construction process and ensure a structure that can withstand seismic and wind forces.

These engineered components are tested in laboratories before approval by the building code officials. Correctly installed, they provide greater strength and speed up the construction process. But in the laboratory, tests are prepared by master craftsmen, who use great care and precision in assembling the test. Actual installations in the field often bear little resemblance to test conditions. For one line of engineered metal brackets used to hold wooden framing members together, the manufacture produces 23 different types of nails and screws. Each of hundreds of different brackets require different nails or screws to meet the performance standards established during the testing process. You will see in the next slides, that using the right size or type of screw or fastener is a small problem, next to using no fastener at all.

So we see that homes are not always the solid structures that they appear to be from the outside and that homes can and do contain series of disconnected construction defects that appear to be relatively minor.

We also have seen that under certain circumstances apparently minor and separate defects can be linked in ways that no one could have ever imagine, and that this un-imagined linking can produce catastrophic failures.

<u>We are building disaster problems faster than we can ever solve them.</u>

Mitigation is the touted as the way to eliminate disaster hazards to reduce loss of life and property. But, what about PREVENTING them in the first place? What if we stopped building defective structures, structures that fail when natural forces press against them, shake them and flood them. Prevention, can give us a fresh start.

Mitigate: To make or become less severe, less rigorous, or less painful; moderate

Prevent: To act in anticipation of an event, to stop or keep from happening, make impossible by prior action

Over time by using both mitigation and PREVENTION, we can begin to make some real gains on the defective building stock of this country that will fail in disasters.

We don't mitigate in a year, the problems that we create in one day of home building.

We have some of the best building codes in the world. But they are not yet doing the job that we want. PREVENTION will be difficult, it will be unpopular, but it will be our only chance of truly reducing the ever-growing cost of disaster.

We need to become aware of what is happening in our city and county building and safety departments and in community development and planning departments. Unless we educate ourselves and others, and form alliances with those who regulate community development and construction, we will fall ever further behind in our efforts to create disaster resistant communities.

I have not even mentioned mobile homes and manufactured housing whose quality standards are even worse. I have ignored illegal construction, where no engineering at all is used, no permits are ever pulled and no inspections ever performed. Illegal room conversions and garage conversions add another huge layer to this pile of disaster pick up sticks.

If we can't begin to prevent some of the problems that directly and substantially contribute to disasters, we will remain victims without a clue and without a prayer.

I strongly urge our profession to consider taking off the blinders and work with others to make PREVENTION the fifth phase of disaster management.

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Acknowledgements

The author wishes to thank MC Consultants of Carlsbad, California for access to their photographic library of construction defects.

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TEN THINGS YOUR ORGANIZATION CAN DO NOW

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Key Words: Crisis, Continuity, Planning, Hazard, Vulnerability

Abstract

We are faced with a growing threat - ***terrorism***. The events of September 11, 2002 have forever changed the way we live. The security of the United States of America's infrastructure is a key concern of the White House. This presentation focuses on ten things that your organization can do now to improve survivability. Discussed are:

Ten Things Your Organization Can Do Now	
Action # 1	Make Your Enterprise an Unattractive Target
Action # 2	Revise Employee Screening Processes
Action # 3	Validate Business, Community and Government Contacts
Action # 4	Assess Business Continuity Plans
Action # 5	Train and Educate Your Workforce
Action # 6	Equip Your Workforce
Action # 7	Review leases and contracts for risk exposure
Action # 8	Assess value-chain exposure to supply disruptions
Action # 9	Review insurance policies and conduct cost/benefit analysis
Action # 10	Communicate Commitment

You need an open source for information on intelligence collection, data acquisition strategies directed against your company and its most valuable assets - your people.

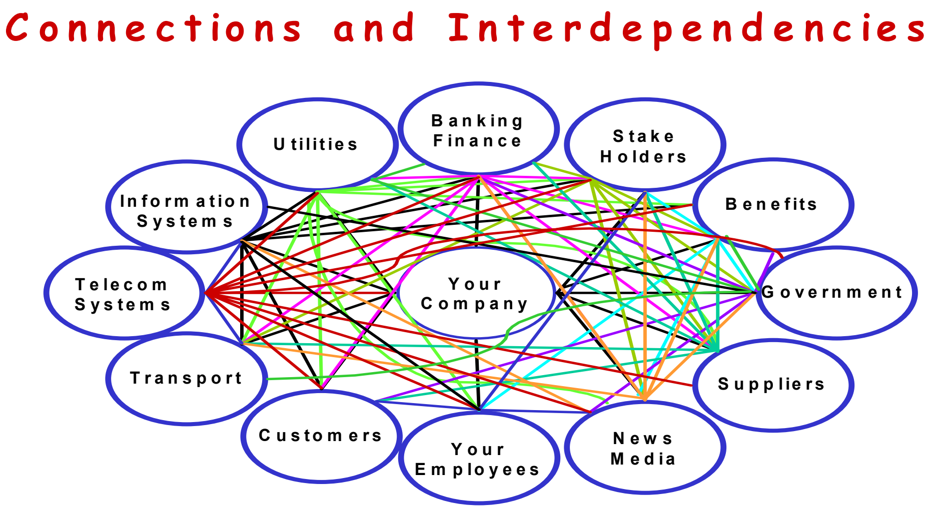
Is your company prepared? Could an event, such as these, affect your company's existence?

- Accidents, explosions, fires
- Natural disaster
- Environmental damage
- Product recall/tampering
- Workplace Violence
- Terrorism

Introduction

In the aftermath of the terrorist attack on the United States of America, the traditional rules governing the conduct of business are being obliterated as businesses are beginning to redefine how they will operate. The world was well on its way to blurring the distinction between traditional business and the appearance of widespread eBusiness operations. Products were becoming services, services became products and business lines were changing constantly. As the authors of the book "*Blur*" state, "*Connectivity, Speed and Intangible Values are the new driving forces in business today. Traditional business boundaries are blurring as everyone becomes electronically connected*." Figure 1 below illustrates just how connected we are in today's world. With all this connectivity, you might ask yourself, "How resilient is my organization if our connectedness is interrupted?"

Figure 1: Connections and Interdependencies



Assumptions

The following assumptions have been made with regard to the recommendations contained in this white paper. First, events that have been building since the end of World War II, including thousands of terrorist attacks on innocent civilians worldwide, have culminated (so far) in vicious and indiscriminate attacks first by domestic terrorists and now by foreign terrorists on our homeland. Second, America is not immune from terrorism. Quite the contrary, we are a target rich environment for both domestic and international terrorists. The stakes are high, and the issues are indeed, life, death, and economic survival. Third, terrorists are driven to kill people and to destroy property. Fourth, all people and all facilities/operations are at risk. Fifth, priority terrorist targets are those of monetary or strategic value, having high human density and with cultural or symbolic value. Sixth, corporate headquarters of major corporations are prime targets. Seventh, most of what has to be done in the corporate environment must be done by the corporations themselves. Indeed, it is their responsibility to their people, their stockholders and to the public that relies on their products and services. Eighth, government, on the other hand, must concentrate its efforts on "critical infrastructures" such as electric power supplies, gas and oil, telecommunications, banking and finance, transportation, water supply systems, emergency services and continuity of government. Finally, corporate America must act now to make key assets (people, properties, equipment and information assets) unattractive targets for terrorists. Failure to do so is to be vulnerable to an attack.

In his book, "*6 Nightmares*", Anthony Lake relates the comments of World War II veterans, stating on page 92, "*…that battle was a struggle not just between two opposing armies but between two opposing ideas, and the qualities those ideas engendered in their respective fighting forces*." With the events of September 11, 2001 The United States of America, its people and corporations have entered a new era of thought and belief. No longer are we able to ignore other ideologies and belief systems. We have created a global reach via the evolution of transcontinental travel, the Internet, communications media and business expansion worldwide. Our new global economy requires us to understand ideologies and beliefs. Nor will we ever be able to think that the trouble is "over there". Our challenge is to maximize the benefits of near instantaneous information while maintaining organizational structures that continue to be effective.

Crisis! Merely mention the word, and you evoke visions of unspeakable affliction and suffering. Recent events make those of the past, Three Mile Island, the Valdez oil spill, Bhopal, the Tylenol incident pale by comparison, and the list continues to grow. It seems that you can't turn on the radio or television or pick up a newspaper, magazine, or periodical any more, without reading about a crisis somewhere. Management is never put more strongly to the test than in a crisis situation. The objectives are immediate and the results have long term implications. Today, individuals responsible for the management of businesses and public agencies must be prepared to deal effectively with threats that could not be conceived of prior to September 11, 2001.

Ten Actions to Take Now

Government and Corporate America have long recognized the importance of being prepared. In the wake of many events, government passed regulations requiring Corporate America to develop and implement programs to assure preparedness. With the recent events we have experienced, can you wait until the government enacts new laws? The answer is no, Corporate America must take action now. Implementing the following seven actions within the context of your situation can produce positive results for your organization. The ***Ten Actions*** provided herein are presented in no order of precedence. You and your organization should assess their applicability and prioritize them as it fits your unique situation.

Ten Actions	
Action # 1	Make Your Enterprise an Unattractive Target
Action # 2	Revise Employee Screening Processes
Action # 3	Validate Business, Community and Government Contacts
Action # 4	Assess Business Continuity Plans
Action # 5	Train and Educate Your Workforce
Action # 6	Equip Your Workforce
Action # 7	Review leases and contracts for risk exposure
Action # 8	Assess value-chain exposure to supply disruptions
Action # 9	Review insurance policies and conduct cost/benefit analysis
Action # 10	Communicate Commitment

Action # 1 Make Your Enterprise an Unattractive Target

Making your enterprise an unattractive target is one of the basic tenants of security, as well as, business continuity preparedness. Whether it is a terrorist or a criminal, if your enterprise presents significant barriers to access it is less likely to be targeted. The application of active security measures, as well as, passive security measures serves to deter the perpetrator to another target. For example, you may wish to change your security personnel's uniforms in order to make them more visible. A simple change like this can have an effect by making people more aware of the presence of the security personnel. You can introduce "Target Hardening" measures, such as, decorative concrete barriers, cameras, perimeter lighting and access badges. These measures act as passive deterrents to unauthorized entry. You can also add barriers to access, such as, manned guard emplacements with gates, tire spikes, reinforced fencing and the removal of vegetation and next to building parking areas.

Action # 2 Revise Employee Screening Processes

Do you really know who your employees are? Are you sure that the person you hire has represented their background honestly? Taking this action may assist you and your organization solve a very real problem, "How do I know?" More than ever, employers need to identify employees and potential employees who are at risk of being exploited, compromised and/or co-opted, by terrorists or criminals for information, access and/or passive cooperation. The better you know your employees, the less likely your organization presents a target. You can accomplish this through implementing a system of more detailed background investigations designed to provide assurance of the information provided to your organization.

Implementing a system of checks and balances whereby critical information and/or access is not subject to compromise can also afford your organization more security. A "Workplace Violence" program is also useful for diffusing potential conflict situations. Employee Assistance programs should be reviewed and assessed for effectiveness and for accessibility by your personnel.

Action # 3 Validate Business, Community and Government Contacts

The more you know about the support services that you depend on and your organization's linkages to suppliers, customers and dependencies on critical infrastructures the less apt your enterprise will be to assume too much. You should learn as much as you can about the Critical Infrastructures your enterprise depends on, including electric power supplies, gas and oil, telecommunications, banking and finance, transportation, water supply systems, emergency services and continuity of government.

In addition to learning about and planning for Critical Infrastructure disruptions, your organization should get to know about the expectations and capabilities of your suppliers, business partners and customers. For example, how would you deal with a situation in which one of your critical suppliers was not able to meet a scheduled delivery? Or what if a customer had an event and could not occupy their facilities? Would your organization be able to coordinate with the supplier or customer to the mutual satisfaction of all parties?

Action # 4 Assess Business Continuity Plans

Does your organization's current approach to business continuity employ an "All Hazards" approach or are your plans segmented into a series of plans that are not integrated? A key question you may wish to ask yourself is, "Does our current Business Continuity Plan address all the threats that face our organization?" If your Business Continuity Plan is focused on only a portion of your organization, such as information systems disaster recovery, you may want to rethink and rework your plans into an "All Hazards" plan. An assessment of your program against the "All Hazards" approach may be the answer to uncertainty. An "All Hazards" plan will take into consideration life safety issues, emergency response, event management, operational events, workplace relocation and external events that can have a negative impact on your organization.

When broken down into its basic elements, the "All Hazards" approach consists of only six parts: preparation and prevention; detection and classification; response and mitigation; reentry, recovery and resumption; training and resource development; and information management.

Although no two business continuity programs are exactly alike, the above six elements form the critical aspects of the "All Hazards" approach to business continuity planning.

Action # 5 Train and Educate Your Workforce

A trained and educated workforce can do more to protect your enterprise than you can imagine. Training of personnel is a critical component of the “All Hazards” approach to business continuity planning and preparedness. Training your personnel at all levels is one of the critical success factors that must be addressed if an adequate response to an event is to be achieved. A “systems” approach to preparing effective training programs should consist of:

- ***Task analysis**:* When designing an integrated training program, first determine the skills, knowledge, and procedures required for satisfactory performance of each task.
- ***Lesson Development**:* Learning objectives are defined from the skills, knowledge, and procedures developed during task analysis. Instructional plans are then prepared to support the learning objectives.
- ***Instruction**:* Lessons are systematically presented using appropriate instructional methods. Instruction may include lecture, self-paced or group-paced mediated instruction, simulation and team training.
- ***Evaluation**:* Performance standards and evaluation criteria are developed from the learning objectives. Each trainee's performance is evaluated during the course and during field-performance testing.

In addition to formal training programs, a program of proficiency demonstration to validate the training and content of plans is also needed. This can be accomplished by establishing a program that supplements the training with simulations (drills and exercises).

Consider developing programs to educate your employees on basic life safety (first aid, CPR, Evacuation, Assembly, Accountability), what to do if an event occurs and what to do after the event. In addition, a community outreach program can provide your organization with many benefits. A community outreach program can enhance coordination with local emergency response and law enforcement agencies, put your organization in a positive light in the community and provide your employees more information on community resources.

Action # 6 Equip Your Workforce

You cannot stop at classroom training and expect your organization to respond effectively to an event. Corporate America needs to assess how prepared it is to deal with workplace events. The government must focus its attention on the protection of critical infrastructures and international issues.

Corporate America has to address protective measures that ensure its survival; it cannot depend blindly on the government to be there for assistance. Being able to respond appropriately will be essential, however, responding without the proper equipment can lead to failure. You need to equip your workforce with the appropriate emergency response equipment, such as: first aid kits, fire extinguishers, event response kits, and evacuation, assembly, accountability procedures.

You should also understand that when you purchase the equipment and train your personnel on its use, you have to develop and implement a maintenance program to assure that the equipment is there and that it works when it is needed.

Action # 7 Review leases and contracts for risk exposure

Every organization needs to completely assess its risk exposure. This includes the standard risk exposure methodologies currently employed by your organization. In addition to the standard risk assessment methodologies, however, your organization should review all leases and contracts for potential risk exposure specifically addressing the issue of terrorism and terrorism related events. As described in item # 8, LMS' "CARVER Analysis" system provides an integrated approach to determining risk exposures.

Action # 8 Assess value-chain exposure to supply disruptions

Critical to all organizations is their value chain. The value chain includes all the internal external "touch points" to suppliers, customers, outsourcing, strategic partners and other entities that assure your organization's continued success. As with the critical infrastructure assessments, your organization needs to assess the potential effects of a disruption of its value chain to supply disruptions. In conducting the assessment a variety of scenarios need to be developed to assess the short term, intermediate term and long term effects of a disruption. This assessment should consider the following key factors as depicted in the table below, entitled, "LMS' CARVER Analysis Elements." The first element is "Criticality". A determination as to the criticality of the service, product, etc. being supplied via the value chain is essential, if you are going to adequately assess the potential risk exposure. Once criticality is established, an assessment of "Accessibility" is necessary. By "Accessibility" I am referring to how accessible an item is.

One needs to assess the accessibility to the item, the accessibility to alternative items that can be substituted and the accessibility of the item to disruption. Once "Criticality" and "Accessibility" are established, you need to determine "Recognizability". That is, how readily recognizable is the item with respect to its loss from your organization's value chain. If I am targeting your organization, I am going to look at readily recognizable items that can be accessed and are critical to your operations. Once the first three items' weighting parameters are established, one must determine the "Vulnerability" presented by the potential loss of the element in your value chain. For example; let's say you are a distributor and are concerned over critical inventory. While your information systems may be able to accurately depict your inventory, if you were to lose access to your inventory supply location or ability to move the inventory to market it would not matter how accurately you could determine the level of inventory, as you and your customers would not be able to access the items. A "Vulnerability" can therefore be defined as a the potential for any degradation, interruption or non-recoverability to such an extent that the consequence is likely to result in harm to the organization, harm to others (suppliers, customers, etc.) and/or substantial negative financial impact. A "Vulnerability", therefore, can arise from a: false ASSUMPTION; blocked or altered COMPONENT; blocked or altered FUNCTION; or blocked or altered OPERATION.

Once you have established, "Criticality", "Accessibility", Recognizability and "Vulnerability" you must determine the "Effect" of the loss of the value chain item. "Effect" can and will generally be associated to the impact of the loss. However, one must consider all aspects of "Effect", there can and may be some positive "Effect" that can arise from the loss or interdiction of the value chain. Lastly, one must determine the "Recouperability" aspects associated with the potential loss or disruption. How resilient is my organization? Can we quickly respond to, manage and recover from a disruption of the value chain? The net result of conducting a "CARVER Analysis" is to be able to determine the potential significance of an event from a consequence management perspective.

Table 1: LMS' CARVER Analysis Elements

LMS' CARVER Analysis Elements
C = **Criticality**
A = Accessibility
R = Recognizability
V = Vulnerability
E = Effect
R = Recouperability

Action # 9 Review insurance policies and conduct cost/benefit analysis

As a result of the events that occurred on September 11, 2001 and subsequent events taking place now, a review of insurance policies with respect to coverage, exclusions and exceptions needs to be accomplished. Insurance companies have been and will be impacted by the events of September 11th and events yet to occur.

Many organizations will find that a cost benefit analysis will offer an effective aid to decision making, strategy planning and the development of risk reduction solutions. By applying LMS' "CARVER Analysis" tool to the evaluation, cost/benefit analysis can be finely tuned to reflect a clearer picture of true costs and benefits. Changes in insurance coverage for many organizations in what are deemed to be high risk/high exposure areas will potentially cause a financial burden for many organizations. This could lead to adverse effects on the organization's ability to maintain its business orientation, retain and/or increase staff and continue to operate from current domicile locations.

Action # 10 Communicate Commitment

Without the support of the entire enterprise all the preparation and planning, all the equipment and training, all of the liaison and information sharing will go for naught. From the highest level to the lowest, everyone in your organization must be kept well informed. Information is a corporate asset, and it's expensive. It must be shared and managed effectively. Information management is also critical during an event. The need for active systems to provide information on materials, personnel, capabilities and processes is essential. It is extremely important to have a system and adequate backup systems in place that serves to identify, catalog, prioritize, and track issues and commitments relating to event management and response activities.

The need to communicate commitment throughout the organization on an ongoing basis is also very important. If your personnel feel that you are only giving lip service to preparedness they are soon going to develop a lax attitude toward preparedness.

Communicating commitment is an ongoing dynamic process that is cyclical and must be supported and actively worked on by all levels of the organization. Active participation can ensure operational resilience. The process doesn't end just because you finished your plan, have involved management and have trained the staff.

Conclusion

Trust and confidence in the abilities of all levels within your organization must be established. "How well prepared are we?" This question can only be answered satisfactorily if you have established a level of trust and confidence, can communicate risk and are willing to allow your people to practice upward management — to delegate up. They must have the ability to recognize needs and have a process in place that allows them to delegate up without fear of repercussions.

You can ensure that all levels within the organization are involved in preparedness. This can be achieved in several ways. The first is to establish a formal program and assign the program to a senior manager directly responsible to top management and the board of directors. Second, establish performance measurements throughout your organization that incorporate an evaluation of preparedness. This goes both ways. Upper management has to take responsibility for developing measurable and attainable goals for the organization to achieve. Third, set aside a specific time for reports on preparedness (business continuity and operational resilience) issues. This can be accomplished by preparing an agenda for senior staff and board of directors' meetings that includes a discussion of management preparedness as a mandatory item. You have to give it more than lip service, though, and you must make the discussion substantive. Provide more than the dull and tiring statistics on reportable accidents, etc. Include all levels of personnel in the presentation process. This can be very effective, and it gets the message out to all personnel that your organization is serious about its preparedness. Fourth, make preparedness issues part of the strategic planning process and a component of your competitive analysis activities. Making preparedness a part of the way you do business, instead of an adjunct to the business is critical. Finally, communicate the information on the importance of preparedness through all levels of your enterprise. This can be accomplished through formal adoption of policy at the highest levels of the organization. The board of directors should endorse your preparedness actions.

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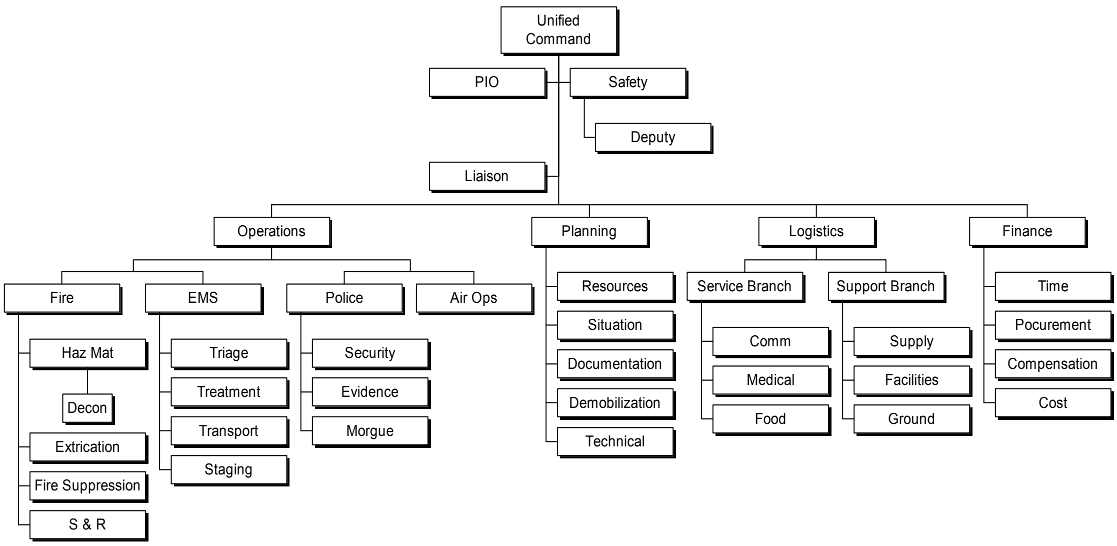
INCIDENT MANAGEMENT SYSTEM: A DISASTER MANAGEMENT TOOL WORKSHOP

Peter I. Dworsky, MPh, EMT-P

IMS Organizational Chart



The Incident Management System (IMS) provides a comprehensive structure and system for conducting both emergency and non-emergency operations. It is equally applicable to small-scale daily operational activities as well as major mobilizations. IMS, because of its standardized operational structure and common terminology, provides a useful and flexible management system that is particularly adaptable to incidents involving multi-jurisdictional or multi-disciplinary responses. IMS provides the flexibility needed to rapidly activate and establish an organizational format around the functions that need to be performed.

Initial IMS applications were originally designed for responding to the wild land fires in California during the 1970s. A task force comprised of local, state and federal agencies developed the basic structure of what is now known as the Incident Management System. Early in the development process, several problems were identified:

- Too many people reporting to one supervisor.
- Different emergency response organizational structures.
- Lack of reliable incident information.
- Inadequate and incompatible communications.
- Lack of structure for coordinated planning between agencies.
- Unclear lines of authority.
- Terminology differences between agencies

- Unclear or unspecified incident objectives.

The task force also established four essential requirements for the structure being designed:

1. The system must be organizationally flexible to meet the needs of incidents of any kind and size.
2. Agencies must be able to use the system on a day-to-day basis for routine situations as well as for major emergencies.
3. The system must be sufficiently standard to allow personnel from a variety of agencies and diverse geographic locations to rapidly meld into a common management structure.
4. The system must be cost effective.

IMS should not be unfamiliar to most people, as it is based on common managerial concepts:

- Unified Command Structure
- Common Terminology
- Modular Organization
- Incident Action Plan - PCDA
- Span-of-Control
- Comprehensive Resource Management
- Integrated Communications

The IMS is designed to be implemented in the following types of situations, regardless of the specific nature of the incident:

- Single jurisdiction responsibility with single agency involvement
- Single jurisdiction responsibility with multi-agency involvement
- Multi-jurisdictional responsibility with multi-agency involvement

Within IMS, there is a concept of Unified Command that simply means, that all agencies which have a jurisdictional responsibility, at a multi-jurisdictional incident, contribute to the process of:

- Determining the overall incident objectives.
- Selection of strategies and tactical operations.
- Integrating appropriate tactical operations.
- Making maximum use of all assigned resources.

The proper selection of participants to work within a Unified Command structure will depend upon the location of the incident, the nature of incident, i.e. HazMat, Fire, and Police Action. Selection of the Unified Command staff typically consists of a responsible official from each jurisdiction in a multi-jurisdictional situation or from each agency in a multi-agency response. Within the IMS, all members of the "Unified Command" structure *share equally* in the overall management of the incident and all personnel assigned must have a clear understanding of the goals and objects as well as the IMS process. The goals of Unified Command are to:

- Improve the information flow and interfaces among agencies.
- Develop a single collective approach to the incident regardless of its functional or geographical complexity.
- Ensure that all agencies with responsibility for the management of the incident have an understanding of their organization's goals, policies and restrictions.
- Optimize the efforts of all agencies as they perform their respective missions.
- Reduce or eliminate duplicated efforts.

With the Unified Command Structure, the Incident Commander is responsible for incident activities including the development and implementation of strategic decisions and for approving the ordering and releasing of resources. The IC, regardless of rank, has complete authority and responsibility for conducting the overall operation.

These responsibilities include:

- Assume command and assess incident situation.
- Setting up an appropriate Incident Command Post
- Assign personnel to General Staff positions as appropriate.
    - Operations
    - Planning
    - Finance
    - Logistics
- Assign personnel to Command Staff positions as appropriate.
    - Public Information Officer
    - Safety Officer
    - Liaison Officer
- Conducting initial briefing.
- Ensuring that planning and intelligence meetings are conducted, if necessary.
- Approving and authorizing the implementation of an incident action plan.
- Establishing a flow of pertinent information for command personnel.
- Authorizing the release of information to news media.

The success and acceptance of IMS nationally have led to its inclusion in a number of regulations and standards. The primary reason for this is IMS's ability to be adopted and utilized by jurisdictions and agencies needing one common emergency management system capable of dealing with all types of emergencies and suitable for use when multiple jurisdictions or agencies are involved.

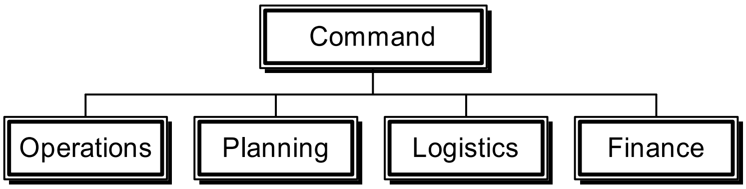
As a result of the Superfund Amendments and Reauthorization Act (SARA) of 1986, the Occupational Safety and Health Administration (OSHA) has implemented regulations that require departments to utilize an IMS at all hazardous materials incidents: 29CFR 1910.120(q)(3)(i-ix).

For those departments in states that do not require following OSHA standards, the Environmental Protection Agency has adopted regulations that impose the same requirements in non-OSHA states. The regulation states, "The incident command system shall be established by those employers ("employers" includes fire departments) for the incidents that will be under their control and shall be interfaced with the other organizations or agencies who may respond to such an incident."

After the Exxon Valdez oil spill, the federal government passed the Oil Pollution Control Act of 1900 (OPA-90), which mandates the use of an IMS and specifies that when a spill occurs, the management of the incident will incorporate a Unified Command Structure.

The National Fire Protection Agency has also implemented guidelines that require the use of an IMS. Standard 1500: Fire Department Occupational Health and Safety Program, states that all departments shall establish written procedures for IMS, and that all departmental members shall be trained in and familiar with the system. It fixes responsibility for firefighter safety at all supervisory levels at an incident and requires a method of tracking and accounting for personnel. It places strong emphasis on scene safety and the role of the incident safety officer. Standard 1561: Fire Department Emergency Management Systems, provides broad guidelines for what should be included in any emergency management system; the appendix gives examples of successful systems currently in use. It does not provide a new emergency management system or impose rigid rules for adoption.

IMS is broken down into five interrelated functional areas:



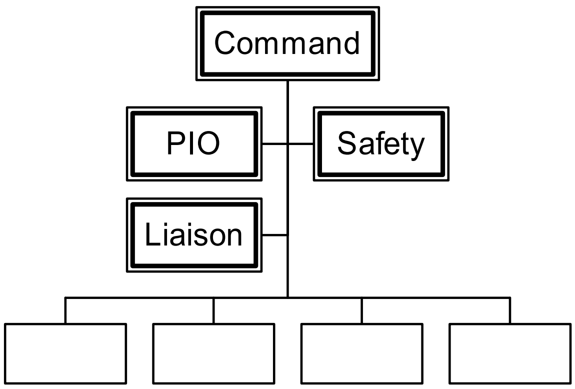
The function of Command is to assume responsibility for the overall management of the incident. Command establishes the strategy and tactics for the incident and has the ultimate responsibility for the success or failure of the incident activities. The Command role is filled by the Incident Commander (IC) and is the position that is established at every incident no matter how small or whether it involves only a single resource. The IC will assign personnel to the remainder of positions. Only those positions that are needed to help get the job done should be implemented. The others remain available for an incident in which they may be required. However, the IC remains responsible for the functions of any unfilled position. The IC should avoid falling into the trap of creating a complex organizational chart with a variety of subordinate positions and having no one left to manage the incident.

Operations direct all of the tactical operations in order to accomplish the goals and objectives developed by Command and assists in the development of the action plan.

The Planning function is to collect and evaluate information that is needed for preparation of the action plan. Planning forecasts the probable course of events the incident may take and prepares alternative strategies for changes in or modifications to the action plan. The planning section will also display the current status of the incident.

Logistics provides services and supplies in support of the tactical operations. Included in Logistics' responsibilities are providing for facilities, transportation, supplies, equipment maintenance and fueling, and feeding and medical services for response personnel.

Usually formally implemented during large-scale incidents, Finance is responsible for the required fiscal documentation needed and produced as a result of the emergency. This includes payroll, workman's compensation issues and paying for equipment obtained by the Logistics sector.



The Command Staff positions are designed to provide aid and assistance in helping the IC fulfill the responsibilities associated with managing the emergency. They handle key incident activities that enable the IC to concentrate on managing the incident. Command Staff is not part of the line organization and does not count when determining the number of positions under the IC's span of control. The three positions that form the Command Staff positions are Safety Officer, Liaison Officer and Public Information Officer (PIO).

The Safety Officer is responsible for monitoring and assessing safety hazards or unsafe situations and developing measures for ensuring personnel safety. After identifying the hazards, the information is conveyed to the IC, and any necessary adjustments are made to the action plan. The Safety Officer can take immediate action to correct an unsafe act or practice or to remove personnel from the threat of imminent danger. A Safety Officer should be appointed when the IC cannot adequately monitor hazards or unsafe conditions due to the size, complexity, or numbers of resources involved in the incident. Anyone given the responsibility of Safety Officer should have the background knowledge and a clear understanding of what dangers the incident can present to personnel.

An incident where multiple agencies are involved may require a Liaison Officer whose responsibilities are to provide the point of contact and coordination for assisting agencies not involved in the Command function, i.e. the Red Cross.

The PIO, in conjunction with the IC, is responsible for the development and dissemination of information regarding the incident and to serve as the point of contact for the media

An individual can only process so much information at any given time before reaching a point of overload, where you can no longer effectively understand what is being said. You need to maintain an appropriate span of control. This theory basically states that no more than five people should report to any individual in a crisis setting. As you exceed this ratio, you will not be able to give your full attention to any one person or problem. In the disaster setting, when you have six or more people reporting to an individual, you should add another link in the chain of command or assign that person a deputy.

Whenever possible, you should use face-to-face communications. This is very import when unpopular policy decisions need to be implemented. This type of communications allows you to receive instantaneous feedback. It also permits a dialogue (the whole purpose of communications) with a group of people, which is an often very difficult using radio. Another essential communication procedure is to use plain text messages. Avoid using radio codes. Neighboring agencies may use codes with vastly different meanings from yours. Every version of the Incident Management System requires the use of plain English radio traffic.

Every incident must have a written or an oral action plan. The purpose of this document is to provide all managerial elements with a working blue print of the event. The main elements to be included in the IAP are the statement of objectives, the organization structure, specific assignments that outline the strategy, tactics and resources to be used. The supporting materials section should have a map of the incident, communications plan, medical plan and so on.

The most important point to remember is the IMS is a tool that is only useful if it is implemented early in the incident and everyone needs to buy into it. Also it does not replace common sense.

Biographical Sketch

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The International Emergency Management Society
9th Annual Conference Proceedings
University of Waterloo, Canada, May 14-17, 2002

SELECTING AN EFFECTIVE COURSE OF ACTION – ANALYZING CONSEQUENCES AND OUTCOMES IN ASSESSING DECISION OPTIONS

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Keywords: decision making, situation awareness, outcomes and consequences, crisis management, emergency management

Abstract:

Over recent years research and practice in emergency and crisis management have evolved interests that emphasize resilience, sustainability, and leadership. Within decision making, crisis and emergency research and practice parallels mainstream decision making interests – confidence and biases in judgement and contextual and situational variables – and considers decision maps of the cognitive process and situational awareness. The ability to manage effectively within emergency and crisis situations, however, remains of primary importance as we are unlikely to eliminate emergencies and crisis situations.

Recent research and thinking in mainstream and crisis and emergency decision making moved into mapping and replicating "good" judgement. Recognition Primed Decision making (Klein, 1996), for example, tries to use experienced-based learning to promote situation assessment, evaluation of options, and elaboration of these options. The Method of Tactical Reasoning (Pandele, 1995) makes a similar effort with its use of five stages of processing – information search, analysis and anticipation of information based on current and future states, identifying tasks, time management, and elaboration options or intentions to act. Underscoring such efforts is a need for a process to do so across situations, as outlined in **FAST** © (Heath, 2001). Fundamental to these, however, is an ability to effectively assess options.

This paper and workshop introduces a fundamental method for evaluating options (or choices), outcomes and consequences. Options are examined in terms of management ability to directly manage options and the capacity of the managing team to manage the situation. Options are then assessed in terms of applicability to the situation, identifying factors or changes in the situation that measure the interaction of choice and situation in terms of whether the choice is working, and wanted and unwanted consequences and outcomes. This assessment includes validity, framing, and management of the consequences (both wanted and unwanted). Through this process the future outcomes and consequences can be probed and the best set of outcomes and consequences can be identified. This then enables more effective evaluation and choice of options. Decisions can thus be made with more rigorous foresight rather than discovered to be less than optimal by hindsight.

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1. Introduction

Trying to select the best option or action choice becomes increasingly important when the decision environment has limited (or appears to have limited) time in which to act, missing or uncertain information, a threat to humans or resources valued by humans, and /or a demand on resources that exceeds the resources available with which to manage. These factors broadly define crisis and emergency situations (Heath, 1998). Consequently we need to continue to improve our capability to think and decide during our interaction with crisis and emergency situations.

Recent approaches that consider effective decision making in emergency and crisis decisions reflect or launch from parallel interests and findings found in the mainstream decision research domain. These approaches have moved from broad cognitive perspectives (such as Recognition-Primed Decision making) to more specific applications (such as Pandele's Methode Tactique). These need to be seen against the broader streams of decision making and against the emergent interests in crisis, disaster and emergency management practice and research.

2. Mainstream Decision Making Research and Emergency and Crisis Management Decision Making

Over the last sixty years research into decision making explored confidence in judgement, decision mapping, normative and subjective models, and aspects within the decision maker and the decision environment that may influence judgement and choice. Aspects included exactingness (Hogarth, Gibbs, Mackenzie, & Marquis, 1991) cue relevance and situation context (Schwartz & Norman, 1989). Exactingness is the degree to which a variable reflects the severity of penalties for poor judgement. Cue relevance considers the degree to which a cue is perceived by decision makers as being contributory to making a specific decision. Situation context includes aspects of the decision maker (attention, memory, and knowledge), type of judgement required (evaluation, choice, and prediction), and task specific factors.

Research also focussed on sources of decisional and confidence bias (Fischhoff, 1975, 1982; Kahneman & Tversky, 1973; Paese & Sniezek, 1991). Decision processing included investment in an industrial plant (Sterman, 1989) medical decision making (Kleinmuntz & Thomas, 1987) and general business simulations that contrasted human and artificial decision teams (Hogarth & Makridakis, 1987).

3. Decision Making Research and Practice in Emergency and Crisis Management

Early research and practice in emergency and crisis decision making applied systems theory and adapted existing approaches (usually military or paramilitary) for use in community, industrial or business settings. This led to the development of common operational structures – from ICS (Incident Command Structures) and UCS (Unified Command Structures) to SEMS (Standardised Emergency Management Systems).

Current research places an emphasis on resilience, sustainability and mitigation. These interests draw on issues in psychological ecology (Reed, 1996), sustainable development (Robertson, 1999), and elements that support resilience (Buckle, Mars & Smale 2000). Other areas of interest include systems approaches for resilience (Paton, Johnston, Smith, & Millar, 2001), individuals and resilience and self efficacy (Lindell & Whitney, 2000) and coping with problems (Bachrach & Zautra, 1985). While such efforts are important in our efforts to reduce risk and threat, we need to consider that ultimately emergencies and crisis situations cannot be designed completely out of our environments. Consequently we need to continue an equal emphasis on how we lead and manage in emergency and management situations.

Some current research looks at types of leadership within the context of emergency and crisis situations. In one example, Yates (1999), in contemplating the book on Intelligent Leadership by Mant (1997), considers leadership in terms of transactional and transformational characteristics. Transactional leadership is seen by both to be the art of building and maintaining transactions or relationships between people. Yates considers that leaders in emergency services are good transactional leaders. Transformational leadership is seen as complementary but different – where a situation is transformed or changed by a focus on desired outcomes. In essence, transformational leaders stand back and see systems in a whole of system or big picture. This is seen by Yates as a lesser characteristic in emergency management and admits a need for a fusion of both transactional and transformational leadership styles. Transformational leaders assess situations and the surrounding environments (including the response management environment) to develop situation awareness of a "big" picture and desired outcomes.

Parallel research explores remembered and recorded reconstructions and experience to develop mental models to handle critical problem and crisis situations. On the cognitive side, for example, Mitroff, Pearson & Harington (1996) suggest that organisations may be worse off if they substitute planning and/or "thinking on their feet" for actual competence in crisis management. Regester (1989) warns of the need to consider the worst case scenarios when managing in such situations. Interest turns to one of how to probe the situation and develop the decision process so that the user is neither locked in a speculative worst case scenario nor moved too readily to a dangerous underestimation of the problem or crisis. In turn, this suggests that decision makers need to assess situations – what can be termed *situation awareness* (Endsley, 1995) – and formulate effective tactical and strategic options.

Situation awareness either indirectly or directly forms part of many suggested approaches that include improving team interaction, especially when that team is likely to encounter problem or crisis situations. One such approach is Crew Resource Management [CRM] – also known as Cockpit Resource Management (see Weiner, Kanki, & Helmreich, 1993). CRM involves a combination of communication, self-knowledge, and focus skills to enhance behavioural interactions.

Recognition-Primed Decision making [RPD] (Klein, 1993) is an approach that reflects knowledge and experience. RPD looks at situation assessment, evaluation of options, and on the elaboration of (and improvement in) these options (Klein, 1993; Flin, 1996). Subjective determination models like RPD assume that consensual knowledge from "experts" produces a good satisficing outcome. A satisficing outcome is one that meets many *but not all* possible decision choice requirements – and seems acceptable ("satisfying") to the decision maker. However, more optimal choices can reduce likelihood of inquiries, litigation, and better outcomes and consequences.

Pandele (1995) offers an approach that appears to link situation awareness and problem or decision analysis in *Methode de Raissonnement Tactique* [Method of Tactical Reasoning – MTR]. MTR essentially outlines five stages of processing:

1. Search for information.
2. Analysis and anticipation of information based on current and future states.
3. Identification of tasks.
4. Management of time.
5. Elaboration of options for manoeuvre (the "intentions" of a fire sector leader).

These stages can be re-defined as find information, analyse information in terms of situation and what needs to be done, determine workable solutions. In this sense, the stages can underscore general decision making processes.

In ***FAST***, Heath (2001) outlines an approach that develops situation awareness and problem solving/decision making by identifying or developing sets of three options (plus a stated target or goal) to produce a choice or option, an alternative to that choice, and a safety option. This process uses evaluation of options and perceived outcomes and consequences to improve choice selection and increase the ability to monitor, manage, and – if necessary – change to another option should the selected option no longer apply or begin to fail. This procedure is based on managing through choice, outcome and consequence analysis and enables us to:

- Consider the range of outcomes and consequences (wanted and unwanted) and determine how we may handle these *before* we interact with a situation, and,
- Develop the skills to consider the range of outcomes and consequences (wanted and unwanted) and determine how we may handle these while working in a situation.

In the workshop we will focus on developing the basic evaluation skills that link consequence, outcome, and choice.

4. The Stimulating Situation

For a central and common focus we will use a very visible emergency – an aircraft crash on an urban (city) environment. We can choose between:

1. The destruction of the World Trade Centre by terrorist action (crashing two large highjacked commercial passenger aircraft into the towers), or,
2. Views of a table top simulation of a commercial jet aircraft crashing into a near-harbour area of a city (due to structural failure involving a tail mounted engine).

We can further determine our "stake" in the process – by group consent (if working in a group). Stakes can include responder organisations (police, fire service, paramedic), business organisations (within impact site, adjacent to impact site, potentially affected by impacts), or associated or involved agencies (government, local government, hospitals, schools).

If there is time we will look at first impact, during and recovery moments for this scenario, and we will also try to determine options and evaluate those options for a stakeholder from an organisation that is different from ours. This last activity is worth doing even if we cannot fit it within this workshop. We can see outcomes and consequences for others. This helps us manage in such situations and plan our own actions more effectively.

5. Developing Choice or Option, Outcome and Consequence Evaluation Skills.

We will try a taste of doing this process before working at a more systematic pace.

1. On the next page write down what organisation and organisational position you choose.
2. Without too much thought or discussion determine the first choice or option you would do.

Most times you will find that your brief statement is a "what to do" type statement. This is a goal or target statement. This statement can be divided into sub-goals by looking at who does it and where it is done, and even when it is done. We usually gain multiple options when we outline "how" it can be done. So let us check whether we have a "how to" part to our statement (and add one if we do not have one present).

3. In the next space, note any other "how-to" options or choices that can achieve the target.
4. Once this is done, choose the option that seems best.

This choice is likely to be largely influenced by a heuristic or rule-of-thumb, like "cheapest", "easiest to do", "best meets the situation as I see it", or "quickest course to the goal or target".

5. Have a look at the outcomes. Do other "good" outcomes exist? Are there any "bad" outcomes? What could go wrong while/when we attempt this course of action? Can we manage those

"wrong" or "bad" situations? How? Notice more outcome-driven options emerge here. What are the consequences for each of these outcomes – for each stakeholder group and for the organisations involved? Can we manage these effectively?

Choice/Option Analysis

1. **POV:**

2. **Option**

3. **Other "how-to" options for the above choice:**

4. **Clearly indicate the "option you (the group) would choose to use".**

5. **Identify *all possible* outcomes – good and bad – including what goes right or wrong while we undertake the choice.**

6. **Indicate with a tick each of these good and bad outcomes that can be *directly* managed.**

7. **Identify *all possible* consequences – good and bad – (1) for you and your organisation, and, (2) for other stakeholders (employees, customers, and so on).**

8. **Indicate which of these we can we effectively manage with a tick.**

9. **Do the same for your other options. Is your choice still the one you would choose?**

Now we can consider a more systematic approach to the twin process of evaluating and expanding the choices, outcomes and consequences.

We can choose:

- *to return to the previous choice domain,*

- *select another target and develop a set of choices from the immediate impact, or,*
- *select a target and develop a set of choices for the "during the situation" interaction.*

As before, we need to:

1. Identify the POV (organisation, your position, the situation context).

2. Identify the target goal (outcome).

3. Identify *all options* we can generate.

4. Do a quick "keep" or "drop" check of each option by looking at whether we can actually manage it and at whether our organisation has the capability to implement it:

- *Can we directly manage and implement this option strategy?* If yes, give the strategy a tick. If we believe we can strongly influence their management and implementation of the option, place a question mark on the option. If we cannot directly manage and implement or strongly influence the management and implementation of the option, place a cross against it and drop the option.
- *Has our organisation the capability to manage and implement the strategy*? Capability in this context means having the resources, training, and corporate "will" to manage. If the answer is yes, give the strategy or option a tick. If the answer is no, we may take a few minutes to consider whether we can fix this. If this is the case, put a question mark on the option. If the answer remains no, place a cross against the option and drop the option.

We now have options with two ticks, a tick and a question mark, or two question marks (having dropped any option with a cross). Options with two question marks can also be dropped where we have a lot of "good" options. Options with question marks may prove costly in time and effort to improve them. In some complex or difficult situations and environments, however, we may need to meet such costs. We may even need to change crossed-out options into ticked options.

Any option with a question mark means we need to spend more time making it workable. If we have a lot of double ticked options we may find we can ignore these "questioned" options as well, although we need to check them for quality of outcome and consequence in case these would be very good should we accept this effort and costs.

For this exercise, let us take all options with one or two ticks (and assume we can convert the question mark into a tick in the future).

Choice/Option Analysis

1. POV:

2. Target:

Options (how to):

Leave work space around each option you write down as you will be adding informational phrases to each option.

We now check that the options are applicable to the given impact situation. In planning and pre-situation mode, we do this across risks, threats, and impacts.

We do this by seeking factors or features in a situation (or possible situation) that clearly signal we can or should use the option. We also look for features or factors that signal "do not use this option". *Sometimes the "apply" or "reject" features or factors are the same. Sometimes these are different.*

1. **Have a look through the "ticked" options and establish some clear apply-reject factors or features**. *Where we have found some apply-reject features or factors let us write the option and the apply-reject features or factors down*.
2. Next we need to assess the option and the (possible) situation to identify any factors or features that will tell us whether or not the implemented option is working and thus still applicable. These features or factors may be "measures" of decreasing or increasing impact damage, threat to people and resources, and/or reductions in the situation. **Look at the options and identify any factors or features that will tell us *over the duration of the situation or duration of the implementation of the option* whether that option is working or not working.** *These factors or features can differ from the apply-reject factors or features.*

We next need to assess the potential results of these in consequences and outcomes. To do this, select one of the options that have so far made it through the analysis (that is, can be managed or influenced, has apply-reject features, has factors or features that allow us to monitor success or failure during implementation). If we have time we will do this for other options and increase our practice with this process.

3. **Write out your (or the group) selected option, including pointers for apply-reject and ongoing performance evaluation**.
4. **Identify our desired outcomes, desired consequences, other positive outcomes and consequences, unwanted or bad outcomes, and unwanted or bad consequences**. We need to do this in terms of ourselves (and our organisation) and then in terms of others (and their organisations).

Outcome and Consequence Evaluation

Option plus apply-reject elements plus working-not working elements:

Desired outcomes

Desired consequences:

Other positive or beneficial outcomes and consequences:

Negative or unwanted outcomes

Negative or unwanted consequences:

We may need to check our thinking for assumptions, stereotypes, and bias. A useful check of our thinking is to ask ourselves:

How do we know this is so?

If we can point to facts and logical argument then the proposed results are possible. If we resort to expressions of wishes ("because it just has to end up like this!") or poorly thought through or stereotypic responses ("what else could happen", "that's the way I would act"), we are expressing potentially delusional thinking and assumptions.

Two further hints may also help:

1. *When thinking hard about an option, be very guarded about any statement that feels as if it has an exclamation mark at the end of the statement.*
2. *Ask "What if this is not the case?" and "What could happen if this does not occur?"*

"Desired" outcomes. *We need to check that the desired outcomes are logical and expected given the situation, the option, and the interaction likely to arise when we implement the option.* Often, our desired outcomes and consequences can be based on wishful thinking and hope rather than a hard assessment of likely results.

If the desired results still seem "true" then tick the desired outcomes that seem true. In most cases we become more aware that the desired results can be achieved but other not-so-desired results are possible, so check that we have these not-so-desired results covered in the negative outcome list.

Should we find the desired outcomes are weak or need more support we place a question mark next to them.

If we find the desired outcomes do not stand up to scrutiny we place a cross against them – and the option shifts to a discard option decision. *If we are in planning and development mode (rather than in a situation) we may take the opportunity to rebuild, re-shape, or somehow modify the option so that the desired results are more certain or more likely and the negative results are eliminated or reduced in impact and/or likelihood.*

1. **We do the same for positive consequences (and again look at both "us" and "other" POVs)**
2. **We do the same for any other (peripheral) positive outcomes and consequences we may have identified.**
3. **We do the same for our lists of unwanted or bad outcomes and consequences.**
4. **Now we do a risk evaluation of these negative outcomes and negative consequences**. We look to see if we can eliminate or reduce them by altering the option or the way the option can be implemented. We then look at the reduced and left-over outcomes and consequences and look at how we could manage should these arise. *This is called contingency planning*.
5. We now look for features within the environment and/or situation that can signal the onset of the negative results and use these to trigger implementation of any such contingency plans.

Should we find that we **cannot** eliminate or reduce and manage any negative results we need to be very cautious about selecting the option to which these belong. *Where there are other options with no or fewer or lesser negative outcomes and consequences – and after we have looked at eliminating or reducing and managing any of the negative results but cannot do so – we discard the option.*

We have now sifted through our options and identified wanted and unwanted outcomes and consequences attached to the options.

Often the best option appears to be the one with the most desired and positive outcomes and consequences and the fewest unwanted or negative outcomes or consequences. Be careful*. There are options with wanted and unwanted outcomes and consequences that may be "best" because we can effectively manage the unwanted or negative outcomes and consequences.*

We may feel somewhat overwhelmed by the amount of thinking and work we have to do across all chains and all risk/threat situation and interactions. If we take the work a little at a time we will find it can be done (and even fun!). As we get experienced this evaluation process gets faster and can become almost semi-automatic.

6. Conclusion

This paper and workshop has indicated a trend toward, and a need for, greater situational evaluation and more systematic and detailed exploration of future states in terms of outcomes and consequences. By looking at how options may apply and may continue to apply, we establish a more effective implementation and a management approach that is more ready to change action-choices during a situation or decision implementation activity. By looking at the wanted and unwanted outcomes and the expected or unexpected responses or reactions (consequences) these outcomes elicit, we can choose better long-term options and make early preparations to handle positive and negative outcomes and consequences.

We have a basic Option Outcome Consequence Evaluation process:

1. **Situation or Component of Interaction and/or Situation:**
2. **Option or Choice:**
3. **Points indicating we can use this option in the interaction/situation:**
4. **Points indicating we need to reject this option in the interaction/situation:**
5. **Expected and wanted results (outcomes and consequences):**
6. **Indicators showing these expected and wanted results are emerging:**
7. **Indicators showing these expected and wanted results *are not* emerging:**
8. **Other possible peripheral positive outcomes and consequences:**
9. **Indicators showing whether these are emerging:**
10. **What we can do to take *advantage* of these as these emerge:**
11. **What we can do with any positive outcomes and/or consequences *after* these emerge:**
12. **Indicators that any peripheral possible positive results are not emerging:**
13. **Negative or unwanted results (outcomes and/or consequences):**
14. **Indicators that these unwanted outcomes and/or consequences are emerging:**
15. **Indicators that these unwanted outcomes and/or consequences are not emerging:**

16. What can we do to manage these as these emerge:

17. What can we do to manage these *after* these emerge:

18. What we need to do to implement this option:

This process provides a systematic way of not only identifying the most applicable or workable choice, but also the beginning of strategic future management of outcomes and consequences before these add impacts, risks, and costs.

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