Free Executive Summary

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

Committee on Planning for Catastrophe: A Blueprint for Improving Geospatial Data, Tools, and Infrastructure, National Research Council

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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 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 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. This report assesses the status of the use of geospatial data, tools, and infrastructure in disaster management, and recommends ways to increase and improve their use. It explores emergency planning and response; how geospatial data and tools are currently being used in this field; the current policies that govern their use; various issues related to data accessibility and security; training; and funding. The report recommends significant investments be made in training of personnel, coordination among agencies, sharing of data and tools, planning and preparedness, and the tools themselves.

Summary

In the past few years the United States has experienced a series of disasters that have severely taxed and, in many cases, overwhelmed the capacity of responding agencies. Hurricane Katrina in 2005 provided perhaps the most obvious instance as millions around the world watched a region of the world's most powerful nation apparently degenerate into chaos. With modern technologies such as satellite imaging and services such as Google Earth, it was possible for anyone with access to the Internet to see the magnitude of the disaster and to marvel at how breakdown could be so complete and pervasive in an era of such technological and information abundance.

This study is about one type of information technology and the role it plays in emergency management. Geospatial data describe the locations of things on the Earth's surface, and geospatial tools manipulate such data to create useful products. Thus, this report is about the maps that are an essential part of search-and-rescue operations, about the GPS (Global Positioning System) receivers that allow first responders to locate damaged buildings or injured residents, about images that are captured from aircraft to provide the first comprehensive picture of an event's impact, about road maps that form the basis of evacuation planning, and about all of the other information connected to a location that can be used in emergency management.

Great strides have been made in the past four decades in the development of geospatial data and tools, and the Google Earth service is just one example of the power and sophistication of this type of technology. Yet

no amount of technological sophistication will be sufficient to address the kinds of breakdowns that occurred in the supply and use of geospatial data and tools in recent disasters. The effectiveness of any technology is as much about the human systems in which it is embedded as about the technology itself. The committee concluded that issues of training, coordination among agencies, sharing of data and tools, planning and preparedness, and the attention and resources invested in technology turn out to be the critical factors and the ones that have to be addressed if future responses are to be more effective.

The goal of this study was to evaluate the current use of geospatial data and tools in emergency management and to make recommendations to improve that use. The study tasks assigned to the committee addressed both planning and response; the status of tools for predicting and mapping vulnerability; the types of data required for emergency management; the techniques available for discovering and accessing data from diverse sources; training requirements; and issues of data security. The committee approached the task by holding a series of meetings at which it heard evidence from individuals and representatives of organizations; organizing a workshop that included extensive formal and informal discussion; and drawing on the considerable experience of its members.

The committee's central conclusion is that geospatial data and tools should be an essential part of all aspects of emergency management—from planning for future events, through response and recovery, to the mitigation of future events. Yet they are rarely recognized as such, because society consistently fails to invest sufficiently in preparing for future events, however inevitable they may be. Moreover, the overwhelming concern in the immediate aftermath of an event is for food, shelter, and the saving of lives. It is widely acknowledged that maps are essential in the earliest stages of search and rescue, that evacuation planning is important, and that overhead images provide the best early source of information on damage; yet the necessary investments in resources, training, and coordination are rarely given sufficient priority either by the general public or by society's leaders.

In all aspects of emergency management, geospatial data and tools have the potential to contribute to the saving of lives, the limitation of damage, and the reduction in the costs to society of dealing with emergencies. Responders who know where impacts are greatest, where critical assets are stored, or where infrastructure is likely to be damaged are able to act more quickly, especially during the "golden hour" immediately after the event when there is the greatest possibility of saving lives. Geospatial data that are collected and distributed rapidly in the form of useful products allow response to proceed without the confusion that often occurs in the absence of critically important information. Indeed, it is

impossible to imagine the chaos that would result if first responders were entirely unfamiliar with an area and had none of the geospatial information—maps, GPS coordinates, images—that is so essential to effective emergency management.

Massive investments have been made in geospatial data and tools over the past few decades in many areas of human activity, but the special and specific needs of emergency management—rapid operational capability and access to data, extensive planning, training of first responders, and tools that work under the difficult circumstances of search and rescue—have rarely been addressed. The committee found that while enormous amounts of data relevant and indeed essential to emergency management exist, they are frequently scattered among multiple jurisdictions, in disparate and often incompatible formats. Numerous impediments exist to data sharing, including lack of interoperability at many levels, lack of knowledge about what data exist and where, restrictions on use, lack of training on the part of users, concerns about data security, and lack of operational infrastructure in the immediate aftermath of disaster.

This report makes 12 recommendations. The first reflects the committee's central conclusion and urges that the role of geospatial data and tools should be recognized in relevant emergency management policy documents, directives, and procedures (Chapter 4):

> **RECOMMENDATION 1: The role of geospatial data and tools should be addressed explicitly by the responsible agency in strategic planning documents at all levels, including the National Response Plan, the National Incident Management System, the Target Capabilities List, and other pertinent plans, procedures, and policies (including future Homeland Security Presidential Directives). Geospatial procedures and plans developed for all but the smallest of emergencies should be multiagency, involving all local, state, and federal agencies and nongovernmental organizations (NGOs) that might participate in such events.**

In the early 1990s a new effort to coordinate the production, distribution, and use of geospatial data began under the rubric of the National Spatial Data Infrastructure (NSDI). Standards have been developed and implemented, clearinghouses have been built and access portals deployed, and today the NSDI provides a coherent framework for the sharing of geospatial data. To date, however, the special needs of emergency management have not been recognized as fully as the committee considers desirable, and emergency management is only weakly represented within the NSDI's existing governance structure. Accordingly, the committee's second and third recommendations seek to strengthen the NSDI as a framework for the effective sharing of geospatial data for emergency man-

agement. Since the Department of Homeland Security has been given responsibilities for geospatial data coordination for emergency management, the committee specifically identifies it in the recommendations, proposing that it play a leading role in strengthening the NSDI in this way (Sections 4.1 and 4.2):

RECOMMENDATION 2: The current system of governance of the NSDI 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 effective data sharing and collaboration are recognized as an important area of emphasis for this new governance structure.

RECOMMENDATION 3: A new effort should be established, within the framework of the NSDI and its governance structure and led by DHS, to develop policies and guidelines that address the sharing of geospatial data in support of all phases of emergency management. 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.

Security is one of the many reasons cited by organizations for failing to share data and failing to make data available in support of emergency response. The committee's fourth recommendation seeks to address this issue through a system that would restrict access where necessary to appropriately authorized emergency management personnel (Section 4.3):

RECOMMENDATION 4: DHS should lead, within the framework of the 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 for all data shared in support of emergency management and should use them where necessary to restrict access to appropriately authorized personnel. In concert with these efforts, the leveraging of existing organizations that could potentially serve as a "clearinghouse" for critical infrastructure data should be explored.

Section 4.4 of this report describes the problems that occur in the immediate aftermath of events when geospatial data must be acquired as quickly as possible to assess impacts and plan response and recovery. All

too often a lack of planning produces delays as organizations scramble to overcome administrative roadblocks:

RECOMMENDATION 5: Standing contracts and other procurement mechanisms should be put in place at local, regional, and national levels by the responsible agencies to permit state and local emergency managers to acquire overhead imagery and other types of event-related geospatial data rapidly during disasters.

Hurricane Katrina and other recent events have shown all too clearly the potential magnitude of disasters and their ability to overwhelm agency resources. Chapter 2 of this report describes the experience of the attacks on the World Trade Center as well as two additional hypothetical scenarios, one a major storm in the New York area and the other a major earthquake in the Los Angeles Basin. The committee believes that events of this magnitude should be the basis for extensive preparedness exercises, since they will allow many of the issues that arose during recent responses to be anticipated and explored (Section 4.5):

RECOMMENDATION 6: Interpersonal, institutional, technical, and procedural communications problems that currently inhibit communication between first responders in the field and emergency operations centers, emergency management agency headquarters, and other coordinating centers 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 and assets. 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, including the difficulty of specifying requirements, the difficulty of communicating in a context of compromised infrastructure, and the difficulty of overcoming logistical obstacles.

It is surprising perhaps that despite the intensity of the efforts that went into recovering from the World Trade Center attacks, very little documentation exists detailing the geospatial data and tools that were employed that might serve as a basis for improved responses to similar events in the future and as a basis for training. The experience of recent events, particularly the World Trade Center attacks, also points to the need for effective policies regarding the backing up of geospatial data and tools in geographically separate locations (Section 4.6):

RECOMMENDATION 7: DHS should revise Emergency Support Function 5 of the National Response Plan to include 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, with an appropriate level of funding provided to perform this function.

As noted earlier, geospatial data and tools are now widely deployed in many areas of human activity. Emergency management presents specific circumstances, however, and demands a different approach to the development and deployment of technologies. The committee finds that there is a significant gap between the needs of emergency management and the capabilities of current systems and recommends (Section 4.7) the following:

RECOMMENDATION 8: 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.

The committee believes strongly that 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 and there must be an increase in the number of personnel trained in the use of geospatial data and tools available to support emergency management. The committee's next three recommendations address this issue (Section 4.8):

RECOMMENDATION 9: 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.

RECOMMENDATION 10: The Federal Emergency Management Agency should expand its team of permanent geospatial professionals and develop strategies that will lead to their more rapid deployment both in response to events and in advance of events when specific and reliable warnings are given.

RECOMMENDATION 11: The Department of Homeland Security should establish and maintain a secure list of appropriately quali-

fied geospatial professionals who can support emergency response during disasters.

Finally, the committee found that funding for geospatial preparedness is insufficient and the funding that exists is often used ineffectively (Section 4.9):

RECOMMENDATION 12: To address the current shortfall in funding for geospatial preparedness, especially at the state and local levels, the committee recommends: (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.

Besides these recommendations, the report also provides a set of more detailed guidelines for the assessment of geospatial preparedness in emergency management organizations in Chapter 5 and Appendix C. The list is not intended to be exhaustive, but rather to provide a basis for enhancing geospatial preparedness and for directing planning and investment.

In essence, the report paints a picture of technological abundance, but of geospatial data and tools that despite their power have not yet been applied systematically and appropriately to emergency management. It lists numerous institutional factors that have inhibited the effective deployment of technology and numerous reasons why organizations have failed to anticipate and plan for the particular circumstances created by disasters. The committee hopes that the recommendations made in this report, and the examples and guidelines that it provides, will help to create a world in which future responses to disasters will be faster and more effective.

SUCCESSFUL RESPONSE STARTS WITH A MAP

Improving Geospatial Support for Disaster Management

Committee on Planning for Catastrophe:
A Blueprint for Improving Geospatial Data, Tools, and Infrastructure

Mapping Science Committee

Board on Earth Sciences and Resources

Division on Earth and Life Studies

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Cover: Designed by Michele de la Menardiere. Top left shows a U.S. Coast Guard rescue from a home surrounded by floodwaters after Hurricane Katrina in New Orleans (AP photo by David J. Phillip); middle right, a simulation of a category-3 storm surge in New Orleans showing emergency services (image courtesy the National Geospatial-Intelligence Agency); bottom left shows an area in Long Beach, Mississippi, roughly 1 week after Hurricane Katrina (image, courtesy of Bruce Davis, Department of Homeland Security). Background shows satellite imagery of a forest fire (image courtesy Digital Globe).

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This report has been reviewed in draft form by individuals chosen for their diverse perspectives and technical expertise, in accordance with procedures approved by the National Research Council's (NRC's) Report Review Committee. The purpose of this independent review is to provide candid and critical comments that will assist the institution in making its published report as sound as possible and to ensure that the report meets institutional standards for objectivity, evidence, and responsiveness to the study charge. The review comments and draft manuscript remain confidential to protect the integrity of the deliberative process. We wish to thank the following individuals for their review of this report:

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Although the reviewers listed above have provided many constructive comments and suggestions, they were not asked to endorse the conclusions or recommendations, nor did they see the final draft of the report before its release. The review of this report was overseen by Dr. Robert

Hamilton, National Research Council (retired) and U.S. Geological Survey (retired), and Dr. Chris G. Whipple, ENVIRON International Corporation. Appointed by the NRC, they were responsible for making certain that an independent examination of the report was carried out in accordance with institutional procedures and that all review comments were carefully considered. Responsibility for the final content of this report rests entirely with the authoring committee and the institution.

Preface

After the events of September 11, 2001, there was a widespread sense in the United States and in many other parts of the world that humanity was entering a new and more dangerous era. Subsequent events, such as the Indian Ocean tsunami of 2004, the Gulf Coast hurricanes of 2005, and the terrorist bombings of July 7, 2005, in London have if anything strengthened that feeling, as have the potential threats of pandemic flu, dirty bombs, and smallpox. Whether one believes that greenhouse gas emissions are responsible for an increase in the frequency and severity of hurricanes, or that television and the Internet make us all too aware of potential dangers, or that the sheer magnitude of historical events such as the European Black Death of the fourteenth century, the 1556 earthquake in Shansi, China, or the Asian flu pandemic of 1919 overshadow our modern disasters by orders of magnitude, the sheer complexity and interdependencies of modern society clearly make us enormously vulnerable, whether it be to natural disasters or to terrorist attacks. The modern systems that we require to sustain our way of life—the systems that transport our energy, create our food supply, allow us to communicate over vast distances, and maintain our low infant mortality and high life expectancy—are all vulnerable to degrees that would have been unimaginable a few decades ago. Furthermore, the dollar toll from these events is increasing due to population growth in disaster-prone areas, especially in those areas susceptible to hurricanes, floods, and earthquakes.

In this new world of the twenty-first century it is essential that we anticipate such events and their potential impacts. It is impossible to know exactly what form they will take, how severe they will be, or where and

when they will occur, but the value of planning has been amply demonstrated. This report is about the value of a specific area of planning and about how the United States might make improvements in that specific area. Geospatial data and tools are currently used for emergency response, but recent events have demonstrated the many ways in which our geospatial data and tools and the use we make of them fail us, both in preparing for unpredictable events and in responding to them afterwards. This report examines the current use of geospatial data and tools in emergency management and makes recommendations to improve that use.

The National Research Council's (NRC's) Committee on Geography, now the Geographical Sciences Committee, first discussed the need for this study in 2000, well before the events of September 11, 2001. Those and subsequent events led to a greater sense of urgency, a search for sponsorship, refinement of the study's charge, and to the eventual formation of a study committee in 2004 under the auspices of the NRC Mapping Science Committee. We thank the sponsors, the National Aeronautics and Space Administration, the National Oceanic and Atmospheric Administration, the National Geospatial-Intelligence Agency, and the U.S. Geological Survey, for providing funding for this study.

The committee was composed of 13 members and included scientists, social scientists, and engineers from academia, industry, government, and nongovernmental organizations. Committee members included people with experience in designing decision support tools; users of these tools; and experts in natural hazards, risk analysis, transportation, utility infrastructure, geospatial data and remote sensing, disaster planning and response, and computer and information science. The committee included members with extensive field experience in emergency management and response.

Several meetings were held to gather evidence from individuals and representatives of organizations and agencies, including emergency response practitioners and experts in geospatial data and tools. The primary information-gathering event was a workshop held on October 5-6, 2005, which included five discussion panels with approximately 25 panelists from the relevant academic disciplines and agencies and from the commercial software and data products industry. The workshop included a mix of discussion panels and breakout discussions.

This report presents the committee's findings and recommendations. It is designed to be read by any public official who is concerned to make his or her community disaster resilient: leaders of emergency response and emergency operations agencies, elected officials and citizens who are concerned about community vulnerability, agency staff who make or recommend decisions about the allocation or acquisition of resources, developers of technologies, or members of committees charged with developing policies.

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