Successful Response Starts with a Map
Improving Geospatial Support for Disaster Management

Geospatial data and tools should be an essential part of every stage of emergency management, from planning through response and recovery to the mitigation of future events. If future emergency responses are to be more effective, significant investments should be made in training of personnel, coordination among agencies, sharing of data and tools, planning and preparedness, and the tools themselves.

In the past few years the United States has experienced a series of disasters, such as Hurricane Katrina in 2005, which have severely taxed and in many cases overwhelmed responding agencies. In the immediate aftermath of Hurricane Katrina, high-resolution images began to appear on the Google Earth site, showing in detail the impacts of the disaster. People from all over the world could explore the impacted area, seeing the levee breaks in New Orleans, the extent of the flooding, the damage to buildings, and the impacts on the environment. Images from Google Earth appeared on television newscasts around the world. Within the impacted area, however, where computers were damaged, electrical power networks were destroyed, and Internet communications were disrupted, it was difficult for emergency managers to make use of many geospatial data and tools for days and in some cases weeks or months. Paradoxically, the availability of and access to geospatial data and tools resembled a donut—abundant far away from the impact area, but almost non-existent where it was most needed, locally.

Photo courtesy Bruce Davis, Dept. of Homeland Security

In all aspects of emergency management, geospatial data and tools have the potential to help save lives, limit damage, and reduce the costs of dealing with emergencies. Great strides have been made in the past four decades in the development of geospatial data and tools, such as satellite imaging and geobrowsers, that describe locations of objects on the Earth's surface and make it possible for anyone with access to the Internet to witness the magnitude of a disaster. However, the effectiveness of any technology is as much about the human systems in which it is embedded as about the technology itself. Issues of training, coordination among agencies, sharing of data and tools, planning and preparedness, and resources invested in technology need to be addressed if future responses are to be more effective.

Successful Response Starts with a Map: Improving Geospatial Support for Disaster Management assesses the status of the use of geospatial data and tools and infrastructure in disaster management, and recommends ways to increase and improve their use. The report explores emergency plan-

ning and response, how geospatial data and tools are currently being used in this field, the current policies that govern their use, and various issues related to data accessibility and security, training, and funding.

What Are Geospatial Tools?

The term geospatial is used to refer to those interdependent resources—maps, data sets, tools, and procedures—that tie every event, feature, or entity to a location on the Earth's surface and use that information for a particular purpose. Location is expressed in some standard and readily understood form, such as latitude/longitude, street address, or position in a coordinate system. For example, today the Global Positioning System (GPS) is a cost-effective way of associating an event, feature, or entity with a location, and thus of making data geospatial.

Geospatial tools can take many forms including paper maps; in-car navigation systems; Internet sites; software and databases of local governments; and analytical, mapping, and visualization tools that support decision-making in private and public-sector organizations (see Box 1). Because of their usefulness for so many diverse applications—from zoning and taxation, to environmental management, to the national census, and of course emergency response—communities at all levels have made investments in acquiring geospatial information, converting it to digital form, and maintaining computer-based systems for accessing and using it.

Using Geospatial Information In Emergency Management

All disasters have a temporal and geographic footprint that identifies the duration of impact and its extent on the Earth's surface. Using geospatial tools, responders can determine where impacts are greatest, locate damaged buildings or injured residents so that they are able to act more quickly, especially during the critical period immediately after the event when there is the greatest possibility of saving lives.

Effective emergency management requires access to tools that can process data to generate products that responders can use, such as maps of the area showing the search grid, images showing damage, lists of locations flagged for inspection, or predictions of the spread of wildfires or smoke plumes. Responders and managers need to be able to easily locate points on the map and on the ground. Street addresses normally provide an easy way to locate points in urban areas, but not in rural areas or when street signs and house numbers have been destroyed. GPS provides an effective

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Box 1. Types of Geospatial Data and Tools

Remote sensing is the collection of data from a wide range of automated systems, including satellites and aircraft, and ground-based sensors and surveillance cameras.

Geographic information systems (GIS), which are among the most important and widely used of geospatial tools, are software systems used to capture, store, manage, analyze, and display geospatial data resources. A coordinate system is used as an organizing principle for these data resources.
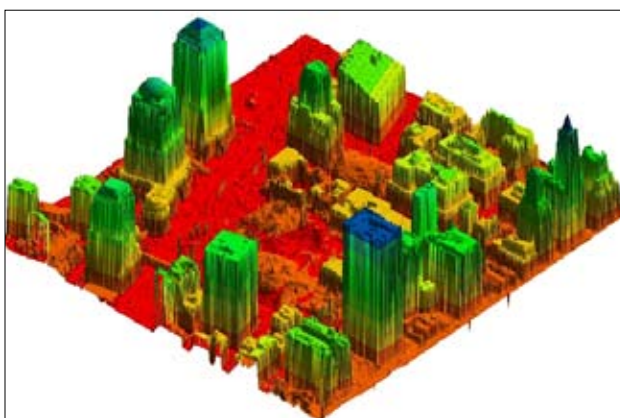
Computer-assisted design (CAD) systems are widely used to create and manage three-dimensional digital models of buildings and other engineering structures. When accurately registered to the Earth's surface, CAD data can be combined with other geospatial data.

Clearinghouses, geolibraries, archives, geoportals, and geobrowsers are Web sites that provide access to large collections of geospatial data sets.

Spatial decision-support systems (SDSS) provide decision-makers the information they need when decisions involve location. They are designed to make comparisons between many possible alternatives.

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alternative, especially when combined with geocoding (determining geographic coordinates of an address in a geographic information system).

Although location is an essential part of any item of geospatial data, it is the ability to link a location to the properties of events, features, or entities at that location that gives geospatial data their value. These properties are collectively termed attributes, and may include the owner of a parcel of land, the population

This aerial imagery of lower Manhattan (post September 11) depicts detailed elevation data obtained through the use of LIDAR (light detection and ranging) technology. Image courtesy New York State Office of Cyber Security and Critical Infrastructure Coordination.

of a neighborhood, the temperature of a point in a burning building, or the wind speed and direction at a point in a hazardous plume. Further, responders need to be able to map an event as it changes in real time, and print and distribute updates quickly.
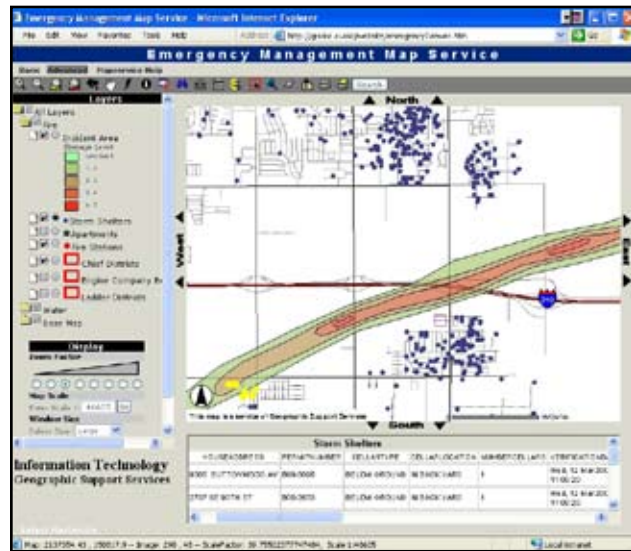
Challenges of Using Geospatial Information

The emergency management community relies heavily on the ability to discover and use accurate up-to-date information in order to prepare for and respond to disasters and other emergency events. However, there are numerous institutional factors that have inhibited the effective deployment of technology and reasons why organizations have failed to anticipate and plan for the particular circumstances created by disasters.

While there are enormous amounts of data essential to emergency management, they are frequently scattered among multiple jurisdictions, in disparate and often incompatible formats. Government agencies are typically responsible for large volumes of data, including property records, street centerlines, and floodplain delineations. Additional data, such as critical infrastructure data, are maintained by the private sector. Many organizations are unwilling to share their data or will provide it only under very restrictive agreements because of concerns about data security or liability. Additional problems are caused by lack of data interoperability, lack of knowledge about what data exist and where, lack of training on the part of users, the constantly changing technological environment, and lack of operational infrastructure in the immediate aftermath of disaster.

Recommendations for Future Emergency Management

The report points to steps that can be taken to improve emergency management through increased utilization and more effective integration of geospatial data and tools into emergency management processes.

Leadership. In the early 1990s, the National Spatial Data Infrastructure (NSDI) was established as a framework for coordinating the production, distribution, and use of geospatial data. Currently, NSDI provides a means for sharing geospatial data, but the special needs of emergency management have not been fully recognized. The current system of governance should be strengthened to include the full range of agencies, governments, and sectors that share geospatial data and tools, in order to provide strong national leadership. The Department of Homeland Security (DHS) should play a leading role in ensuring that the special needs of emergency management for

A screen shot shows one use of GIS in emergency management, in this case, mapping the path of a tornado. Image courtesy Schad Meldrum, City of Oklahoma City.

effective data sharing and collaboration are recognized as an important area of emphasis for this new governance structure. These policies and guidelines should define the conditions under which each type of data should be shared, the roles and responsibilities of each participating organization, data-quality requirements, and the interoperability requirements that should be implemented to facilitate sharing.

Data Security. Security is one of the major reasons cited by organizations for failing to share data in support of emergency response. This issue should be addressed through a system that would restrict access where necessary to appropriately authorized emergency management personnel. DHS should lead, within the framework of NSDI, the development of a nationally coordinated set of security requirements for data to be shared for emergency preparedness and response. All organizations should implement these guidelines.

Preparedness Exercises. Various interpersonal, institutional, technical, and procedural problems currently inhibit communication between first responders in the field, emergency operations centers, emergency management agency headquarters, and other coordinating centers. These challenges should be addressed through intensive preparedness exercises by groups involved in all aspects of disaster management. Such exercises should be tailored to focus on clear objectives with respect to the use of geospatial data. They should involve decision-making representatives from all levels of government, as well as other relevant organizations and institutions, and should be coordinated nationally so that common problems can be identified. They

should be realistic in their complexity and should allow participants to work carefully through the geospatial challenges posed by disasters.

Backing Up and Archiving Geospatial Information. Many times, the geospatial data that would be most useful in emergency management can be destroyed by the disaster itself. There is a need for effective policies regarding backing up geospatial data and keeping data sets in geographically separate locations. The geospatial data gathered during the recovery and response efforts could be extremely useful in helping prepare for future events or in modeling or research studies, yet these data are often not archived. DHS should revise the National Response Plan to require backup and archiving of geospatial data, tools, and procedures developed as part of disaster response and recovery. It should assign responsibility for archiving and backup in the Joint Field Offices during an incident to the Federal Emergency Management Agency (FEMA), with an appropriate level of funding provided to perform this function.

Research. There is a significant gap between the needs of emergency management for geospatial tools and the capabilities of current systems. The National Science Foundation and federal agencies with responsibility for funding research on emergency management should support the adaptation, development, and improvement of geospatial tools for the specific conditions and requirements of all phases of emergency management.

Training. It is extremely difficult to learn new tools or technologies while in the midst of responding to a disaster. Therefore, if geospatial technologies are to become an integral part of emergency response and recovery, they must be part of the day-to-day operations of emergency managers and responders at all levels of government. Academic institutions offering emergency management curricula should increase the emphasis given to geospatial data and tools in their programs. Geospatial professionals who are likely to be involved in emergency response should receive increased training in emergency management business processes and practices. FEMA should expand its team of permanent geospatial professionals and develop strategies that will lead to their more rapid deployment in response to events and in advance of events when specific and reliable warnings are given. Finally, DHS should establish and maintain a secure list of appropriately qualified geospatial professionals who can support emergency response.

Funding. Lack of funding is usually identified as a major barrier to effective use of geospatial data and tools in emergency management. Although some funding is available, it is not sufficient to meet the need. To address this shortfall, especially at the state and local level, 1) DHS should expand and focus a specifically designated component of its grant programs to promote geospatial preparedness through development, acquisition, sharing, and use of standard-based geospatial information and technology; 2) states should include geospatial preparedness in their planning for homeland security; and 3) DHS, working with the Office of Management and Budget, should identify and request additional appropriations and identify areas where state, local, and federal funding can be better aligned to increase the nation's level of geospatial preparedness.

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