KEY CONSIDERATIONS FOR EMERGENCY RESPONSE COMPUTER SYSTEMS IN THE 1990s

Frank W. Koleszar and
Dr. Paul Rigterink
Computer Sciences Corporation
15245 Shady Grove Road
Rockville, MD 20850

ABSTRACT

Recent advances in computer technology, together with analyses of several recent disaster responses, indicate that emergency management computer support systems can achieve much higher levels of usefulness than has been possible in the past. An emergency response computer support system can assist government officials in planning for, responding to, and recovering from hurricanes, floods, earthquakes, oil spills, hazardous materials accidents, and other emergencies. Key requirements include a fully integrated, Geographic Information System (GIS)-based computer system; functional support for each phase of the emergency cycle; and a fully developed operations concept. Keys to operational success include the ability to integrate the system with normal office procedures, the ability to share map and attribute data between agencies, full and continuous exchange of information between all parties, and organizational engineering to insure the maximum alignment between the computer functions and organizational units.

INTRODUCTION

Hurricanes, floods, earthquakes, oil spills, hazardous materials accidents, and terrorism have caused billions of dollars of property damage in the United States within the past decade. Recent disasters have shown State and local governments' need to improve emergency response services to respond to natural and man-made disasters. The public demands their governments provide, and often improve, emergency response services despite general cutbacks in budgets and personnel.

Several recently published documents, taken together, give remarkably good insight into the emergency management functions needed by local, municipal and State governments now and in the future [1,2,3,4]. Coupled with recent advances in computer technology and integrated into the fabric of the daily activities of the government organization, an emergency response computer support system can assist government officials in planning for, responding to, and recovering from hurricanes, floods, earthquakes, oil spills, hazardous materials accidents, and other emergencies. We propose that the lessons from these recent disasters, combined with emerging technological capabilities, yield key considerations or design criteria that emergency response computer systems must take into account.

These key considerations include a computer support system which should be fully integrated, GIS-based, with a fully developed emergency management operations concept, and support for each phase of the emergency management cycle. The remainder of this paper addresses these three key areas: technology, operations concept, and emergency management cycle support functions.

TECHNOLOGY

Let's examine the first of these key considerations: technology. The continuing explosion in personal computers and client/server and network technology, as well as related advances in GIS, databases, and Graphical User Interfaces (GUIs), can now provide a powerful, fully integrated emergency management system.

A system often consists of computer and data communications hardware, as well as software for the operating system, data communications, applications, user interface, GIS, and database management system. The system itself can be supported by computers of various manufactures and types, in a distributed configuration, possibly including a client/server system [5].

In addition to hardware and software, a system requires the collection of often extensive amounts of spatial and nonspatial data that describe the local sites and service areas for a region or state. These data can now be accessed as one logical database, with both spatial and attribute components.

High-end commercial GIS's now have the capability for full customization, including system-level and user-level tailoring. These characteristics support a software architecture where the GIS as well as the database, emergency alert modules, and other applications are completely transparent, allowing emergency analysts to concentrate on responding to the disaster, not trying to determine how the system operates.

Finally, with windows environments, the emergency responder has one GUI for all systemwide information tools and applications, making it very easy to access needed data for decision making.

OPERATIONS CONCEPT

The second key consideration we want to address in this paper is the operations concept. Recent work in emergency management and recently published disaster analyses have reinforced the necessity of having a fully-developed operations concept as the basis for the design of any emergency management computer system. This operations concept takes into account the data model, the required interfaces to the emergency alert system, and the necessity for precomputed actions. Additional considerations include a seamless map base, a continuous exchange of information among all parties, use of the system in daily operations, and a system carefully designed to be a component of the fabric of the organization.

Data Sharing

A typical system uses data collected by agencies such as public safety, transportation, environmental protection, natural resources, public works, and health. A shared data model between different agencies enables emergency management personnel to use the most current data available and reduces the amount of money an organization has to pay to build or maintain the system. Such a system will have many users trying to access the data at once, and requires record locking and data integrity capabilities.

Emergency Alert System Interface

An emergency alert system can consist of fixed sirens, radio and television, mobile loudspeakers, personal notification, personal pagers, and automated phone dialing systems. A computer support system with a database of key people and organizations and their telephone numbers can be interfaced to an automated phone dial system, greatly enhancing and reinforcing notification of various categories and types of emergencies. When coupled to the precomputed actions database, the automated phone dialing interface allows the system to exactly target only those individuals directly involved in the current disaster.

Daily Operations

An important part of the operations concept is using the system for daily operations as well as emergencies. This implies that office automation functions such as word processing, spread sheet, E-mail, desktop publishing, and project scheduling be fully integrated with database access, automated phone dial-up, precomputed actions databases, key geocoded MIS databases, and the spatial database and GIS functions. In this manner operators can insure that emergency databases are as up-to-date as possible. It also implies that simulation scenarios and other such databases be sized and constructed directly as part of the computer system to provide for frequent training of emergency management personnel. This parameter also reinforces the global user-view criteria, mentioned earlier, that one GUI be used for all systemwide information tools and applications.

Precomputed Actions

In an emergency such as a toxic cloud, chemical spill, or earthquake, there is no time for any planning whatsoever. Seconds count. Thus initial

responses should be based on scenario-based, precomputed actions. A capable computer support system is essential in this case to the response, as there may be as many as 70 to 100 precomputed actions in the database to choose from, as well as an extensive hierarchy of Emergency Implementation Procedures (EIPs) (Standard Operating Procedures) that can be accessed and executed as necessary. These EIPs can be based on not only the type of emergency, but also its phase (planning, response, recovery) and the organizational function being performed by the analyst (operational, logistic, public affairs).

Continuous Information Exchange

Another important part of the operations concept is the necessity of insuring full and continuous exchange of information among all parties during all phases of the emergency. It is important not only that police know of the current location of rescue crews in earthquake rubble, but that everyone is quickly made aware of the fact that the building in question housed a medical radiology laboratory, and that there may be a radiation hazard for rescue workers. In a rapidly developing fluid emergency situation, ad hoc queries may be the norm, as analysts and directors attempt to stabilize the situation. The implications of full and continuous information exchange for the computer support system are that large numbers of ad hoc data queries can be expected, and that key MIS databases, which preexist the emergency support system, must be geocoded and integrated into the system.

Map Displays

The map displays and their related spatial databases are the key reference documents around which the entire emergency management operation is focused. With multiple disasters possible at various locations and covering various geographic extents, it is important to have map displays of variable scales so that the appropriate levels of detail for the emergency in question are displayed. For the computer system this implies that to the user there be a seamless database: an unbroken map display automatically unfolding as, for example, a gas plume wafts northeastward past the edge of the computer display. This seamless database is especially important in times of multiple emergencies in the same general area; the user must not have to figure out what map sheets are needed next.

Organizational Alignment

One aspect of the environment which is being recognized as increasingly important is the organizational context within which the emergency management computer support system operates. In emergency management, often the breakdown of tasks between personnel or even organizations within the same government entity has evolved on an ad hoc basis. This often results in inefficiencies which, if not corrected, end up being locked in stone in the computer support system. The entire field of business process reengineering, or in a government context, organizational reengineering, addresses this situation. The idea is to automate procedures in a way that represents an efficient organizational breakdown of functions.

EMERGENCY MANAGEMENT CYCLE SUPPORT FUNCTIONS

The third set of key considerations this paper will address for computer support systems is that support functions specific to each phase of the emergency management cycle are required: planning, response, and recovery. The following section highlights functional requirements by phases of the emergency management cycle. No attempt has been made to include all possible requirements, as they are jurisdiction-dependent. Instead, a sampling of functions that generally would be required for any disaster has been included.

Emergency Planning Functions

Planning and analysis modules are used well before the onset of an emergency. This is because the rapid onset of an incident often allows little to no time for planning. The planning and analysis modules are designed to determine three things: the sizes, shapes, and distances of the emergency response area; corrective actions; and the traffic flows and times for evacuation from designated areas in case of a major fire or toxic release.

Detecting and Scaling the Severity of a Potential Disaster. The system should show Emergency Operations Center (EOC) locations for all levels of government, as well as the impact the disaster will have on the following: population and housing, vital resources including transportation, and the environment. The system should also show the population at risk, the housing and other structures at risk, geographic areas that will be effected by an imminent disaster, and the potential environmental impact. As an example the system should show not only how a rail disaster affects rail traffic, but how the disaster will affect the entire transportation system in and throughout the region.

Evacuating and Sheltering the Public. Another important planning (and operational) function is evacuation and public shelters. The system should assist Emergency Response teams to determine potential evacuation routes due to an imminent disaster. In addition, the system should query the spatial database and the text database to show which large scale evacuation shelters to use and where the shelters are located. Road data and aerial imagery should be used to help locate potential tent city sites.

Activating the Response Plan. Activating the response plan is a crucial function of the computer system. Thus, the appropriate telephone auto-dial database is activated, the appropriate EIP identified, and to as great an extent as possible, the execution of the plan is begun automatically. The system should also assist with mobilizing and prepositioning resources, predetermining the location of medical services, sanitation equipment, and food stores and other staples.

The system should indicate the amount of resources required and where to preposition them, as well as determine the amount of resources required based on population density. This includes determining the optimal locations for positioning medical services, sanitation equipment, food and other staples, and temporary State or local Emergency Management offices.

The system should also have the capability to continuously provide the status of the Chain of Command, so that location of key members can be queried and displayed.

Delivering Immediate Emergency Response Services

Response and operations modules are used to alert appropriate authorities and responsible individuals, to keep users informed immediately after an accident, and to track progress as the procedures for dealing with the emergency are being executed.

Gaining Access to the Disaster Site. The system should identify all major and minor roads going into, out of, and through the disaster area, as well as those presently open for use by emergency relief, those that need to be cleared immediately, and those blocked by police or as a result of the disaster.

The system should be able to identify the company or organization responsible for clearing or removing debris from the roads and for restoring traffic signals using a situation map of the area and polygon overlays. The amount of equipment available to each organization must also be identifiable. All airports and railway lines providing service into, out of, and through the disaster area should also be identified.

Coordinating Transportation Requirements. The system should be able to record vehicles available for emergency transportation and prioritize and allocate available transportation. The system should be able to track hazardous material and hazardous material-related transportation problems, as well as funding to make emergency highway repairs and reopen inoperable airports and railway lines.

Conducting Search and Rescue. The system should be able to record both the search and rescue assets available for support during an emergency and where these assets are needed. The system should also be able to record the location of damaged areas that have been inspected, and record the location and extent of fires.

Providing Medical Services. The system operator should be able to record the location of casualty clearing and staging sites as well as the personnel and resources available at each site. Medical services available for support during an emergency should also be tracked, and the need for replacing volunteers with full time personnel or other volunteers should be recorded. The system operator should be able to record the additional medical services needed to support an emergency as well as where these assets are needed. The location of specialized medical services such as burn treatment centers should be recorded and located.

Providing Mass Care. An emergency management analyst should be able to record the location of mass care sites as well as the personnel and resources available at each site, including volunteers and replacements. The system operator should be able to record additional mass care services available for support during an emergency, as well as record where additional mass care personnel and resources are needed.

Providing Security and Law Enforcement. A system should be able to record where additional security and law enforcement services are available for support during an emergency, as well as where they are needed. The system should record the plan for coordinating law enforcement assets in each region, the amount of law enforcement personnel and equipment available in each region, and the level of security required for each area. The system should record the plan for coordinating fire-fighting assets in each region, the amount of fire-fighting personnel and equipment available, and the level of fire fighting required for each area.

Providing Emergency Recovery Assistance to Victims

Recovery and reentry modules evaluate the accident, including its root causes; analyze possible noncompliance with State and local laws; keep users informed of the cleanup operations; and track progress as the emergency response and recovery procedures are implemented.

Understanding Assistance Programs Available. The system should provide a checklist that can be printed so a victim can determine which disaster relief programs are available to assist him or her. The system should be able to access information about how to apply for assistance programs available from public and private organizations.

Delivering Needed Assistance. The system should be able to record which victims have applied for assistance, and the amount and type of assistance from each Federal, State, or local program. In addition, the system should be able to record which victims have applied for property damage payments, and the amount and type of property damage payments that have been given to each victim from each program. The system should also be able to record a list of inspection contractors available to verify housing and personnel property losses, as well as a list of utility companies available to fix needed utilities damaged or destroyed during an emergency. The system should be able to record a list of victim complaints and the response to the complaints. Finally, the system should also be able to record a list of action items, their due date, their completion date, and how each action item was resolved.

CONCLUSIONS

This paper has highlighted some key considerations for municipal, State, and local governments when considering the purchase or upgrade of a computer support system to respond to large or small emergencies. Recent advances in technology and analysis of recent disasters from small- to large-scale point to the fact that fully integrated, GIS-based systems, with fully developed operations concepts and support for each phase of the emergency management cycle, can result in high payback for State and local governments and commercial enterprises.

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