# Simulation Techniques for Training Emergency Response[1]

J. Peter Kincaid, Ph.D.
Institute for Simulation and Training
University of Central Florida
3280 Progress Drive
Orlando, Florida 32826 USA
pkincaid@ist.ucf.edu

Chief Joseph Donovan
Orange County Fire Rescue Department
Orlando, Florida
Joseph.Donovan@co.orange.fl.us

Beth Pettitt
US Army STRICOM
Orlando, Florida
pettittb@stricom.army.mil

**Key Words:** Simulation, Emergency Management, Incident Command, Training

## Abstract

The Institute for Simulation and Training (IST), University of Central Florida, in conjunction with the US Army and the Orange County (Florida) Fire Rescue Department have developed and fielded a series of simulation techniques for conducting disaster exercises and for training public safety personnel for responding to disasters. Simulator training offers several important advantages, including cost and safety. We are also gathering persuasive evidence that training effectiveness is substantially improved by the use of simulation as compared with traditional field exercises. Our program is now in its seventh year and has concentrated on training for two main skill domains: emergency management incident command, and emergency medical care performed in the field. We provide a programmatic overview including descriptions and illustrations of the following projects. *Project Plowshares* sponsored by the US Army, involved conversion of a wargame simulation to support civilian emergency management exercises. The *Combat Trauma Patient Simulator* project funded by the US Army and the manufacturer (METI) uses a highly realistic medical simulator connected to the Internet to model treatment of battlefield casualties. *Crisis management field exercises* have been supported by the use of simulation techniques and technology, in conjunction with the US and Swedish military and local public safety agencies, particularly the Orange County Fire Rescue Department.

[1] Opinions expressed in this paper are those of the authors and do not necessarily reflect policy of the US government.

## Introduction

The scope of emergency response services continues to expand. 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 law enforcement, fire departments, 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. The use of conventional techniques for decision making training are not efficient because of:

- the cost to conduct large scale simulated emergencies
- the risk to the participants
- the limited number of persons who actually receive decision making training
- the unique nature of each type of emergency situation.

There is a need for methods and tools for improving all emergency training sequences from rescue planning to individual agency responses during disasters and emergencies. IST has been developing a variety of such tools for the past six years (Kincaid, Williams, and Juge, 1995).

Especially, there is a 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. Some of this inter-agency training can be conducted using web-based techniques (Jenvald, Morin, and Kincaid, in press)

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 between sub-units and among different agencies motivates trainees and enhances learning effectiveness..

This paper provides a programmatic overview of a cooperative program among the University of Central Florida (UCF), the US Army Simulation, Training and Instrumentation Command (STRICOM), and the Orange County (Florida) Fire Rescue Department. All of the projects we describe made effective use of a variety of simulation techniques. Much of the research and development which we are now using for training for emergency response was partly the result of a legacy of simulation technology developed for military and aerospace use.

## Project Plowshares

One of the first uses of simulation to enhance emergency management training was Project Plowshares which was based on Janus, a United States Army constructive simulation system.

The Janus program was enhanced to support emergency management scenarios that included hurricanes, fires, tornadoes and chemical spills. The resulting software, "TERRA" provided the stimulus for training command post personnel during emergency management exercises.

The complete system, "Plowshares" contained its own terrain database, an event planning and scheduling tool, a message logger and after action review criteria.

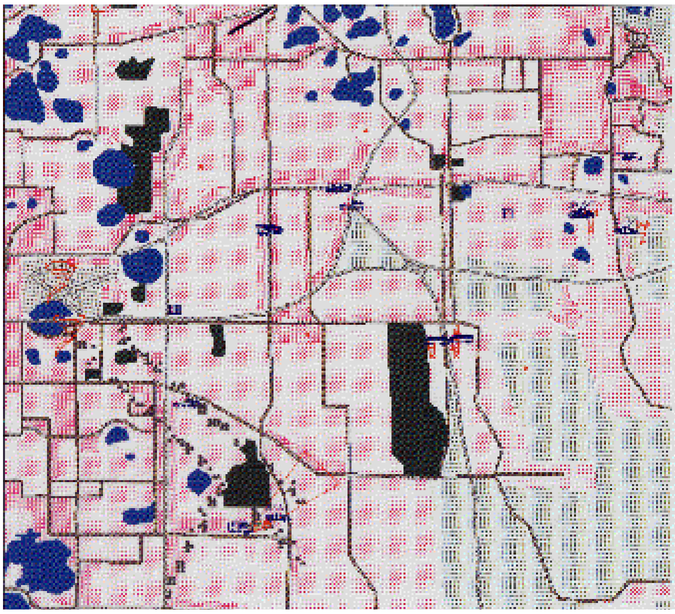

Figure 1. Terrain database for the TERRA program showing a 60km x 60km area of Orange County Florida. The database contained many overlays (roads, floodplains, public safety buildings, moving vehicles, etc.) and could be viewed in areas as small as 10m x 10m showing considerable detail.

This project was sponsored by the US Army and involved the conversion of Army wargame technology for use in training for civilian disasters, such as hurricanes (Slepow, Petty, and Kincaid, 1997; Bermester, Petty, and Slepow, 1996). Plowshares is currently part of the common software load for every Janus system fielded to US Army National Guard units.

The TERRA exercise was held in August 1995 at Orange County Florida's Emergency Operations Center and spanned six hours of simulated time. There were approximately 40 participants drawn from departments of fire/rescue, police and public works who were at separated locations. They communicated via a networked computer system, radios, phones and fax machines.

The original version of TERRA, based on the Army's Janus program, ran under the Unix operating system and was hosted on expensive work stations, rather than PCs. The program's data handling requirements at the time of its development and fielding (1995) were considerably above what could then be handled on a PC. However, current PCs now have caught up and even exceed the data handling capabilities of the UNIX work stations we used for the Plowshares project. Variations of the TERRA program are now hosted on

PCs which is important because emergency management simulations must be affordable to local and state government agencies and universities.

### Combat Trauma Patient Simulator

The Combat Trauma Patient Simulation Program (CTPS) is a congressionally funded, US Army Medical Research and Materiel Command (MRMC) sponsored research and development program (Pettitt, et al., 1998; Petty and Windyga, 1999). The program was initiated to provide and field an integrated military medical simulation system for training, test and evaluation. The purpose of CTPS is to more realistically assess and react to battlefield casualties. The system primarily consists of Commercial-off-the-shelf (COTS)/Government-off-the-shelf (GOTS) live, virtual, and constructive simulation components. The system's capabilities include simulating, replicating and assessing battlefield injuries by type and category, monitoring the movement of casualties on the battlefield, capturing the time of patient diagnosis and treatment, and comparing interventions and outcomes at each military health care service delivery level. Much of the development work was conducted at IST in conjunction with the manufacturer (METI, Inc., located in Sarasota Florida) and other groups. The CTPS supports the following major events in a mass casualty incident.

- At the ***Point of Injury***, care is delivered by a medic. Casualties are computer-generated or triggered using an electronic device (the Electronic Casualty Card).
- At the ***Casualty Collection Point***, care is delivered by a medic. A Computer-based Triage Controller allows multiple casualties to be assessed. Treatment of the most critically injured is performed on a Pre-Hospital Human Patient Simulator (PHS).
- During the ***Ground Medical Evacuation***, a Combat Medic can monitor casualties using computer-based patient simulation software (PATSIM) and perform treatment on a second PHS.
- At the ***Battalion or Medical Aid Station***, field medical care is provided by a physician assistant or medic. Status of all casualties continues to reflect the care provided at previous levels. See Figure 2 below.
- At the ***Hospital*** level, casualties receive trauma surgical, anesthesia, and post-operative care, such as would be provided by a Forward Surgical Team, Combat Support Hospital, or Hospital Ship.

### Live Field Exercises

We have been involved in five major live field exercises in the last two years. Two have simulated terrorist attacks and have involved both local responders as well as the US military, particularly Civil Support Teams (CST). CSTs are units consisting of 22 military reserve personnel (on active duty) with special skills in incident command, logistics, medical response, and analysis and identification of weapons of mass response such as chemical and biological agents.

An initial group of 11 CSTs was set up in 1999 and plans are to have one in each of the 50 states in the US within a few years. Eventually time for the CSTs to respond to terrorist events may be as short as four hours; however local public safety agencies will typically have to handle such incidents without CSTs on the scene for as long as 12 hours.

Achieving effective coordination among the many local, military, and federal agencies (e.g., the Federal Bureau of Investigation) which will respond to any major terrorist attack, involves a myriad of issues that are just now starting to be addressed and understood. The exercises we have run have yielded many "lessons learned" regarding the issues of joint incident command and mass casualty care under dangerous conditions.

Figure 2. As the victim arrives at the medical-aid station the person acting as casualty is replaced with the human patient simulator. Military medics or civilian paramedics provide advanced life support. Photographer: Magnus Morin.

Other exercises have dealt with major hazardous material incidents, such as large chlorine gas spills. Described below are two major exercises conducted in Orlando in 2000 and 2001. The first exercise we describe is a chlorine gas incident, which was supported by a team from the Swedish military and the Swedish Rescue Service. They provided a technique for rapidly assembly effective After Action Review information and then providing it to participants (Jenvald, 1999). Their system called MIND, has been in use in Sweden and other European countries for several years for both military and civilian disaster exercises. The results are being presented in several papers at this conference and the projects are referenced repeatedly throughout this paper. The MIND system is illustrated in Figure 3 below.

***Chlorine Gas Exercise (Orlando, May 2000).*** The Orlando exercise was planned, executed, documented and analyzed by a team of scientists and domain experts from Sweden and the United States. The Swedish team provided methods and tools for monitoring and visualizing the rescue force (Crissey, et al., 2001; Jenvald, 1999). The American part of the team provided the life sized human patient simulator (shown in Figure 2) for detailed simulation of the casualties from the exercise incident. Both countries provided subject matter experts from rescue agencies, and police and military forces.

The methods used for the exercise addressed the problem of how to transform the operational objectives of a task force into goals for the visualization and evaluation of the operation, and how those goals directed the modeling of the operation. The end result was a *mission history* (Morin, et al., 1999), 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 representing state transitions that take place in those objects. Each event is marked with the time when it occurred during the operation.

The exercise involved Orange and Seminole County Fire Rescue Services and Sheriffs' departments, the University of Central Florida Police Department and the Institute for Simulation and Training, part of the University of Central Florida. The emergency situation involved a chlorine spill, a very real threat in Central Florida with over 175 storage locations in the area and many vehicles transporting the chemical through local neighborhoods on a daily basis. The scenario that was simulated for training purposes was, in actuality, repeated the very next day in a real incident involving evacuation of 150 homes.

Providing an overall view of the operation gives a common frame of reference facilitates subsequent analysis and evaluation, during After Action Reviews and later. A multimedia depiction of a rescue operation on a standard desktop computer or on the Internet enables emergency managers and first responders to examine the course of events of a rescue operation. This support can help professionals both to grasp the big picture and to explore the interaction between critical factors in great detail (Morin, et al., 1999; Jenvald, et al., in press).

A screen dump from the MIND replay tool during the replay of the mission history of the Orlando exercise, shows the various features of the system (Figure 3). The upper left pane displays a digital map based on an aerial photograph of the University of Central Florida campus. Boxes with call signs represent rescue units.

At the end of the exercise, the Swedish team gathered the data collected via the Global Positioning System (GPS) from locators on all vehicles, digital photographs, observer reports and digitally recorded radio traffic. Using the MIND system the data was compiled for presentation. After a lunch break, the participants gathered for the AAR to view the results, discuss what happened, and evaluate their respective performance. Trainee comments reflected not only the usefulness of the training and the positive benefits of the AAR, but gave unit commanders insight for improving future exercises.

Movements of the different rescue units were displayed on digital maps. Critical events were illustrated with audio from synchronized radio communications together with photographs. Different colored boxes represent different vehicles from several agencies. The lower left pane shows the status of the casualties in the exercise. The upper right pane contains a list of the participating units. The middle right pane shows a list of digital photographs together with their time stamps and text annotations. The lower right pane displays recorded radio traffic from the tactical radio network set up to coordinate the response to the incident. In the upper right corner a clock shows the current mission time.

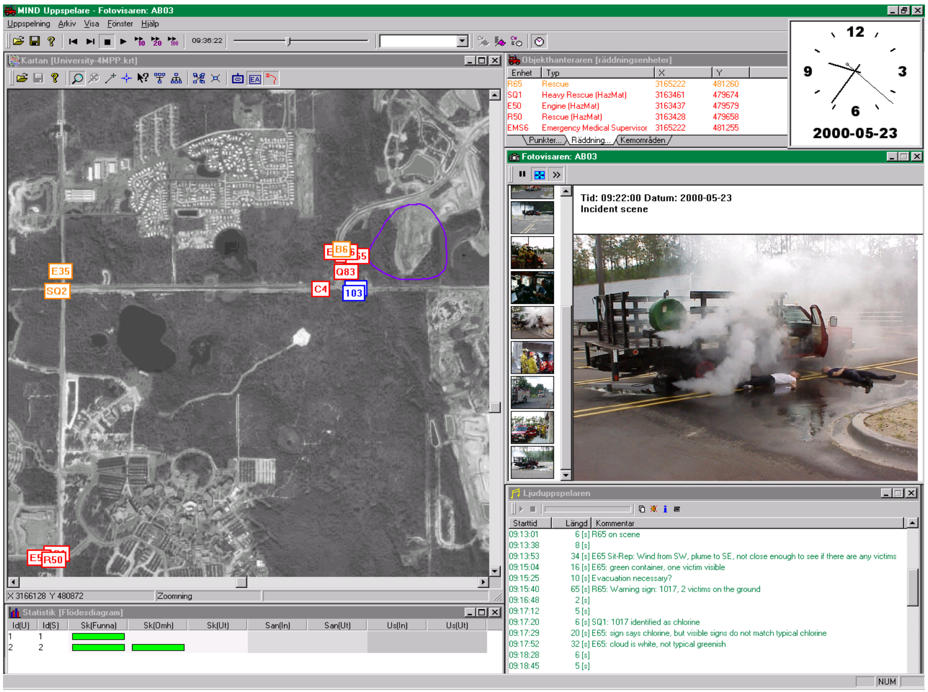


Figure 3. The after-action review (AAR) included a replay of the whole event using the Swedish MIND system.

***Weapons of Mass Destruction Exercise (Orlando, February 2001).*** The very real threat of a weapons of mass destruction (WMD) attack in the US has heightened public awareness with the demand for better emergency response that includes well-managed crisis teams who can respond to this type of large-scale emergency. The exercise described in this section was one of the most realistic civilian/military field exercises yet conducted to prepare for such an event.

On February 10, 2001, the exercise was held on the campus of the University of Central Florida campus involving both military and civilian responders. 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 "died" due to skin exposure to the nerve gas.

Later responders wore "Level A" suits which provided sufficient 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. There were about 100 participants in addition to referees 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.

The exercise was supported by an elaborate array of special equipment and teams from both military and civilian agencies, including special communication, chemical/biological analysis, and decontamination resources. 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 (see figure 4); recordings of all voice traffic routed through the Orange County dispatch center; a series of hand-written event logs; and after action reviews conducted by the 4th WMD Civil Support Team and OCFRD.

Figure 4 below shows a mass decontamination as part of the WMD exercise.

## Conclusions

Simulator training offers several important advantages over other forms of training, including ***cost*** (it is substantially less expensive than comparable training using actual equipment and other expensive resources), ***safety*** (it is better to "die" in a simulation than in an actual event for obvious reasons) and ***instructional effectiveness***. Approaches and applications we describe in this paper allow for a large number of personnel to participate and receive the benefits of training for several important aspects of disaster response.

## References


Burmester, J. H., Petty, M., and Slepow, M. P. (1996). Plowshares: Using military simulation for emergency management training. *Military Simulation and Training*, 1/1996, 6-11.

Crissey, M. J., Morin, M, and Jenvald, J. (2001). Computer-Supported Emergency Response Training: Observations from a Field Exercise. ITEC Proceedings.

Jenvald, J. (1999). *Methods and Tools in Computer-Supported Taskforce Training*. Linköping Studies in Science and Technology, Dissertation No. 598, ISBN 91-7219-547-9, Linköpings universitet, Linköping, Sweden.

Jenvald, J., Morin, M., and Kincaid, J. P. (in press). A framework for web-based dissemination of models and lessons learned from emergency-response exercises and operations. *Journal of Safety Science.*

Kincaid, J. P. (1992). Developing a military standard for cost and training effectiveness analysis. In *Proceedings of the 14th Interservice/Industry Training systems and Education Conference*, San Antonio, Texas, USA

Kincaid, J. P., Williams, S., and Juge, K. (1995, March). Computer-based instruction for the fire services. *Southcon/95 Conference Record*, Ft. Lauderdale, FL.

Morin, M., Axelsson, M., Rejnus, L. and Jenvald, J. (1999). Simulation-based decision support for management of chemical incidents, *Proceedings of the 13th European Simulation Multiconference*, ESM99, pp. 585-590, Warsaw, Poland.

Pettitt, M. B., Goldiez, B. F., Petty, M. D., Rajput, S., and Tu, H. K. (1998). Combat Trauma Patient Simulator. *Proceedings of the 1998 Spring Simulation Interoperability Workshop,* Orlando, Florida, USA.

Petty M. K. and Windyga P. (1999). A high level architecture-based medical simulation system. Special issue "High Level Architecture," *Simulation*, 73(5), 281-287.

Slepow, C., Petty, M, and Kincaid, J. P. (1997). From military wargame to emergency management. *Ergonomics in Design.*



**J. Peter Kincaid** is a Principal Scientist at the University of Central Florida (UCF), Institute for Simulation and Training and Professor of Psychology at UCF. His Ph.D., in Human Factors, was awarded by Ohio State University. He currently conducts most of his research on projects related to public safety and teaches related academic courses at his university.

**Joseph Donovan** is currently Chief of Training with the Orange County (Florida) Fire Rescue Department. He is past Director of the US National Fire Academy and has been Chief of several fire/rescue departments and state fire agencies in his career.

**Beth Pettitt** is a Program Manager with the Army Simulation, Training and Instrumentation Command and directs the CTPS and related projects. She holds an master's degree in simulation from UCF's Industrial Engineering Department.