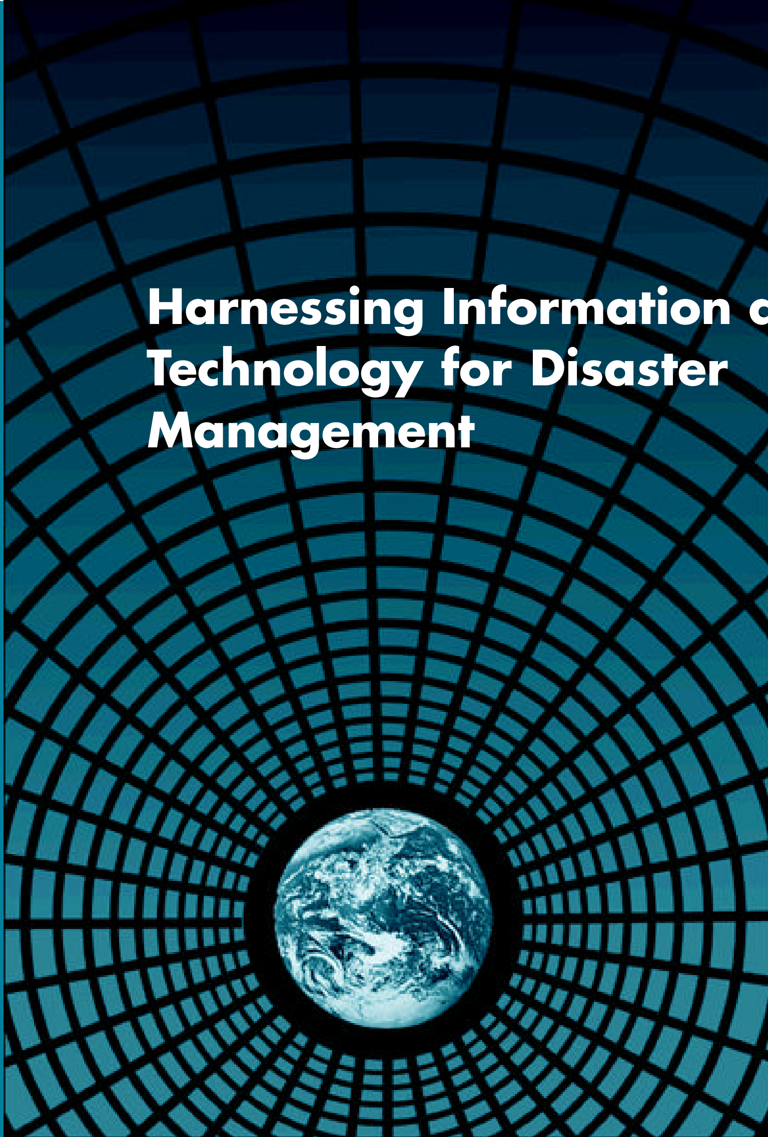
Harnessing Information and Technology for Disaster Management



The Global Disaster Information Network

GDIN

Disaster Information
Task Force Report

NOVEMBER 1997

THE VICE PRESIDENT

WASHINGTON

February 26, 1997

The Honorable James Lee Witt
Director of the Federal Emergency
Management Agency
500 C Street, S.W.
Washington, D.C. 20472-0001

Dear Mr. Witt:

Recent work by MEDEA suggests that there are untapped opportunities for providing better early warning to emergency managers, thereby improving preparedness and responsiveness to natural or environmental disasters. There is a need to ensure that Federal disaster agencies have access to the tools, infrastructure and financial resources to exploit, insofar as security concerns may permit, all relevant civil and national security remote sensing systems in response to disasters. The need is even greater in the international disaster management community.

As a result, I have directed Leon Fuerth to convene a meeting with a senior designee from your agency to discuss the feasibility of establishing a global disaster information network that would integrate this information and disseminate it to Federal agencies, regional centers and the international community.

I would like your agency to designate a senior official to participate in this meeting to discuss this concept and to help determine the best ways to proceed with a study of it. The initial meeting, to be chaired by Leon, will be coordinated by Dr. James Baker of NOAA who will assemble the senior officials and provide additional information to them on this proposal prior to the meeting.

My staff point of contact, Mike Orfini, is also available at 202-456-9515 to address any of your concerns. I look forward to reviewing your recommendations.

Sincerely,

Al Gore

Original letters sent to:
William S. Cohen, DOD
George Tenet, CIA
William M. Daley, DOC
Bruce Babbitt, DOI
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Franklin D. Raines, OMB
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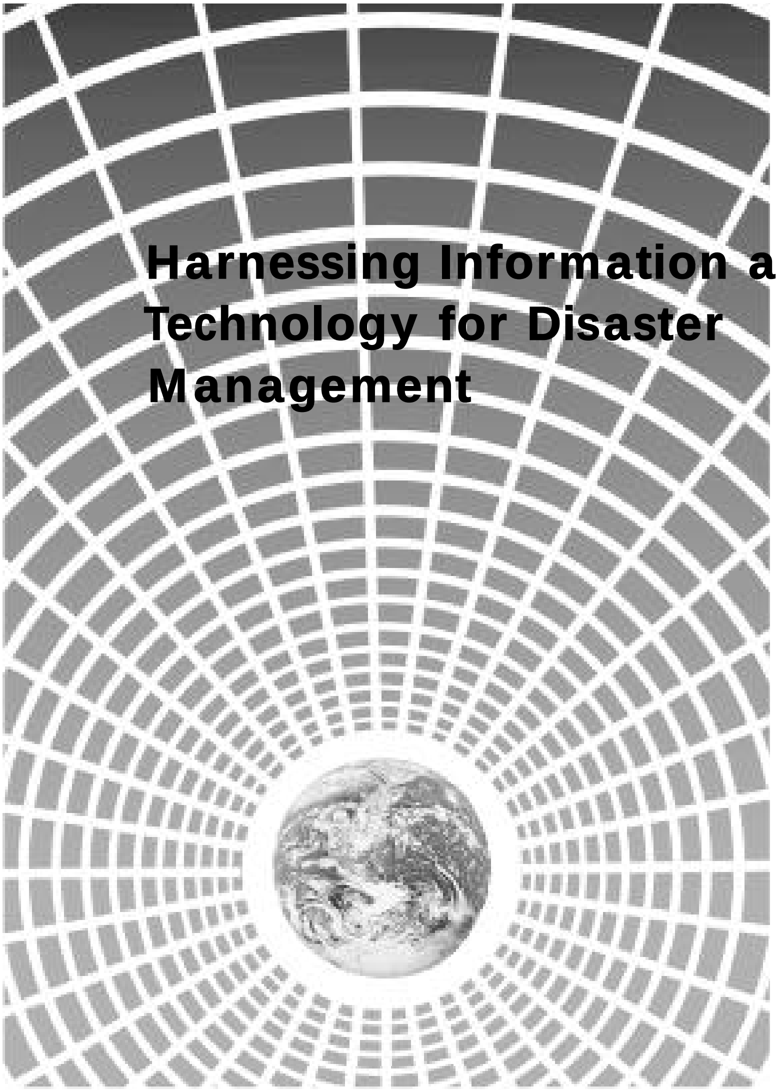

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Preface

On February 26, 1997, Vice President Albert Gore sent a letter to key Federal departments and agencies requesting that senior officials "discuss the feasibility of establishing a global disaster information network." In response to this request, senior agency officials created a Disaster Information Task Force (DITF) to evaluate the needs and issues, examine the feasibility, and outline a phased, integrated approach to collect and disseminate all-source data and information to appropriate users.

Interagency working groups were formed by the DITF and meetings were held to baseline current capabilities and to identify the management information needs. These working groups were focused by function (users, providers, and disseminators); by disaster types (severe weather, geologic, fires, and man-made); and by disaster phases (pre- and post-). Once the assessments were completed and the information needs captured, the nine working groups combined into three (users, providers, and disseminators). At this point, a process was implemented to identify the major issues or "findings" derived from the needs of the disaster management community. These served as the basis for subsequent analysis leading to conclusions and recommendations.

The needs and findings identified by the DITF were provided to a workshop of disaster experts that convened on July 22–24, 1997. The workshop built a consensus for the Global Disaster Information Network (GDIN) based on the work resulting from the DITF working groups. The findings were refined and amended by workshop participants, and recommendations for development of the GDIN began to take shape.

The value-added disaster management activities found at the Federal, state, local, and private levels in the United States provided the operational guidelines for the DITF. These were examined in detail against the vision of the GDIN as a robust, interactive knowledge base of disaster-related information accessible to disaster managers throughout the United States and to all whose lives and property might be affected by national disasters.

The primary DITF focus was on the integration of current sources of information and on the interconnection of these with disaster managers at all levels. Ways in which this could be accomplished as a self-organizing network were examined so that eventually all relevant disaster information would be accessible.

The amount and diversity of disaster management activity available in the United States, as compared to the rest of the world, led to an initial emphasis on a national solution with segues for international connectivity.

In addition, the potential for public and private sector partnerships to aid in the implementation of the GDIN was examined, and there was little question that this was a promising area of great potential. GDIN is an endeavor that requires customized design of cooperative undertakings on the part of the Federal agencies and a broad spectrum of other public participants (state and local) and the private sector, including transportation, power, gas, information services, insurance, medical, and construction interests.

Finally, the complexity of forming disaster information networks at the Federal or national level is indicative of what might be expected globally. Moreover, the evolution of such a system is realized through the linkage of subnets into larger nets. For these and other reasons, it is advisable to develop the GDIN from national disaster information networks. Thus, the GDIN is likely to evolve from the interconnecting of national networks.

This report synthesizes the results of the DITF activities. The Steering Committee wishes to stress that the intent of GDIN is to take advantage of the wealth of information and capabilities already in existence. It is further stressed that the GDIN concept should proceed along evolutionary lines—from Federal to national to global implementation. Such a phasing will ensure that development occurs in a systematic and orderly fashion. Finally, it should also be noted that current Federal agency missions and responsibilities would not be significantly perturbed in the evolution of a GDIN.

The Steering Committee wishes to thank all DITF and workshop participants for their help in articulating the GDIN vision.

Leon Fuerth, GDIN Steering Committee Chair
Office of the Vice President

D. James Baker, GDIN Steering Committee Co-chair
National Oceanic and Atmospheric Administration

Acknowledgments

The GDIN team wishes to acknowledge the contributions of the following individuals:

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Contents

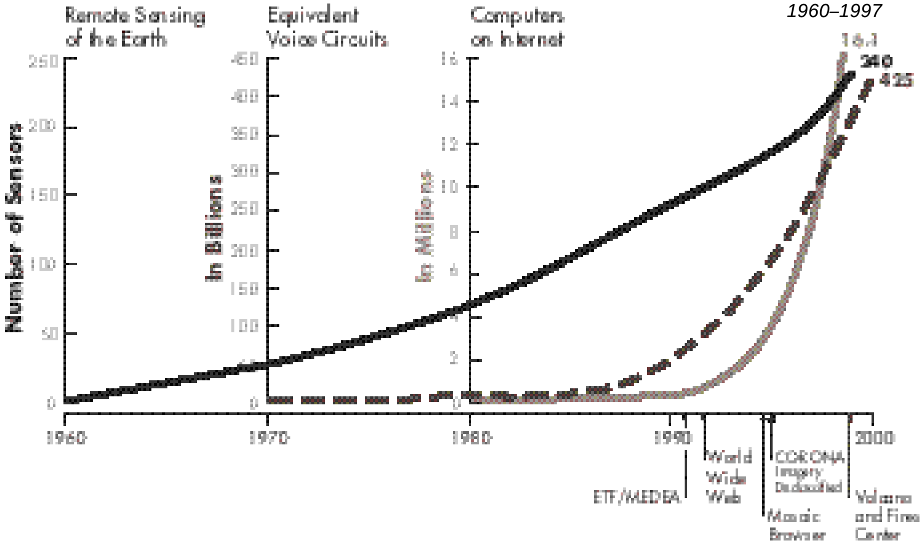
Overview and Summary

Global disaster costs are rising. Annual global economic costs related to disaster events average over $440 billion per year (International Federation of Red Cross and Red Crescent Societies, 1996). In the United States, the number of lives lost due to natural disasters has been decreasing over the last several decades, largely due to advances in disaster indication and warning capabilities. In terms of damage sustained, however, the trend is reversed. These rising costs are the combined result of increasing urbanization, particularly in high-risk coastal areas, and the increasing complexity of our infrastructure.

In many regions of the world, loss of life and property are on the rise. In 1970, for example, the densely populated delta region of Bangladesh experienced one of the greatest disasters on record in the form of a tropical cyclone. From that single event, approximately 300,000 people were killed (Tobin and Montz, 1997), crop losses were estimated at $63 million, and some 280,000 head of cattle were swept away (Burton, Kates, and White, 1993). The rich delta soil continues to lure people to this area, so recurrence is highly likely.

Clearly, no society is immune from the natural disaster threat. As the risk continues to grow, it is imperative that recent technological advances be harnessed to aid the disaster manager in reducing loss of life and property. Revolutionary advances in the areas of communications, remote sensing, and computing capabilities now enable the sharing of information as never before.

Technology's Advance: The growth in the number of space-based sensors, equivalent voice communication circuits, and computers connected to the Internet, 1960–1997



Definitions

DIN (Disaster Information Network): Robust, integrated, virtual network for cooperative exchange of timely, relevant information that can be used during all phases of disaster management to save lives and reduce economic loss.

NDIN (National Disaster Information Network): An effort well under way by FY99 involving all stakeholders in meeting national disaster management needs.

GDIN (Global Disaster Information Network): An effort beginning in FY00 to integrate NDINs among nations of the globe.

The potential for reducing disaster costs through better application of information technology to disaster management (DM) was emphasized in 1984 in a report released by the House Subcommittee on Investigations and Oversight (U.S. Congress House, 1984). In 1988, the Symposium on Information Technology and Emergency Management convened in Gatlinburg, Tennessee, to “assess present response capabilities and identify areas that may require improvement” (Chartrand and Chartrand, 1989). The results of the symposium were encouraging, and further technical strides now suggest that the development of an integrated network to support DM information is entirely feasible.

The tremendous growth of the Internet attests to trends in the communications industry. Internet usage grew from a meager 235 interlinked computers in 1981 to over 300,000 in 1991. The introduction of the World Wide Web (WWW) and web browsers in 1991 and 1993 has raised the current number of interlinked computers to more than 19.5 million (http://www.nw.com/zone/host-count-history). These trends indicate that over 100 million people worldwide now have some type of network access. However, access in many disaster-prone areas of the developing world is often severely limited or nonexistent.

Both the number of communication circuits and the speed at which they can transfer information have grown exponentially in recent years. This has created the potential for affordable instant voice and video communication over computer networks. Developing technologies such as the Asynchronous Transfer Mode (ATM), satellite-based personal communications, and electronic commerce are critical to achieving wider bandwidths, mobile operations, and information security.

Disaster managers, even in remote regions of the developing world, will benefit greatly from the parallel growth in remote sensing if these communication services are tied together in an effective early warning and response system that takes into account the globally varied levels of communications capabilities. Weather satellites such as the National Oceanic and Atmospheric Administration's (NOAA's) Geostationary Operational Environmental Satellite (GOES), in combination with land measurement sensors such as NOAA's Advanced Very High Resolution Radiometer (AVHRR), are essential capabilities for delineating disaster events and their aftermath. New sensors, such as RADARSAT and the planned commercial offerings of Space Imaging, EarthWatch, and other companies, will continue to enhance our ability to support disaster management. The dissemination of products from previously classified systems such as CORONA and the ability to derive unclassified products from currently classified systems further extend our sources of data.

There has also been tremendous growth in the use of geographic information systems (GISs), global positioning systems (GPSs), and modeling and simulation techniques. Each adds significant value in characterizing infrastructure, risk areas, and disaster zones, which is essential to rapidly bringing scarce resources to bear in the most effective manner.

The Disaster Information Task Force (DITF) was formed to evaluate these technological advances and associated organizational and policy-related issues in order to assess the feasibility of a Global Disaster Information Network. The need for a network extends beyond the technical aspects of a physical communications system to include the need for better cooperation and interorganizational relationships. The DITF recommendations for follow-on steps are an essential part of achieving the primary DITF goal. The DITF evaluated the utility of a GDIN, baselined current capabilities, and investigated and recommended the means for integrating the following:

- New information products, including those derived from national security data
- Archival and real-time data sets
- New and emerging technologies
- Information infrastructure for disaster support.

The development of a National Disaster Information Network concept with provision for international link-ups was a prerequisite for the feasibility study. Of major importance in defining the network were the consideration of user needs, the products and services of information providers, and the multi-tier possibilities for interconnectivity. In addition, the issues of public/private partnerships and program cost-effectiveness or paybacks were examined. This involved identifying the key elements of public/private partnerships in disaster management and exploring alternative ways of assessing investment return/payback of a disaster management information network and storehouse.

An important consideration of the DITF was to define the necessary follow-on work to ensure efficient and mission-effective GDIN development. This follow-on work includes establishing:

- Network standards
- Protocols and information finders
- Informational quality assurance
- More complete cost-effectiveness estimates
- More definitive public/private partnership endeavors
- Directed technology support
- Information integration
- Modeling technologies for disaster effects
- Approaches to international connectivity.

Finally, the DITF was to define sound implementation steps to begin substantive progress on a GDIN.

This report details the results of the DITF activities. Chapter 1 describes the role of information in disaster management. Chapter 2 describes the DM user community and what it needs to conduct its day-to-day operations. Chapter 3 describes the provider community and the associated methodologies available and under development to support user needs. Chapter 4 synthesizes these needs and capabilities and evaluates the various means by which disaster-related information could be effectively disseminated. Chapter 5 discusses the DITF findings and some fundamental considerations associated with the development of a disaster information network. Chapter 6 presents the DITF recommendations and action plan. Chapter 7 highlights the GDIN considerations.

The major observations and associated recommendations are as follows:

Much progress has already been made. The availability of disaster information is greater than ever before. Hundreds of Federal, state, local, public, and private agencies have created WWW sites rich in data, information, and knowledge. One can view data within seconds of its collection, see how a river is rising, track a tornado or hurricane, or observe the likely extent of damage caused by an earthquake that just occurred. One can access the latest information on disaster-resistant design, regions of high and low risk, sources of emergency supplies, preparedness plans, and more. Virtual forums such as the Emergency Information Infrastructure Partnership (EIIP) exist for disaster managers to share ideas. Virtual organizations are being established such as the National Institute for Urban Search and Rescue (NI/USR), where committees work to solve problems and develop new approaches. The Internet and the WWW make it possible for millions of people to share data and information and to work together in ways not previously possible, yet most of the disaster-prone world has limited access to the Internet.

The various technical problems appear to be manageable. There are technical barriers, but these appear to be resolvable. For instance, the Internet can be overloaded, thereby slowing response time. Through the addition of mirrored servers and similar approaches, a larger share of users can be expeditiously served. Until Internet traffic can be prioritized, similar to the Government Emergency Telecommunications Service (GETS), it may not be reliable for time-sensitive traffic such as warnings and interactive resource management. The DM community needs a robust intranet such as that being implemented within the National Guard (GuardNet XXI) to ensure that reliability and capacity can be sustained through the course of disaster events. The restoration of communication links via satellites will ameliorate the effects of network damage. New technologies such as ATM, personal communications, and electronic commerce allow for scalable and flexible connectivity, mobile access, and secure information transactions. In addition, information generation, fusion, and accessibility are rapidly improving. Finally, emerging technologies provide new opportunities, but a consistent approach among many parties is essential for interoperability and efficiency.

There is a significant need to involve all stakeholders. Disaster response, recovery, mitigation, and preparedness are primarily the responsibility of local communities, although they often require state and Federal assistance. The fundamental problem is that disasters cut across many boundaries, including organizational, political, geographic, professional, topical, and sociological. This means that disaster information needs to be disseminated to all stakeholders at local, state, and Federal levels, both public and private. Furthermore, there is a need to integrate information across many disciplines, organizations, and geographical regions. Representatives from various sectors, therefore, must be involved in the design and integration of a disaster information network. This is where Federal leadership and the meaningful involvement of all stakeholders can lead to major improvements in capability and a noticeable reduction in disaster losses. An effective organizational approach on public/private partnership models must be established and maintained to guide this development. The organization's role would be to: develop and implement the system, identify deficiencies and recommend improvements, obtain consensus and stimulate public and private participation, identify training/outreach opportunities and directed technology needs, strive for standardized procedures wherever possible, and provide leadership facilitating international growth. Private industry will in fact become a key element due to its unique value in disaster management (i.e., critical infrastructure including power, water, sewer, banking, communications, transportation companies) and the involvement of the insurance industry and the effect of disasters on the national economy.

The information network should be developed in a phased manner. Recognizing that there are many technical and organizational barriers to overcome, it is clear that the network should be developed using a phased approach. Federal-level organizations can immediately begin the process of integrating their data and information sources. This phase would involve the development of a logical arrangement of federally provided observational data, information, models, tools, and related resources. A strategy for integrating Federal intranets should be devised in order to provide a more robust network for disaster managers. The next step would be to extend to a national-level network, which would take advantage of public/private partnerships. This phase involves the incorporation of national-level information—a clearinghouse for tools, models, simulations, and decision support capabilities. Under the leadership of the State Department, the plans for a concurrent global extension would be developed and demonstrated in conjunction with the national strategy. Industry, universities, and research organizations also need to be integrated as soon as possible in the process, as do international organizations, existing bilateral and multilateral systems, and non-government organizations. The third phase would implement the plans for international aspects of GDIN and fully extend national-level participation in GDIN.

There is a need for clear policies and procedures. The Federal Government needs to take direct action in making data and information from classified sources more accessible for disaster reduction. The Civil Applications Committee (CAC) is responsible for coordinating among civil agencies the appropriate tasking of classified resources and the certification of appropriate use and dissemination of the data to appropriate Federal agencies. While current policy allows for the use of this information, procedures and communications lines are not in place for direct and timely access, particularly during times of crisis. It is therefore recommended that the Director of Central Intelligence (DCI), in conjunction with the CAC, examine and implement policies and procedures for sustainable and timely utilization of classified data and derived products for comprehensive DM. This is essential to the success of the global system. The GDIN will need to contact the U.S. national system in order to acquire derived products in support of disasters worldwide.

In summary, we are now in a position to take advantage of technologies that make it feasible to build a robust, integrated, virtual network for the cooperative exchange of timely, relevant information through all phases of disaster management to save lives and reduce economic loss. Such a virtual network would consist of a knowledge base with data, information, sensor characteristics, analyses, and models contributed and utilized by a wide variety of stakeholders. This virtual network would connect people to resources and people to people. The information would be organized in a logical manner so that people with widely varying needs and levels of expertise could rapidly find and access what they need to know. The network would be a focus for cooperation in developing standards and tools for integrating data sets into products that could be used to take timely and appropriate action. The National Imagery and Mapping Agency (NIMA) fly-through visualization experience, National Technical Means (NTM) derived products, and the virtual reality assets of NASA and DoD are but a few of the building blocks currently available. GDIN can motivate and facilitate the DM future.

Recommendations

Organization: Build a framework that involves public and private stakeholders in forming a long-term GDIN organizational structure. Begin immediately to solve Federal-level challenges through an Integrated Program Office (IPO) under the auspices of an interagency Executive Committee (EC). Establish a Public/Private Partnership (PPP) to engage all stakeholders.

Policy: Formulate a policy environment that fosters interagency cooperation through integrated strategic planning and coordination of disaster information budget initiatives and promotes public/private partnerships. Develop a sustainable plan for timely access to classified data and derived products.

Information Access: Formulate a logical arrangement of data, information, models, tools, and other resources accessible to users through an integrated information network.

Connectivity: Develop procedures and policies to ensure the Disaster Information Network is robust and secure when necessary and that disaster information stored on Federal intranets and on the Internet is available to disaster managers when needed.

Directed Technology: Develop an approach to integrate new and emerging tools and technologies (models, simulation, data fusion) for use by disaster managers.

Demonstration: Conduct formal exercises to demonstrate that enhanced information access, connectivity, and directed technologies have measurable value in reducing disaster costs.

Global Extension: Begin by building a National Disaster Information Network and construct the appropriate framework to move toward a Global Disaster Information Network.

Chapter 1

Role of Information in Disaster Management

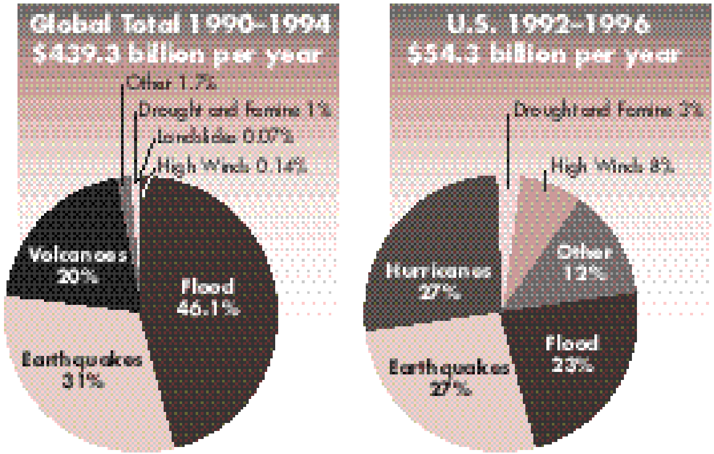
Disaster Costs Are High and Rising

Natural disasters in the United States from 1992 to 1996 cost an average of more than $1 billion per week (Padovani, 1997). Globally, the costs averaged $138 billion per year from 1988 to 1992 and $440 billion per year from 1990 to 1994 (International Federation of Red Cross and Red Crescent Societies, 1996). A prominent global reinsurance company for natural hazards estimates that the volume of losses resulting from natural catastrophes is likely to double between 1995 and 2000 (Munich Re, 1996). The fundamental problems are that population is increasing, more people are moving to urban high-risk areas, and our infrastructure is increasing in complexity and value.

Despite improvements in disaster mitigation and warning, disaster costs are rising rapidly because of increased urbanization and complexity of our massively integrated infrastructure.

Cost estimates are subject to sudden change by high-impact single events. For example, the earthquake in Kobe, Japan, in January 1995, cost on the order of $150 billion (EQE International, 1995). A repeat of the 1906 San Francisco earthquake or the 1857 Los Angeles earthquake is likely to cost on the order of $200 billion, and a repeat of the 1923 earthquake near Tokyo is likely to cost more than $1 trillion (Risk Management Solutions, Inc., 1995).

Average costs by disaster type expressed as a percentage of the average yearly cost.



Source: International Federation of Red Cross and Red Crescent Societies, 1996

The United States has one of the higher rates of natural disasters in the world and they affect every state. Large population centers on the east and west coasts are prone to hurricanes and earthquakes. The high western plains east of the Rocky Mountains have the least risks from hazards but also are relatively low in population.

Lives lost in disasters in the United States average 510 per year, while globally the average is approximately 128,597 (International Federation of Red Cross and Red Crescent Societies, 1996). Improved warnings and mitigation have reduced significantly the number of lives lost in the technologically advanced nations, but the global average that had been rising rapidly before 1976 has remained relatively constant since then. These numbers can also change radically because of high-impact events. In 1970, for example, the densely populated delta region of Bangladesh experienced a tropical cyclone that killed approximately 300,000 people (Tobin and Montz, 1997). The Tangshan earthquake in China in 1976 killed at least 240,000 people (UN Global Programme, 1996). Unofficial reports claim as many as 750,000 people died.

The number of people affected by disaster damage worldwide is typically one thousand times greater than the number of people killed by disasters (Burton, Kates and White, 1996).

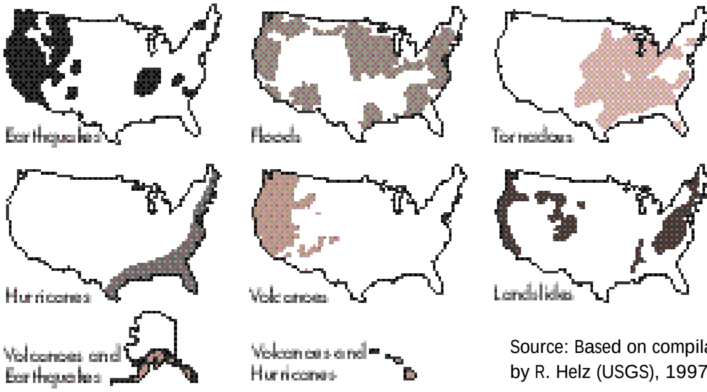
Clearly disasters are a growing problem nationally and internationally. We need to be aggressive in seeking ways to reduce disaster losses and move toward a sustainable society that is more resilient to natural hazards (National Science and Technology Council, 1996).

Information Can Help People Reduce Disaster Losses

There are many examples where accurate and timely information was used to reduce disaster losses. There are other cases where better information clearly would have helped.

Disaster losses are reduced when the people at risk take appropriate actions based on the best information available.

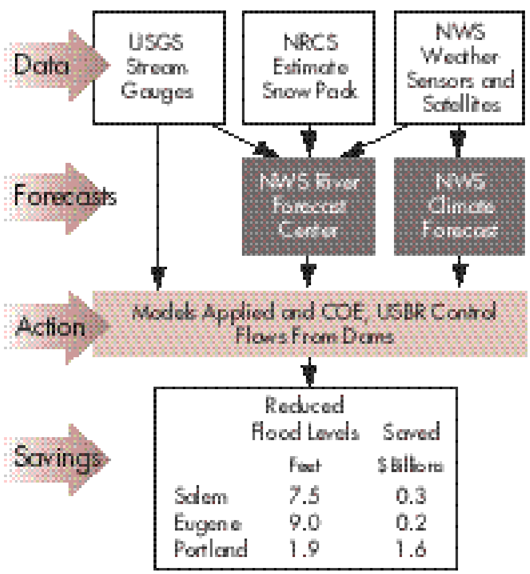
Portland Floods. Estimates by the Corps of Engineers (COE, written communication, 1996) show that floods in northwestern Oregon during 1996 would likely have cost $2.1 billion more had several agencies not worked together closely to control reservoir levels. The U.S. Geological Survey (USGS) collected stream-gauge data. The National Resources Conservation Service (NRCS) estimated snowpack thickness and water content. The National Weather Service (NWS) provided long-range weather forecasts and current weather data. The NWS River Forecast Center projected flood levels. The



Primary extent of disasters in the United States. Disasters occur nearly everywhere. Hurricanes and earthquakes are most common on the densely populated East and West Coasts of the country.

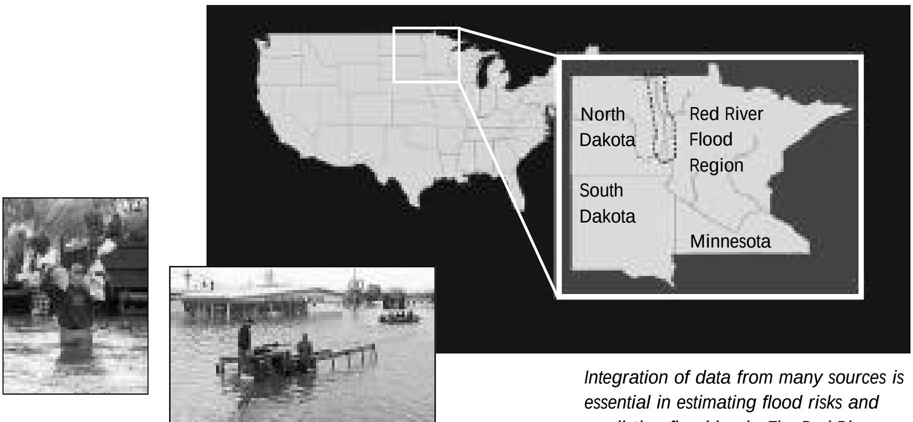
Source: Based on compilation by R. Helz (USGS), 1997.

COE, U.S. Bureau of Reclamation (USBR), and many private operators of dams modeled reservoir storage levels. Based on such integrated data, dam operators were willing to lower reservoir levels far below normal levels prior to the forecast flood and were able to retain more water during the storms and rapid snowmelt, reducing flood levels by up to 9 feet in some communities. A Disaster Information Network could enhance this type of cooperation and integration of information in many regions and for many different types of disasters.

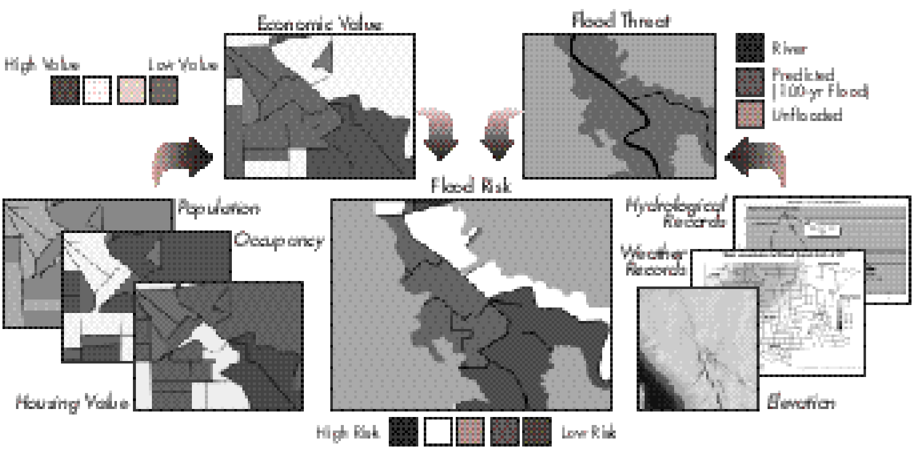


Integration of data from many sources proved essential in estimating flood risks and anticipated flood levels in the Oregon floods of 1996.

Red River Floods, North Dakota. In 1997, Grand Forks, North Dakota, and the surrounding region suffered more than $400 million in losses when the Red River rose several feet above projected levels. Estimating flood potential in the relatively flat area was complicated by levees built for roads with bridges that constricted river channels. Ice jams further limited flow. As our infrastructure becomes more complex, we need to integrate new sources of information to estimate accurately the potential for disaster.

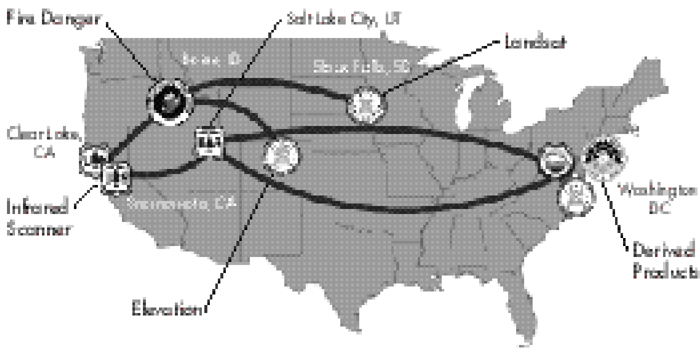


Integration of data from many sources is essential in estimating flood risks and predicting flood levels. The Red River Floods cost $400 million—flood level also understated.



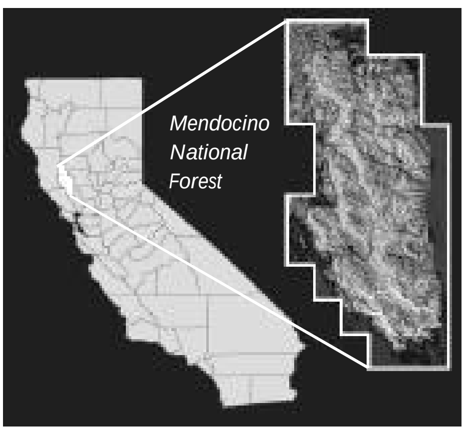
Accurate multi-source information can improve flood risk, predictions, and damage assessments.

Mendocino National Forest Fire, California. In 1996, a forest fire destroyed 80,000 acres in the hills surrounding Mendocino, California, leaving many steep hillsides threatened by heavy winter rains. The problem was how to focus limited resources on recovery efforts. The fire damage was assessed by combining data from the Landsat Thematic Mapper, Digital Elevation Models (DEMs), infrared scanners, information from National Technical Means (NTM), and field reports. The potential for erosion and for new growth was derived from a combination of these data. The land use requirements were determined by combining information on rangeland, wildlife habitats, and recreational needs. The resulting product was a detailed map showing priorities for new vegetation that was used by the U.S. Forest Service to save approximately $250 million by planting less vegetation than originally planned. Integration of data such as this has the potential to enhance each phase of the disaster management life cycle.

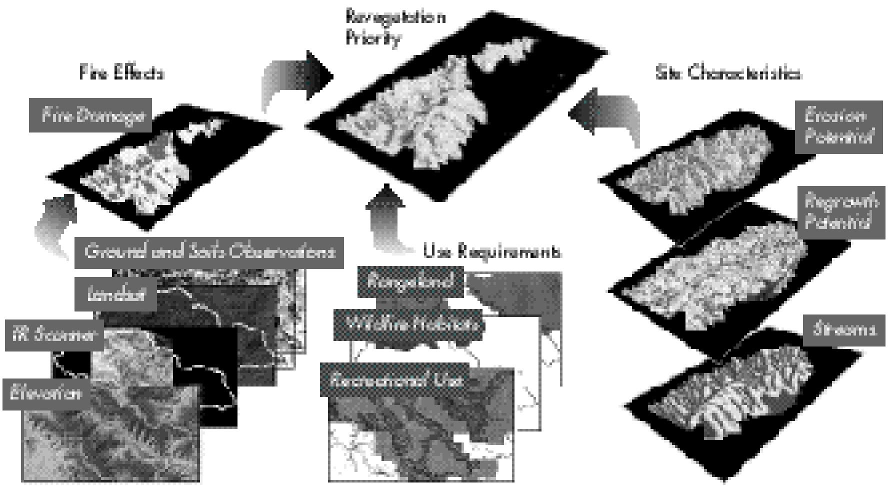


Model for success.

Fire data were transmitted to regional analysis centers from U.S. Federal agencies.



The Mendocino Forest Fire destroyed 80,000 acres and threatened nearby towns.



Integration of data collected by satellites, aircraft, and ground stations enabled the U.S. Forest Service to set priorities for revegetation of Mendocino National Forest following a major forest fire in 1996.

Federal Role in Disasters and Disaster Information

The Federal Emergency Management Agency (FEMA) leads the Federal response to major disasters, and many agencies have important roles that are well defined in the Federal Response Plan (FEMA, 1992) and its 12 emergency support functions. FEMA has also promoted a National Mitigation Strategy (FEMA, 1995) to develop partnerships at all levels to build more disaster-resistant communities. All Federal agencies are responsible for responding to and mitigating disasters that involve lands or facilities that they manage or utilize. The Department of State (DOS) must deal with U.S. interests regarding disasters around the globe.

Responding to and reducing the effects of disasters are primarily the responsibility of local groups at risk, but they often require assistance from state and Federal levels.

The National Mitigation Strategy (FEMA, 1995)

A vision document that provides a roadmap for mitigation actions that can be undertaken by all stakeholders in disaster mitigation.

The Federal Government plays a lead role in disaster monitoring and warning. The Disaster Relief Act Amendments of 1974 (Public Law 93-288) state that “The President shall insure that all appropriate Federal agencies are prepared to issue warnings of disasters to State and local officials." The NWS, for example, has responsibility to monitor and issue warnings for extreme weather events and floods. The USGS is responsible for monitoring and issuing warnings for earthquakes, volcanic eruptions, landslides, etc., and for monitoring floods. The Environmental Protection Agency (EPA) has the lead Federal role for disasters involving pollution. The National Imagery and Mapping Agency (NIMA) collects information for reasons of national security that can be of great value during disasters and in fact during all phases of disaster management nationally and globally. These data are available to other Federal agencies through the Civil Applications Committee and the Advanced Systems Center (ASC) of the USGS. Many Federal disaster information centers have been set up to provide disaster information and warnings (see Appendix A).

As the WWW on the Internet has grown, most agencies have moved aggressively to make disaster-related information available. Increasing numbers of people are using this information to find out what is going on, what is at risk, and what is known about various hazards. They want to use this information to take actions that will make their lives, families, businesses, and communities safer. Disaster managers are finding it easier to obtain and share relevant information, but formats, quality, reliability, and accessibility are problematic. Federal leadership is needed.

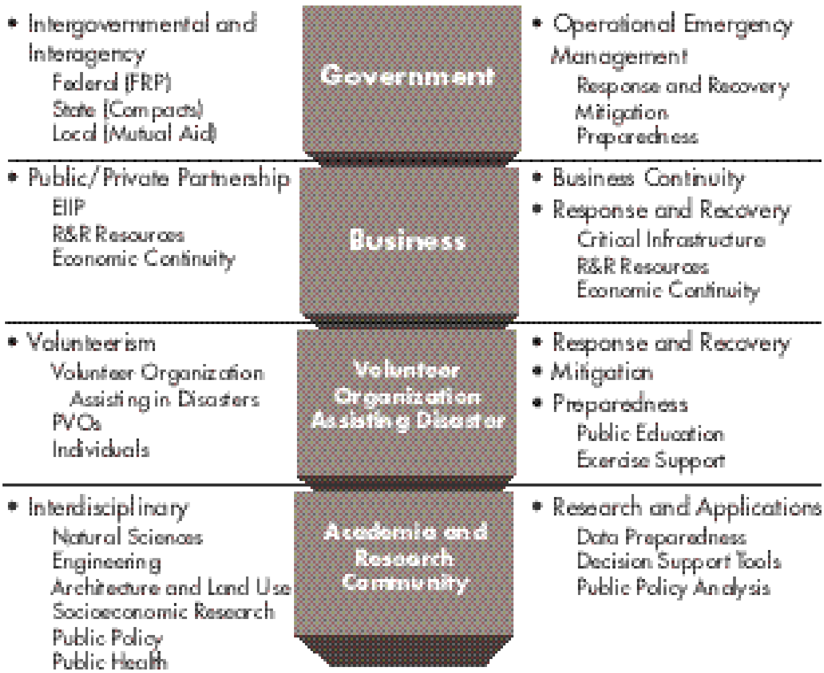
NEMIS

The National Emergency Management Information System (NEMIS) is a new hardware/software telecommunications system for use primarily by FEMA to manage disasters. Key functions include damage assessment, disaster declaration issues, tracking of requests, coordination of donations, processing of damage survey reports, coordination of field inspection teams, human services, grants processing, mitigation plans, and financial processing. These functions are different from but quite complementary to those envisioned for the more widely available Disaster Information Network (DIN) described in this document.

Disaster Information and Management Community

The Federal Government is just one player in the broad disaster information community. State and local agencies, universities, and many private organizations collect basic information about disasters, issue results of detailed analysis, and provide knowledge of key importance for reducing the effects of disasters.

Disasters show little regard for existing boundaries, whether geographical, political, or professional. When a disaster strikes, everyone needs to make informed decisions about what to do to protect their families, their businesses, and their community. Disaster managers and responders suddenly become very important, but so do emergency responders such as physicians, firefighters, and law enforcement personnel. As rebuilding proceeds, architects, engineers, financiers, construction workers, building inspectors, and many others play critical roles. Thus, much of the disaster management community is involved full time, while many of those affected are involved only part time. Disasters involve the public and private sectors, government and business, professionals and volunteers, practitioners, academia, and the research community.



A comprehensive approach to disaster management involves four basic phases: mitigation, preparedness, response, and recovery. In times of disaster, people are preoccupied with response and then with recovery. The greatest potential for loss reduction, though, is typically during the mitigation phase, when communities can be made more disaster resistant. The largest share of costs, however, are directed toward the recovery phase, where good mitigation principles also need to be put into practice rather than just rebuilding only to face a similar disaster in the future. Lessons learned or information gathered during one phase are often valuable when put into practice in other phases. Such interrelationships argue not only for a comprehensive approach to disaster management, but also a comprehensive approach to managing disaster information.

The challenge for a disaster information system is to meet the widely varying needs of a very broad spectrum of users during all four phases of disaster management. In addition to the needs for basic situational awareness and resource management information, there are needs for information to make critical decisions, needs for training, and needs for communication among people with similar responsibilities or interests. The disaster management community throughout the world must continually be improved and benefit from technical assistance, training, and the latest technologies so that it is ready to take crisis preparation and mitigation actions.

The need to integrate across many boundaries, all phases of disasters, and the many different user requirements make designing a Disaster Information Network a formidable task.

Conceptual Flow of Disaster-Related Information

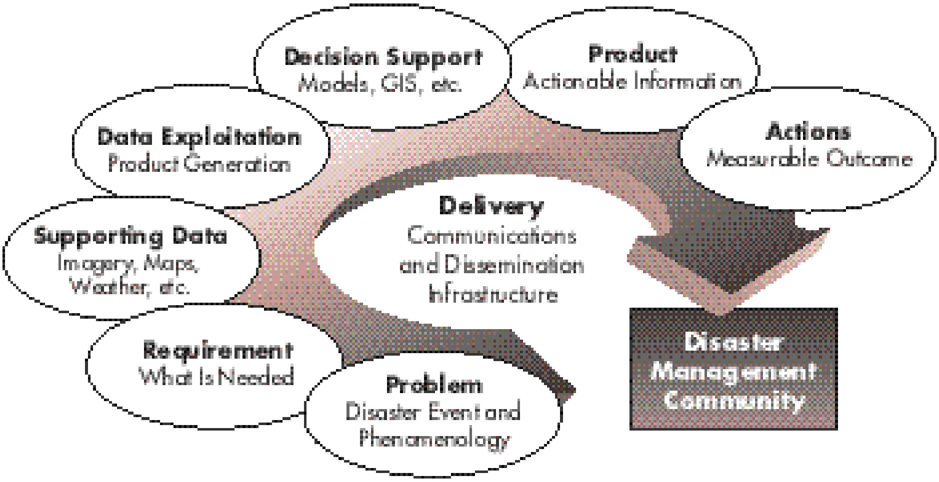
A comprehensive disaster information system must allow access to many different kinds of information at many levels of detail and at many points in time.

Disaster information involves more than just data. Several interconnecting steps are typically required to generate the types of action-oriented products needed by the disaster management community. The exact steps taken depend on the disaster phase and how time critical the need is. The following describes each step in the product generation process:

Problem: Define the problem, event, or phenomena to be studied. For instance, an ability to measure the health of vegetation is critical for land managers to determine fire-prone areas within their jurisdiction. The underlying conditions leading to disaster events must be well understood in order to determine which data need to be collected.

Requirement: Decide what is required to study the problem. By knowing the driving forces behind the measurements, one can commit the right resources, coordinate the activities, determine how to best manage the collection and analysis methodologies, and judge how best to distribute the eventual information products. Knowing what is needed and how to get it is fundamental to every disaster-related action.

Supporting Data: Know which information sources are available to meet disaster manager needs. Because there is an increasing amount of source material available and because varying disaster events require different data sets, the optimal toolset is an up-to-date knowledge base.



Data Exploitation: Analyze data to generate products. This includes the processing of digital data, image integration, feature classification and attribution, classification output, accuracy assessments, and post-processing operations. It is the most technically challenging step in the process and probably best performed at exploitation centers where there is resident expertise.

Decision Support: Provide ways for decision-makers to visualize and merge data and products. This phase essentially involves the synthesis of the data types in order to generate data layers (e.g., soils, vegetation, terrain) along with the models and simulation techniques that stem from use of the data layers.

Product and Actions: Produce products that lead to actions to save lives and reduce damage. Actionable information can be defined as a tangible product that supports these activities such as the delineation of evacuation routes and damage assessments.

Delivery Process: Communicate and disseminate information through all the disaster management stages. This means that the communications and dissemination infrastructure must work in a timely and effective manner.

Understanding this broad conceptual flow of information sets the stage for the required breadth of a disaster information network developed in the following chapters.

Chapter 2 Needs of the Users of Disaster Information

Background

The Disaster Information Task Force had to develop a fundamental understanding of the needs that exist within the U.S. disaster management community. This phase of the DITF process was initiated through analysis of existing and requested information from within the DM community. This served not only as a basis of understanding our domestic needs, but also as a surrogate to obtain insights into the needs of the global disaster management community as well.

The disaster management community is the initiator of the user requirements as well as the beneficiary of the information products developed to effectively meet the decision-making needs for comprehensive disaster management.

To better understand the needs of the DM community, therefore, the GDIN User Working Group conducted a DM requirements assessment in which the following user communities were represented:

- Federal, state, and local governments, including all those engaged in disaster management
- The private sector, including critical infrastructure services
- Scientific and engineering research and systems development communities
- Universities
- Nonprofit organizations, private volunteer organizations, and the public at large, including populations with special needs.

In addition to identifying the importance of information sharing and communication among these entities, discussions helped define the relationship between the DM community, the information provider community, and the community of technologists tasked with identifying communication requirements.

Differences between the DM and information provider communities are becoming less pronounced as analysis tools and communications technology become more robust and readily available.

The DM community is undergoing rapid transformation as it assimilates critical technologies to improve direction and control, operational readiness, and situational awareness. It is among the most interdisciplinary public-service professions. The disaster manager coordinates the plans and actions of engineers and scientists as well as public health, law enforcement, communications, and transportation professionals, among other disciplines. The disaster manager must understand the roles and responsibilities of multiple agencies and must coordinate preparedness and mitigation efforts to inspire readiness through drills, exercises, planning, and training.

Emergence of a nascent emergency information infrastructure and aggressive efforts in implementing professional standards through certification programs, such as that of the National Coordinating Council on Emergency Management (NCCEM), have contributed to a synthesis of DM skills and experience and a convergence of tools and techniques.

Capturing User Needs

The DM community must provide an easily interpreted set of requirements and a clear perspective of measurable outcomes to the provider and dissemination communities.

Guidance. The DITF defined its strategy for the user information needs analysis through a concise fact-finding and evaluation effort. The purpose was to elicit and document those technical requirements and operational needs that must be met to enhance the effectiveness of the DM practitioner's mission.

Survey. The User Working Group developed a survey as a first step to organize and communicate user community requirements. In order to accurately and comprehensively represent the user base—from first responders to national program planners—the User Working Group pursued a multidimensional investigation of needs.

DITF Survey Activities

- Designed, disseminated, collected, and analyzed survey instruments, including a User Requirements Form; made inquiries of U.S. Government hazard assessment experts; and created templates for defining actionable information, building on face-to-face meetings with hazard-oriented teams.
- Conducted Internet and national teleconferences, including briefings on national teleconferences through the Emergency Information Infrastructure Partnership (EIIP), EIIP list server and chat sessions, and extensive search of the WWW to survey a variety of list servers and forums.
- Conducted interviews and attended technical interchange meetings with (1) representatives of critical infrastructure sectors (e.g., oil and gas pipeline and storage, telecommunications, electric power distribution, water); (2) representative developers and integrators of crisis management modeling, simulation, and decision support information management applications; (3) researchers on issues of

data availability, quality, and gaps; and (4) policy analysts, engineers, building code inspectors, and architects supporting risk assessment, mitigation implementation, sustainable communities, and infrastructure assurance initiatives.

Conducted interviews with professionals supporting Emergency Support Functions (ESFs) on-scene, in local and state Emergency Operations Centers (EOCs), and in corporate crisis management centers; and with program leaders and/or reviewed historical documentation for cooperative initiatives and projects, including:

- Global Emergency Management Information Network Initiative (GEMINI) Project
- Emergency Information Infrastructure Partnership (EIIP)
- HazardNet, ReliefWeb, ResponseNet, Earthmap
- State and local emergency managers data users group (SALEM DUG)
- Others

• Performed archival research by reviewing the following:

- After-action reports, lessons learned, situation reports, and independent evaluations of performance in selected ESFs executed as part of the Federal Response Plan (FRP) during major disasters and exercises during the 1992–1997 period
- Inputs from professionals supporting the FRP in the field, at the Disaster Field Offices (DFOs), and at the Federal regional and headquarters echelons
- Supporting historical documentation furnished by the Natural Hazards Research and Applications Information Center (NHRAIC), the FEMA Learning Resources Center, and others
- FEMA Disaster Resistant Communities Initiative, the Emergency Management Institute (EMI) training curriculum, and a variety of preparation, training, and exercise programs and documentation

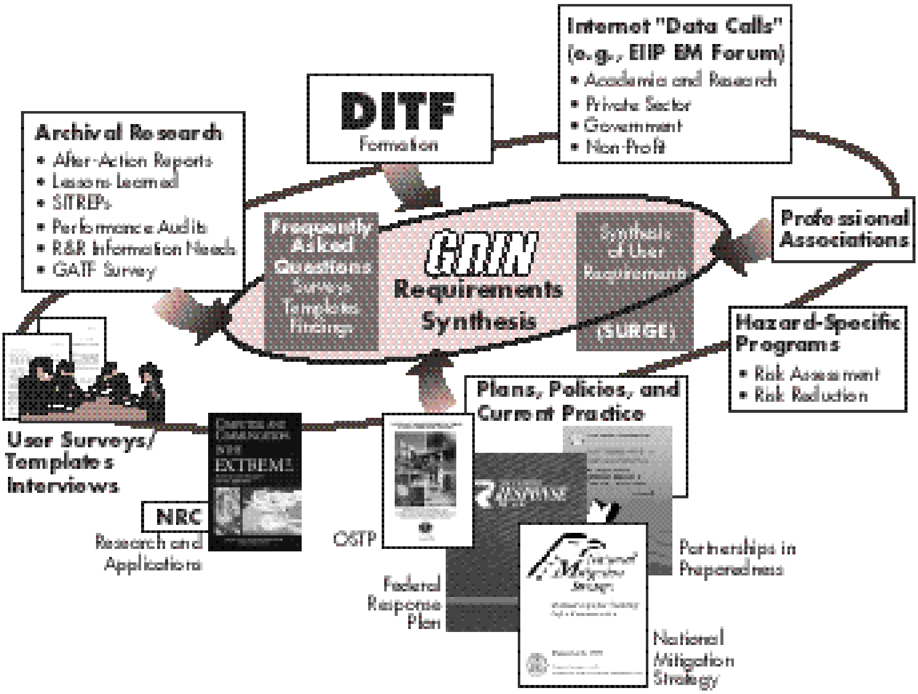
• Examined plans, policies, and current practice through the review of key studies, reports, and strategy documents and plans from the Subcommittee on Natural Disaster Reduction (SNDR), the National Research Council (NRC), the National Mitigation Strategy, the FRP, the Government Applications Task Force (GATF) Report, and hazard-specific programs.

• Reviewed legislation and national security/emergency preparation (NSEP) executive orders.

• Studied Frequently Asked Questions (FAQs) posed by disaster managers in operational settings.

• Conducted detailed analysis of information needs over time-scales of hours to months in pre- and post-event response and recovery actions for specific hazards (e.g., landslides, earthquakes, floods, hurricanes, wildfires, airborne chemical or biological releases, waterborne contaminants, and others).

The diversity of resources, research, and source material employed in the user needs analysis and requirements synthesis activity is illustrated below. The DITF endeavored to recognize, amplify, and complement the findings and activities of the SNDR, NRC, and other distin guished bodies involved in strategic planning and assessment of the DM enterprise worldwide.



Synthesis Activity. The hundreds of survey responses and user input forms were aggregated by the DITF. The data set was then evaluated, and themes, clusters, and commonalities were identified. A compilation of user requirements, referred to as the "Synthesis of User Requirements for GDIN Working Group Evaluation (SURGE)," was developed for evaluation by the User, Provider, Disseminator, Pre-Event, Post-Event, and Hazard-Specific Teams comprising the DITF. These expert teams then derived DM information findings. These findings express composite DM requirements that would translate into appropriate provider and disseminator technical solutions.

Expressed Needs

The following user requirements from the SURGE report highlight the value of enhanced electronic coordination and collaboration before, during, and after emergencies.

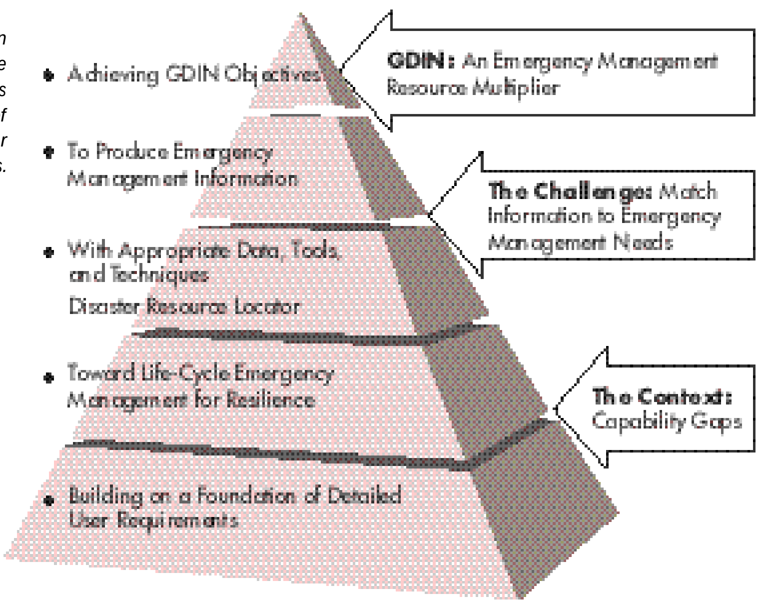
Virtual Forums. Professional exchanges via dedicated Internet chat sessions and list server to support professional interchange on key preparedness and mitigation issues (e.g., building codes, best practices, and construction lessons learned).

Resource Tracking. Definition of resource categories and nomenclature accepted and used by FEMA, states, military, and local jurisdictions to facilitate requests and responses for equipment, personnel, and material resources. A controlled access database system with a common taxonomy and lexicon for tracking resource requests and donations available to DM coordinators.

Geospatial Data and GIS Overlay Databases. Capability to easily pass GIS data overlays from EOC to EOC (response), from modeling and simulation centers to training and exercise settings (mitigation and preparedness), among Federal and state ESF agencies (recovery), and so forth. Recent fusion centers like the Advanced Systems Center (ASC) will also become providers of GIS overlays (e.g., image change detection for damage assessment).

GDIN is built on a foundation of detailed user requirements. This rigor is required to ensure that solutions proposed in a future GDIN are responsive to unmet needs and provide a pathway for cooperation among participants.

A disaster information network is a resource multiplier that builds on a foundation of detailed user requirements.



Current Environment

Utilization of the distributed national information infrastructure is increasing within the DM community. The principal findings from the review of unmet needs and technical requirements among potential GDIN users in the DM community reflect the spectrum of information management issues.

Innovative intranet implementations based on emergency support functions within the U.S. Federal Response Plan illustrate how the Internet model can successfully mesh with the functional mission of the FRP partners. The initial GDIN user needs analysis suggests a similar model can address the full life cycle of DM, encompassing mitigation, preparedness, response, and recovery activities. The following paragraphs are a distillation of the DITF-identified needs of the DM community and the various technologies that are emerging to support them.

Connectivity. The universality of the WWW offers unprecedented portability for the disaster manager on the scene or in the Emergency Operations Center. In addition, services such as the Asynchronous Transfer Mode, modems, and hand-held personal computers (HPCs) with integral GPS and GIS capabilities provide increased secure bandwidth to fulfill the goal of full service to the last mile of connectivity. The review of user needs suggests the last-mile connectivity problem is not yet resolved for the first responder and front-line emergency manager.

The National Academy of Public Administration (NAPA) reports that in 22 states the state emergency management office reports to the Adjutant General, effectively placing both the National Guard and the DM office within the same organization (NAPA, 1997). This legacy of close cooperation between state Emergency Operations Centers (EOCs) and the National Guard facilities creates a unique opportunity for exploitation of the emergent GuardNet XXI (National Guard ATM network) services supporting Federal and state connectivity. Commercial carriers (e.g., AT&T, MCI, Sprint, WorldCom, GTE) are implementing usage-based cost structures for the National Guard that promise a more efficient balance between fixed costs and costs associated with surge scenarios.

Data Dependencies. DM users want to identify, import, condition, and integrate data from geographically disparate data sources and warehouses. The geospatial referencing capability provided by the GPS has greatly improved data quality and GIS, models, and other analytical tools available to the disaster manager. The data/information provider community is responding to calls for organizing an emerging state and national spatial data infrastructure through easy-to-access clearinghouse services. Widely adopted geospatial data standards are expected to facilitate interoperability across complex systems and networks.

Products derived from high-resolution, space-based imagery offer new insights into environmental behavior and processes. These derived products—fused with baseline environmental, socioeconomic, and critical infrastructure data in modeling and simulation processes—offer the promise of enhanced precision and more effective predictive capability for the DM community. The disaster manager who understands the process of capturing data and turning that data into information and decision support products will better address DM issues.

Broadcast Services. The DM community needs global broadcast services to provide wide-area dissemination of warnings, information products such as earthquake damage maps or loss estimation data, and situation reports. Both users and providers recognize the services such as the Emergency Management Weather Information Network (EMWIN) and NOAA Weather Radio as important components of the existing infrastructure; however, these services do not reach many end users. The planned constellations of orbiting satellites (e.g., Teledesic, Orbcomm, Iridium, Odyssey) form the backbone of emergent global cellular services. These systems suggest wide-bandwidth alternatives to terrestrial wireless networks and are anticipated to be operational within 1 to 4 years. Unlike terrestrial networks—which are vulnerable to earthquake, flood, fire, or other catastrophic events—the new global services can provide critical alternative communication pipelines during localized service outages.

Service Priority. Users stressed the need for prioritization for disaster preparation and national security use within these global wireless services, consistent perhaps with the current practice of the Government Emergency Telecommunications Service (GETS) Program managed by the National Communications System (NCS). This requirement will take on a higher profile as the GDIN pursues international cooperation. The need to ensure a quality or class of service was frequently mentioned by both users and providers. Thus, the GDIN will require congestion control during high-stress usage. Secure information capabilities—exemplified in practice by the Defense Information System Agency's Secure Internet Protocol Router Network (SIPRnet) and the Defense Message System (DMS)—have been cited as important attributes for Federal agency nodes linking headquarters, regional, and disaster field offices.

Service Delivery Demands on the GDIN. The DITF survey results suggest that we need an effective dissemination network in order to realize the full potential of the existing data and infrastructure.

The public service challenge for the GDIN is to effectively utilize Federal data resources to fortify state and local decision-making readiness in all phases of the comprehensive DM cycle. The Federal sector can provide key preparation information ranging from base maps to critical infrastructure overlays for response and recovery damage estimation and assessment to mitigation planning for disaster-resistant communities. The importance of information portraying both natural and built environments is perhaps most obvious for preparation and mitigation. Mitigation actions range from structural engineering modifications to community relocation programs, and the need for data/information exists across the spectrum of mitigation actions. Preparedness also requires data/information to improve understanding of existing hazards and features of the natural and built environments, and simulation tools to support plans, exercises, and training—the crucial ingredients of readiness.

Information Resources. The emergency Information Infrastructure (EII) would include best available environmental, socioeconomic, and infrastructure information with coverage of the area of interest, as well as metadata identifying government, research community, and related commercial data. The information might be organized around any number of schema, ranging from the traditional FRP emergency support functions to taxonomy initiatives such as that of the National Emergency Response Information Network (NERIN). Regardless how information resources are arrayed at key nodes, they will be built around existing legacy database management systems and catalogs and must leverage the substantial institutional investment. The continuum of information needs across the comprehensive DM cycle is shown above. This is the framework within which the GDIN can supplement current support functions. The GDIN can make a critical contribution to the DM community, supporting the definition, identification, and availability of essential information for community resilience. With this objective, the GDIN will enhance information preparation and delivery with improved access to and

Resilient communities can be built by integrating disaster information through all four phases of the disaster management cycle.

transport of refined content (e.g., timely products, derived products) for the DM community. It offers a building-block approach of robust, agile services for disseminators and information providers to meet user needs for accurate capability assessment and fortification of community resilience.

Experts' Virtual Forum. The GDIN should support technology currently available for a rapid virtual conference capability. An experts'virtual forum would serve to assimilate on-site conditions from first responders in order to launch models and simulation tools; this permits furnishing mitigation and prediction analysis and damage estimation output products to users in need of rapid situation assessment. It would empower the DM community with unparalleled reachback to geographically dispersed technical or scientific expertise to augment both strategic planning and on-the-scene and EOC decision-making.

The enhancement GDIN could offer, in both communications infrastructure and actionable information data and decision support tools, is perhaps best characterized by a user vision that was articulated during the user needs analysis. Several participants conjured the image of the Director of FEMAand the State Emergency Manager donning a virtual reality headset and taking a self-guided excursion through a variety of "what-if" scenarios surrounding an impending flood.

Imagine decision-makers with the ability to view the three-dimensional environment; to point-and-click on various rainfall scenarios; to watch the progression of a flood through communities at risk; to select various mitigation actions such as levee breaks, sandbagging, and dam releases; and to view in fly-through mode the impacts of their decisions on natural resources (crops, livestock, timber), on the built environment (commercial and residential properties, transportation infrastructure, other lifelines), and on the population, including those with special needs.

The profound insight and foresight such a tool could provide would be an invaluable asset in the portfolio of the DM community. Indeed, many of the features are now in operation or in advanced stages of development. The NIMA fly-through visualization experience, NTM-derived products, the virtual reality assets of NASA, and DoD—these are but a few of the building blocks currently available. GDIN can motivate and facilitate the DM future.

Next Steps

User Community Vision. A systems approach needs to be developed that can serve as a resource multiplier offering improved access to and assured transport of refined and derived data and other actionable information products. The GDIN should be defined and designed within the context of operational assumptions about the DM user community. A sampling of operational assumptions shaping the vision of the Emergency Information Infrastructure (EII) include:

Remote Execution of Simulation Tools. For timely decision support, emergency managers need access to simulation tools (e.g., chemical release models; earthquake ground failure, liquefaction, and landslide models; nuclear plant release models; flood inundation models) maintained by distant institutions or operations centers.

Wireless Interfaces. Unrestricted access to on-scene commanders and first responders will be needed to support the transfer of imagery and overlays to portray a composite picture of areas impacted by an event. Such access extends situational awareness of the EOC to the field in the response and recovery phases.

For improved user capability throughout the comprehensive disaster management cycle, the disaster manager must be a full partner with both the information provider and the network and communication technologists. All-source data fusion, image analysis techniques, and simulation and modeling are among the currently available and emerging resources that would benefit the DM community.

In addition, the burgeoning use of networks and increasing complexity of communication systems present barriers to interoperability. Further, since this diversity of systems, methods, and protocols results in disparate formats, there is need for data compatibility and comprehensive metadata—information about the data—that enables data interoperability. Information assurance must be maintained across all open, restricted, and classified levels of transmission and processing. For effectiveness, coordination to ensure timely information delivery is critical in all phases of the DM cycle. Finally, the information infrastructure for disaster management must be capable of supporting a variety of user knowledge, skills, and experience. Thus, an important function of an end-to-end capability, such as that envisioned for GDIN, is to establish stronger interagency cooperation to improve the capability of the user community throughout the comprehensive DM cycle. A systems approach needs to be established and sustained, serving as a resource multiplier improving access to and assuring transport of refined and derived data and other actionable information.

Chapter 3

Disaster Information Provider

The disaster information provider is an intermediary who generates data and/or processes data supplied by others to generate "actionable information products" distributed to support emergency management decision-making.

Responsibilities of the Provider Community

A multifaceted community of providers supports disaster information needs. Providers include organizations responsible for acquiring *in situ* and remotely sensed data, exploiting these data, generating information products, and developing projections and forecasts that convey dynamics associated with a disaster event.

The disaster information industry prepares information under the most stressful situations during crisis response and recovery. It also develops and maintains vital baseline data used during earlier stages of disaster mitigation and preparedness.

During times of crisis, emergency response teams depend on providers for event-related information such as maps that delineate affected areas and detail critical infrastructure, identification of people at risk, estimates of projected inundation, and weather reports. To support

	Measurable Phenomena	Disaster Events
Severe Weather	Clouds, fog, rain, high winds, lightning, hail, snow cover, run-off, coastal flooding, damaged structures	Thunder/hailstorms, tornadoes, rain/wind storms, tropical cyclones, severe floods, blizzards, ice storms
Wildfires	Lightning strikes, fuel type, vegetation type and status, damaged buildings	Wildfires
Geological Events	Volcanic eruptions, rock slides, rock avalanches, debris and mud flows, ash Subsidence/uplift, faulting Damaged infrastructure	Volcanoes Earthquakes Tsunamis Landslides
Man-Made Events	Water contamination Vegetative stress Soil variations	Oil seeps and spills Industrial pollution Nuclear catastrophe

Measurable phenomena using remote sensing techniques.

crisis management, as well as planning and mitigation efforts during non-crisis periods, emergency managers rely on providers for baseline information such as land cover, topography, housing and public infrastructure, volcanic or earthquake activity, or snow pack.

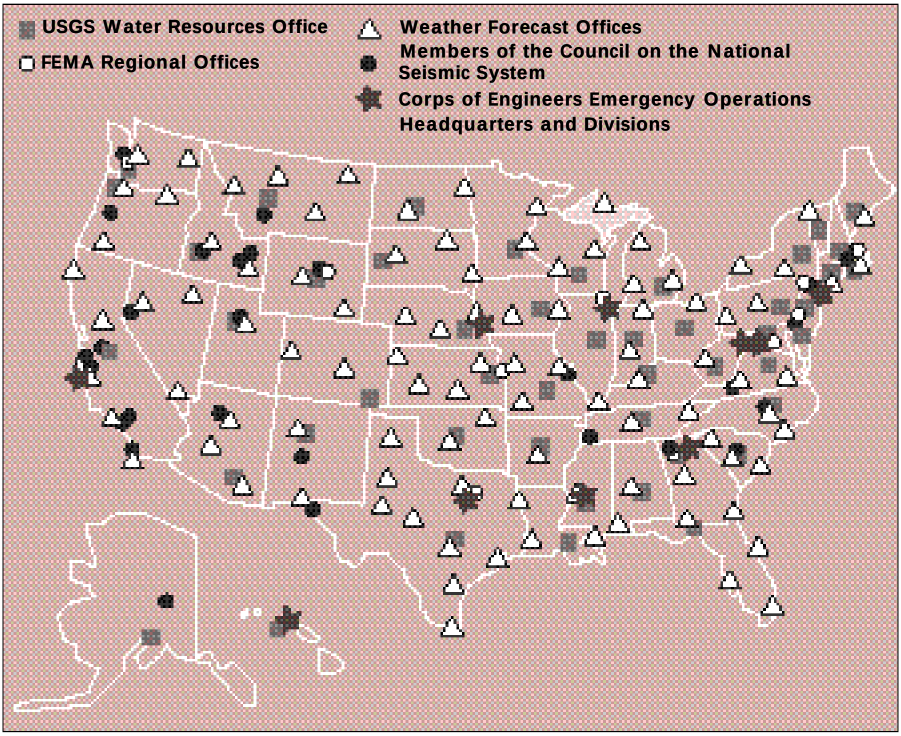
The line is often blurred between information provider and information user. Most organizations responsible for generating information products act as information intermediaries, enhancing supplied data into forms needed by disaster managers now or information providers in the future. For the disaster manager, these products form the basis for developing a plan of action to mitigate against, prepare for, respond to, or recover from a disaster event. The need for such "actionable information products" often creates a complex chain of events involving several organizations.

The DM information community includes participants from the following: Federal, state, and local agencies; the private sector, including data providers and the communications infrastructure sectors; the scientific and engineering research communities; and individual citizens—a critical source of information in crisis settings. The interplay among these entities to prepare and distribute critical disaster information and their relationship with the DM user form the basis for our discussion on the value of a disaster information support network.

Advanced measurement technologies, electronic communications, and exploitation methods are creating a new disaster information paradigm.

Federal centers throughout the United States serve as information provider organizations. (A summary of their responsibilities is provided in Appendix A.) FEMA, for example, supports a National Mapping and Analysis Center that generates national-level baseline data for FEMA's 10 regional centers, each of which shares data through a dedicated communications network (or intranet). During a time of crisis, the national center coordinates acquisition of data through other national-level providers—such as the NIMADisaster Support Center, which generates products derived from classified data sources—and performs decision support functions related to prediction and forecasting. Regional-level products for local crisis management are generated by regional centers that interact with state and local providers.

The organizations described in Appendix A constitute only a fraction of the overall network of public and private participants. The availability of advanced measurement systems—such as space and airborne remote sensing instrumentation, the GPS, and ground-based instrumentation—has resulted in the growth of both a public and private information industry to support the needs of the DM. Communications



Federal centers throughout the United States supply disaster-related data, forecasts, and warnings.

and product dissemination options encompassing diverse electronic communications protocols—such as public networks (the Internet) and private networks (FEMA's intranet)—expand the effectiveness of the DM community in delivering its product. Analytical tools such as GISs and predictive models further expand the breadth of information services.

The changing state of technology has encouraged providers to become less autonomous and more interdependent. Products can be assembled using resources distributed among several organizations at various sites and disseminated to users via new information pathways (e.g., posted on a WWW page or transmitted via fax or cellular phone). One only need examine the depth and variety of disaster- and crisis-related information available on the Internet to realize that the disaster community is operating within a new information paradigm.

These new capabilities transform the way business is conducted, placing a premium on information technology, training, and collaboration. Illustrations of the benefits of these changes are abundant. For example, classified satellite systems can now be tasked to add to information available through other sources. Instruments such as the

Advanced Very High Resolution Radiometer (AVHRR) or Interferometric Synthetic Aperture Radar (IFSAR) can readily provide detailed synoptic representations of affected areas. Social and environmental data can be integrated with information on road and power infrastructure and then related to disaster risk. Data can be readily posted on Internet-based public bulletin boards to increase public awareness. Also, disaster managers can receive map-based damage assessments in minutes.

Technological opportunities bring challenges that require a new degree of cooperation among participants.

Technological opportunities bring new challenges to disaster information providers, who must respond to growing complexity and increased opportunities while satisfying their customers'needs within time and cost constraints. To do this, they need to:

- Understand the multiplicity of new data streams and formats.
- Manage data that seem to continually increase in volume, often outstripping the capacity of current communication bandwidths.
- Meet crisis requirements while maintaining appropriate baseline information and capability to support the needs of disaster mitigation and preparation.
- Maintain user awareness and understanding of ever-broadening capabilities.
- Integrate complex data into understandable thematic information products.
- Recognize interdependencies necessary to assemble products through formation and nurturing of relationships with other providers.
- Maintain awareness of technological and scientific advances in the fields of communications, measurement systems, modeling, and analysis.
- Ensure timely delivery of information to disaster managers despite the complexities of the production process.
- Maintain public awareness by exploiting and managing available communication options.

Current technology has made the disaster information management process even more complex. Yet, the potential exists to achieve unprecedented levels of performance in response to disaster management. This opportunity requires a significant degree of cooperation among participants or we risk leaving some behind. The value of a well-coordinated disaster information network in promoting the cooperation, mechanisms, capabilities, and guidelines necessary to bring the broadest range of new information to all participants is clear. The goal is to optimize the benefits of the information age for the DM community.

Existing and projected increases in the capacity for Earth observations from space and readily accessible *in situ* information—coupled with increased GIS use, model and simulation techniques, improved image processing, and information fusion—result in a potentially powerful and complementary set of tools for the DM community. Effective development and application of the observations through all phases of the DM cycle will depend on the ability of experts to adopt and adapt to the use of imagery and *in situ* data and its associated information.

The provider's ability to meet the needs of the DM community to turn data into useful information and the value of efforts in the pre-event phase to aid in the post-event phase of a disaster are best illustrated through the following example.

The Miller's Reach Fire #2, a fire that burned over 37,000 acres and destroyed 344 structures in Alaska in June 1996, was the worst urban/wildfire in the state's history. Following are a few examples of identified needs, gleaned from the after-action report, that could have benefited from currently available exploitation tools. The report noted that "the use of incident management teams is an important part of managing complex wildfires. But when a team is not familiar with local conditions, be they weather, fuels, terrain, or politics, they need to be closely monitored. This doesn't mean they should be interfered with, but they need to be 'guided'." For example, an interactive training guide would be useful to educate those unfamiliar with local conditions.

The report indicated that the local experts already knew of the types of products that could be generated to help guide the team when it "is not familiar with the local conditions." The first is the local knowledge that "there were two different fuel types involved, mature birch with white spruce undergrowth and pure stands of black spruce. The black spruce was the primary carrier for the crown fire. This is a significant problem fuel in Alaska." After-the-fire analysis showed that indeed "burn patterns and eyewitness accounts indicate the fire spread by crowning and spotting" of black spruce cones, which are the primary source of spot fires. A mitigation strategy that created a species boundary and extent map would easily translate into fire characteristics for a team not familiar with local tree characteristics.

A comment on the information needed for the response phase was also noted: "The topography in the fire area is flat with low rolling hills. The fire burned with the wind, with influence from local topographic features." A GIS in which the local weather conditions were combined with accurate topographic data would be able to create a fire spread assessment useful to the DM team.

Functions of the Provider Community

The DM community would benefit from a mechanism to allow continuous dialog between the field user and the community of practitioners that can provide actionable information. The DITF assembled a team to explore the opportunities for dialog between these two communities. This team was tasked to assimilate the needs of the DM community and to assess the key provider functions in meeting the needs of end users. The following provider functions were identified in this process.

Data Acquisition: Process of capturing and transmitting the measurements, observations, and records that serve as the base materials used to meet DM community needs. Data immediately come to mind when one thinks of the provider community. Data within the context of DM includes a broad spectrum of measurements, observations, and records used to drive models, simulation tools, damage estimation and assessment algorithms, GIS databases, and the decision support tools enabling comprehensive disaster mitigation, preparedness, response, and recovery. In this context, data are not only raw baseline products captured by front-line collection systems but also processed information products used to drive models and as input for fusion techniques.

Requirements Satisfaction: Process of capturing, understanding, and responding to user needs. The provider must capture the DM community baseline requirements and understand community objectives in order to find creative new approaches to meet its needs. The interaction between the user and provider must be a dynamic one with its goal being the expansion of each other's base knowledge. In the Miller's Reach example above, such an effort would have been an effective contribution by the provider community in helping to meet the needs of the user community.

Documentation: Characterization of the data and information products available to the user. Metadata, or "data about data," is a key feature of data documentation and describes its content, quality, condition, and other characteristics. Metadata is one of the key features in the ability of the provider to meet the needs of the DM community. Metadata provides information to help the emergency manager determine what data are available, to evaluate its fitness, and ultimately to acquire, transfer, and process it. The order accessed and relative importance of metadata elements will vary by disaster type and phase. In addition, disaster managers with different objectives and working on different phases of a disaster may require the same information at different levels of abstraction.

Accessibility: The availability of data and information to users within the constraints of policy and confidentiality. User data/information requirements invariably address the issue of access. Knowledge of the existence of data/information, its availability, and the tools necessary to acquire it are key attributes of access. The disaster manager and the provider must identify the technical and other barriers limiting access and make a cooperative effort to surmount them.

Interoperability: Process that enables the inter-use of data/information products. Interoperability is a means to standardize (or harmonize) the data to ensure connectivity between the disaster manager and the provider community. Key features of interoperability include symbology, formats, software, scale resolution, and frequency. In such cases where standards cannot be implemented, it is important to accommodate nonstandard data. This process, known as harmonization, is accomplished through software and other approaches.

Exploitation Tools: Management and enhancement of data into useful information products. A variety of tools is available to the provider community to exploit and turn data into useful information products. The provider can work in a geospatially referenced domain, generate images from satellite and other data sets, integrate and fuse the data into actionable information products, and use models and forecasts to aid the emergency manager. In the Miller's Reach example, enhanced exploitation tools could have been effectively used to delineate the burn characteristics to those unfamiliar with fire spread in Alaska.

Decision Support: Recommended course of action that the disaster manager should take. Decision support includes the following tools and techniques: modeling and simulation capabilities, data visualization and integration tools (particularly those supporting management of geospatial data objects), advanced data mining and core sampling applications, rapid damage assessment tools, logistics planning tools, groupware and collaboration technologies supporting real-time dissemination in distributed environments, and enabling technologies and methodologies supporting virtual expert forums.

Preservation: Maintenance, data integrity, management, and heritage of data/information. It is vital to preserve the data/information generated, usually at great expense and use of resources. Archives that do not manage data/information effectively over time are of little value to the DM community.

Quality: Value of information as represented in the context of user requirements. Quality refers to the data/information accuracy and precision, as well as the adequacy of crucial metadata describing the data or information set. (In a related arena, uncertainty refers to the confidence level associated with a warning or a product of prediction analysis.) GPSs have significantly improved the quality and utility of data by providing enhanced geospatial reference for use in GISs, models, and other analysis tools. Finally, an important attribute of data quality is its heritage, which relates directly back to its documentation.

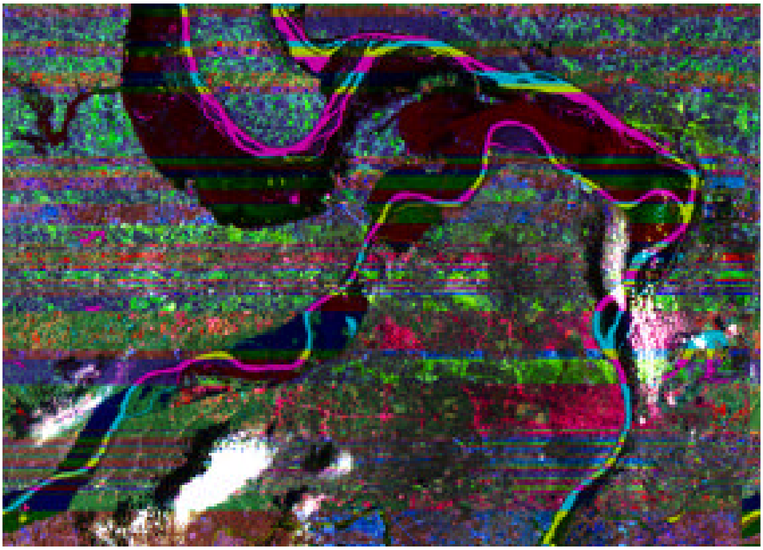
This increasingly complex suite of capabilities is technologically feasible and ready for exploitation by the provider to meet the needs of the DM community.

Information Generation

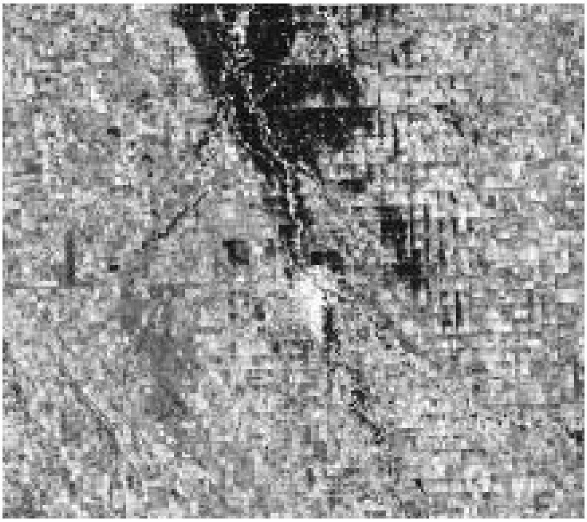
Federal, state, local, and private sector DM information users are amassing a variety of data types with differing formats and accuracy. In addition, new types of sensors are being developed, an increasing number of products are derived from classified sources, and improved hardware and software are coming into operational use. These advances, along with new integration and communication techniques, create new information-sharing opportunities during all phases of disaster support.

Data Acquisition. Data sources that are available to the disaster manager today include remotely sensed imagery, digital maps, and ancillary data (e.g., analog maps, graphs, census data, field reports). Imagery is an extremely powerful information tool, and its use is being demonstrated throughout a growing range of environmental support initiatives. Probably the two most widely recognized remote sensing capabilities that are used in support of disaster management are multispectral scanners and radar collection systems. The advantage of multispectral sensors is that they provide information from a variety of selective bands within the electromagnetic spectrum. This allows for the discrimination between feature types and is therefore useful for classifying various land and sea surface types. Products such as the Thematic Mapper and RADARSAT provide response and recovery teams with information on the extent of a disaster; they are also useful products for updating baseline information during the mitigation and preparedness phases. Radar tends to complement multispectral data by providing crisp representations of topography and drainage patterns and has a day-night, all-weather capability.

Digital maps are derived from a combination of imagery, hardcopy maps, and field surveys. They are available in many forms (e.g., terrain, feature, land use types) for various locations of the world at varying scales. Other ancillary data types that benefit the disaster management community include stream gauge data, meteorological/climactic data, seismic readings, and census data. A challenge, therefore, to analysts using these various data types is not only determining which combination of these data types are available for their area of interest but deciding how they also might be best used.



Landsat Thematic Mapper change image of the St. Louis area indicating the effects of flooding along the Mississippi, Missouri, and Illinois Rivers during the summer of 1993.



RADARSAT image of the extent of flooding in Grand Forks, ND, during the 1997 Red River floods.

The selective fusion of data sources allows for the generation of very sophisticated actionable information (i.e., information that the user community can use to make informed decisions). Advances in other sensor types are also taking place, from microwave through thermal infrared; these sensors can be used to further support the varied requirements during both pre- and post-disaster phases.

Analysis. The key exploitation methodologies and resulting information products that provide support to emergency managers are image generation, data fusion/integration, GIS-derived product generation, and modeling and simulation. Each of the following techniques normally requires specialists in the fields of photogrammetry, imagery interpretation, computer science, and GISs. A number of publications and curricula specialize in these areas of expertise.

Image generation. Once the imagery data have been collected, there are a number of additional steps needed to produce a product of use to the DM community. The collected data will need to be preprocessed, classified, field controlled, and checked for accuracy (Campbell, 1996). In most cases these procedures will be performed by an intermediary who is trained in image processing, not the disaster manager. The disaster managers should be aware, however, of the quality and reliability of all source information under their purview.

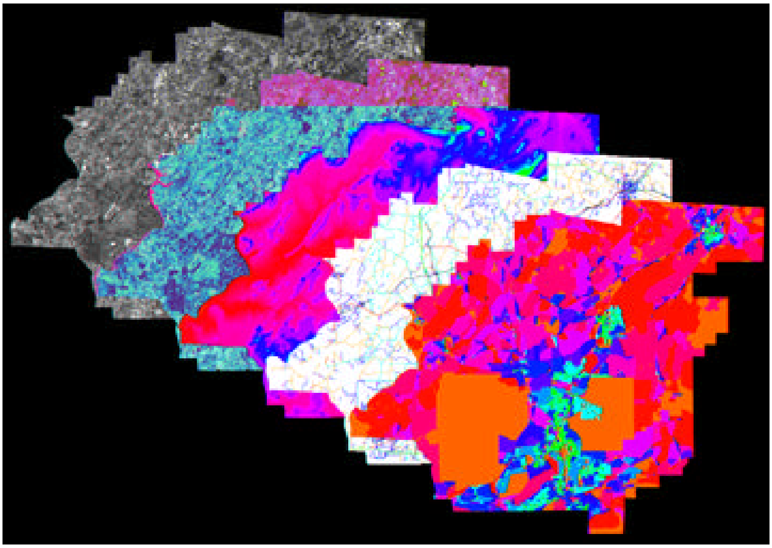
Data fusion/integration. Normally no one source of information will meet the needs of the disaster manager. Individual images or elements of information often become much more meaningful when carefully combined with complementary data types. The fusion/integration of disparate information sources provides a disaster manager with a richer data set from which to create tailored products. Again, these are fairly sophisticated methodologies, many of which are still in their infancy, so a technically trained intermediary is needed to create these fused products.

Geographic Information System (GIS). The GIS is one of the most important tools available to the disaster manager. The growth in geotechnologies has spurred the creation of GIS-based data sources, along with structures and standards that make relevant data more useful across the entire spectrum of GIS applications. GIS data sets naturally lend themselves to disaster reduction efforts. With a GIS infrastructure in place, additional disaster-specific information can be used in making informed decisions to help reduce the loss of life and property.

Pre-event information assembly activities—database development, automated analysis techniques, model incorporation, and system testing—are crucial to the success of disaster relief efforts. Field survey data can be combined with imagery and GPS technologies to yield information that can be produced in GIS-ready formats for use in disaster mitigation. Disaster relief workers and the private sector (e.g., insurance adjusters) could use these GIS information products in the post-disaster recovery phase, replacing the current paper-and-clipboard approach.

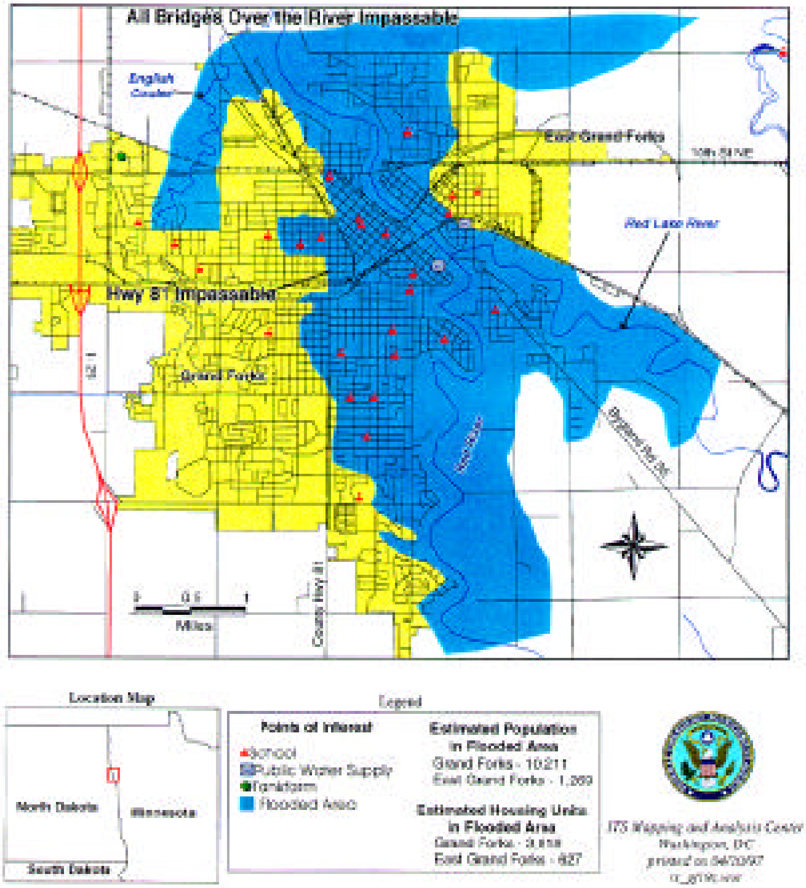
As shown below, data layers from various sources can be combined within a GIS environment to generate disaster support information. In this example a population density map is created to help planners and resource managers efficiently determine evacuation routes, calculate response times, predict resource distribution, and produce other tailored products for disaster management use.

Different layers of GIS information from Calhoun County, AL.



Derived Products. Products derived from National Technical Means often offer unique solutions to disaster information requirements. Derived products contain unclassified imagery and map products that have been derived from national systems. The intelligence community could provide various derived products to aid in both the pre- and post-disaster phases. Typically, NTM products supplement other sources through their ability to provide information in a timely manner, to provide data collected over hard-to-access areas, and to support detailed analyses (large-scale information).

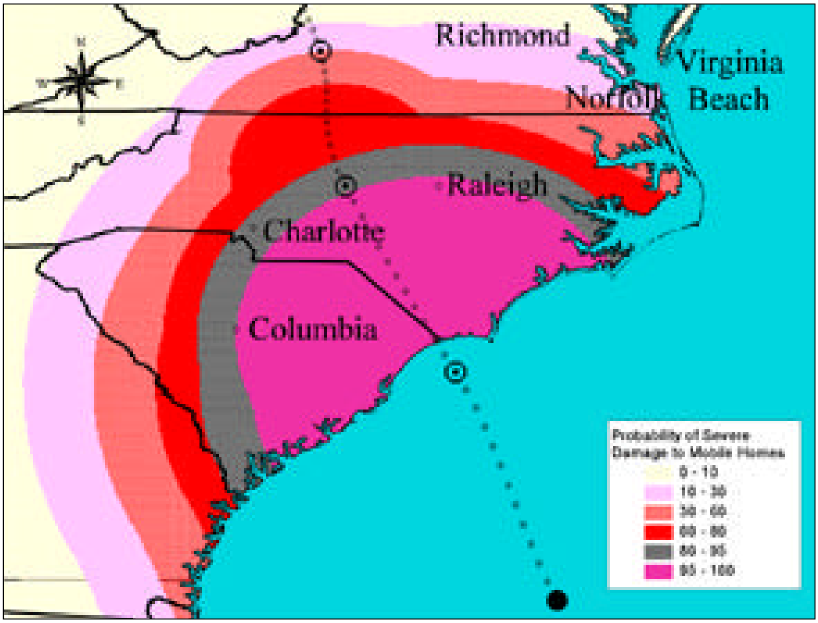
The Imagery Derived Products (IDP) program provides a mechanism by which civilian agencies can acquire derived products. Currently, all derived products for the IDP program are generated at the U.S. Geological Survey's Advanced Systems Center (USGS/ASC). The program provides semiautomated techniques and capabilities for civilian agencies'derived products. All derived product techniques and usage in this program must have prior NIMAreview and approval before dissemination in unclassified format.



Sample product derived from classified data showing the 1997 flooding near Grand Forks, ND.

Modeling and Simulation. Once an appropriate baseline data set is assembled, analysis can be performed for different disaster types. Combining digital products like FEMA's Q3 Flood Rate maps (modeled floods), USFS fire threat and drought data, and NOAA's storm surge models (or the same product updated with current infrastructure information) can delineate at-risk areas. These analyses can yield potential threat maps for different disaster types such as population and infrastructure susceptibility, dangers to aquatic and terrestrial ecosystems, and potential hazardous material effects. This process can be enhanced using expert systems. Such analyses could identify areas that should be rezoned or regulated because of their susceptibility to different disaster types.

Field simulation of communications equipment and GIS product generation under different disaster types and scenarios could aid future system development. Such simulations would also help disaster workers become more proficient and confident in using the GIS and other capabilities so that the whole system works smoothly in an actual disaster event. A sample of model output from the FEMA-sponsored Consequences Assessment Tool Set (CATS) is shown below. Under continual development and upgrade by the Defense Special Weapons Agency (DSWA) and in operation at FEMA and other Federal and state agencies, CATS estimates the potential impact from a threatening hurricane on population, facilities, and infrastructure.



Use of CATS to determine the probability of structural damage to mobile homes on approach of Hurricane Fran. Image courtesy of SAIC

Baseline and Information Products

The following is an example listing of the basic information and products of relevance to the DM community that can be generated using image processing and GIS techniques. The first category, Pre-Event, is a list of baseline information that provides the foundation for what is needed, particularly during the mitigation and preparation phases of the disaster management life cycle. The second category, Post-Event, is a partial list of tailored information products that are more useful during the response and recovery phases. As data sources evolve, the accuracy and detail of products will continue to improve. However, the management of such data will require that resident imagery analysts and GIS managers stay abreast of advances in exploitation methodologies.

PRE-EVENT
Baseline Data and Information: Coastal bathymetry, topography, soil types, vegetation types, housing and public infrastructure (including roads and bridges), land use/land cover, hydrology, atmospheric parameters (temperature, wind, humidity)

Disaster-Specific Data and Information: Earthquake/landslide activities; volcanic activity; ice thickness; coastal erosion; vegetative stress; soil moisture; cloud cover, height, and composition; snowpack

POST-EVENT
Hazardous spills (water and soil), flood inundation mapping, wildfires, fire incident and operations management, earthquake and landslide, debris accumulation, volcanic eruptions, volcanic ash cloud tracking, lightning detection, tsunamis, severe storms (hurricanes, floods, tornadoes, blizzards)

Recent Changes

As previously mentioned, a fundamental change in the disaster information paradigm is occurring, fueled by technological innovations. One of the fundamental characteristics of that paradigm is the greater dependency on information sharing, supported through communication systems such as the Internet. But this information revolution is still in its infancy, foretelling opportunities that will improve our nation's ability to mitigate the impacts of natural disasters. Through the encouragement of broader collaboration among participants, in conjunction with the incorporation of new technologies into information-handling processes, the positive benefits can help to buffer the difficulties organizations experience in adapting to these new challenges. Some of the fundamental challenges facing the provider community are summarized below.

New data sources. Providers can draw upon a growing array of space, airborne, and *in situ* instrumentation to measure terrestrial conditions and monitor a disaster event. Unmanned Aerial Vehicles (UAVs) are being evaluated to support collection of data under precarious conditions. Emerging technologies such as IFSAR enable the measurement of terrain details to millimeter levels of accuracy, with the added advantage of cloud penetration and day or night observation. Spaceborne hyperspectral instrumentation will enable scientists to examine a highly sophisticated spectral profile of surface feature to more fully characterize its condition. The selective use of derived products will provide added value to an expanded user community.

Improved tool set. There continue to be significant developments in the various techniques used to exploit data for the creation of disaster-related information products. Examples include: further advancement of GIS technology to provide both a platform for integrated display of a variety of geographic data and a means for manipulating data layers to explore alternative scenarios; formalization of image conditioning and exploitation techniques in user-friendly interfaces to provide access to complex algorithms formerly the domain of proprietary systems and experts; ongoing development of modeling and simulation tools that enable users to examine alternative scenarios and visualize the impacts of decision alternatives; and availability of more powerful computer platforms and visualization engines supporting the expanding need for manipulation of complex media.

Network technology. Buoyed by the advancement of electronic publication technology such as the WWW, the Internet has become an important vehicle for data sharing, information dissemination, and public awareness. Broadcast technologies are enabling capabilities such as the Emergency Management Weather Information Network (EMWIN), while NOAA Weatherwire relies on two-way satellite-based communications.

Increasingly restricted information is conveyed through protected channels. The ERLink system, managed by the Office of the Manager, National Communications System (OMNCS), uses password protection; Intelnet provides a data communication channel for classified materials; and KG-75 FASTLANE technology enables multi-level network operation. E-mail provides connectivity for individuals over great distances, and the Emergency Information Infrastructure Partnership (EIIP) employs networked-based collaboration tools specifically to increase dialog among those involved in disaster management. These technologies, which change the way information is created and distributed, demand increased bandwidth. ATM and satellite communications constellations of the future will offer a technological pathway to satisfy this growing demand.

Providers. The provider community is transforming as industry organizes to meet the challenges of new opportunities. Regional disaster information centers such as the Pacific Disaster Center (PDC), Alaska Volcano Center (AVC), and the proposed Western Disaster Center (WDC) have been formed to support the integration of information requirements and coordination of response to regional information. National exploitation centers such as the USGS-sponsored National Civil Application Program (NCAP) are designed to support integration of classified data sets. The National Imagery and Mapping Agency (NIMA) now provides classified imagery for disaster applications.

Users. The availability of advanced disaster information products has demanded that the user community become increasingly sophisticated and knowledgeable about new technological applications. This results in two expectations on the part of users. The first is that appropriate tools will be at their disposal to locate, acquire, and integrate information they need. The second is that providers meet more sophisticated demands for information; including better quality data and information products, models, predictions, and forecasts. The user expects to receive insights from the provider community on new ways to improve DM effectiveness.

Next Steps

In order to meet the ultimate objective of an improved capability in times of disaster, provider methodologies must be integrated into the DM life cycle. Providers must be responsive to needs of the DM community and effectively use dissemination community capabilities. They must accomplish their objectives using complex data sources, exploitation tools, and communication capabilities. As the DM community becomes more sophisticated and has increased access to improved technologies, it is demanding more and better products from the information provider.

Furnishing new information products by exploiting multiple measurement assets in response to user needs is a key challenge to the provider community. A pivotal need is for an effective operational infrastructure to enable information sharing within cost constraints. This requires that the user know what data are available and can access and use it. Also, the provider must be able to furnish data/information products in a timely manner and, when appropriate, at the point-of-action. The provider community must ensure that the data/information is disseminated in a usable format. Customer satisfaction becomes a true measure of success, ensuring that the operational requirements are met.

To be most effective, the provider community must ensure that policies are in place to facilitate data/information sharing. Access to after-action reports, such as that produced for the Miller's Reach fire, will help the provider identify DM community requirements and also foster an environment of teaming and collaboration.

Identifying information deficiencies and making logical recommendations for overcoming them become a joint objective. It must also be recognized that this teaming must occur between Federal, state, and local experts and practitioners. Finally, establishing an effective integration of relevant research results into operational environments will cause both the user and provider communities to continually improve through the capture of new capabilities and technologies.

The collective action of various providers will ensure proper response to DM information needs. Such interaction is driven by the necessity to work as a team in a disaster event and by the fact that technological innovations force interdependencies. Today's disaster information management paradigm requires cooperation by providers. This occurs through developing common standards to facilitate data sharing; creating product catalogs, metadata, and software tool sets; collaborating on improved data integration technologies and expert systems for data search and retrieval; and using network-based collaboration and communication mechanisms. The key role of the GDIN is to stimulate, encourage, and support interagency and international cooperation to benefit the disaster management user community.

Chapter 4

Disaster Information Infrastructure

A complete information infrastructure is composed of three essential elements: knowledge, interconnectivity, and integration. The next-generation disaster information infrastructure can exploit new technologies to advance in all areas. However, its architects must focus on its integration infrastructure to ensure that it serves the needs of all stakeholders.

In a message to the Gatlinburg Symposium in May 1988, then Senator Gore wrote, "Those responsible for emergency management learned long ago that their performance in such times of duress often was contingent upon being able to deal with critical and useful information, which in turn was dependent upon communication between key analysts utilizing the best 'systems' available including those drawing upon computer and communications technologies" (Chartrand and Chartrand, 1989). The benefits of improved severe weather warning systems are strong evidence supporting this assertion. These systems depend on an array of sophisticated measurement capabilities deployed on the ground, in the air, and in space. Moreover, they require an information infrastructure to acquire, organize, distribute, and analyze the data and then to disseminate the results of analysis to the appropriate disaster managers. These managers depend on the infrastructure to instruct their support teams on necessary courses of action and to broadcast necessary details and advisories to the affected general public.

Today, the public is informed of weather and severe storm events through postings on the Internet, visually illustrated with storm track graphics and synoptic images taken from space; television advisories of weather developments; newspaper coverage of local, national, and worldwide events; and siren alarms alerting communities to the immediate danger of severe weather. At the same time, the supporting scientific infrastructure relies on computer technology to operate the models that perform the predictions, forecasts, and impact analyses and to communicate these in various ways.

The 1988 Gatlinburg symposium was an opportunity to examine emerging information technologies recognized in an earlier report submitted to Congress by then Congressman Gore entitled "Information Technology for Emergency Management" (U.S. Congress, 1984). This study envisioned an era when tools in the hands of the emergency manager could profoundly impact our nation's ability to save lives and reduce the cost of disasters. This study was aware of the potential for a new communication system called the Internet. But the World Wide Web was still in the future, and the Asynchronous Transfer Mode was a matter of laboratory research and experimentation.

In 1988, important parts of the technology base were still immature. Today the technology base is available to support a robust disaster information infrastructure. The figure in the Overview (page 1) illustrates the exponential growth in the availability of network-connected computers, of bandwidth for communications, and of earth observation systems measuring and monitoring environmental parameters and events. These three technologies are representative but not sufficient to fully address disaster management needs. However, developments are equally profound in other critical technologies such as high-performance computing, geographic information systems, decision support systems, geolocation systems, and ground-based measurement systems.

Today our technological base is placing beneficial and affordable tools in the hands of the disaster manager as envisioned at Gatlinburg. A disaster information infrastructure is indeed emerging. Here, we explore this phenomenon in order to assess its proper evolutionary path and to ensure it is used to maximum advantage. We begin by establishing the following conceptual framework drawing upon the work of Brian Kahin (Kahin, 1993). Three essential elements of a complete information infrastructure include the knowledge infrastructure, the interconnectivity infrastructure, and the integration infrastructure.

Knowledge Infrastructure: Encompasses the systems of measurement, methods of data visualization and exploitation, information analysis, event forecasting, knowledge modeling, and data and information management. These are often the purview of the information providers. In Chapter 3, we learned of the dramatic development of a broad-based provider community to form information products suitable to the needs of the DM community.

Interconnectivity Infrastructure: Encompasses the modes of communication employed to retrieve and distribute data, and to disseminate the information products, knowledge, and understanding developed within the knowledge infrastructure. In this chapter, we will examine DM modes of communication and explore advances that can aid in achieving a more robust disaster information infrastructure.

Integration Infrastructure: Encompasses the processes needed to ensure that the “mechanical” parts of the system are synchronized and that the “human” parts of the system are cooperating. Often ignored, or at best taken for granted, the integration infrastructure is key to an effective overall information infrastructure. The integration infrastructure addresses (1) the tracking of system performance to user requirements; (2) the definition of standards and protocols necessary to ensure system interfaces are understood; (3) the methods, processes, and procedures to ensure quality and reliability of the knowledge base; and (4) the training needed to ensure users can effectively use the system.

The architectural details of any information infrastructure are dependent on its application. The efficiency of any application-specific information system depends on its integration infrastructure. For example, the success of the Internet is often attributed to its standards—those predetermined, such as TCP/IP and FTP, or evolving, such as the WWW. A fundamental thesis of this report is that significant advantages will accrue to the DM community if investment is made in the "integration infrastructure" of a disaster information network as its knowledge and interconnectivity infrastructure evolve.

Information technology opportunities today are providing new ways for disaster managers to address needs. In *Computing and Communications in the Extreme* (1996), the National Research Council recognized the opportunity and need to address crisis management and called for the establishment of crisis management test beds. As valuable as this would be in many respects, disaster managers are not waiting for a scholarly assessment.

The establishment in the past decade of the broad national network of Federal, state, and local (public and private) information providers is a clear indication of our nation's ability to respond to the needs of disaster managers with innovative information products. This development places new pressure on our national information infrastructure, which supports the transfer of vital disaster-related information (along with commerce, scientific research, entertainment, etc.), but which was not designed specifically for this purpose. It is neither optimized nor tuned to the needs of DM. This raises questions. How should disaster managers, scientists, and analysts access complex measurement data to assess a situation in time of crisis or otherwise develop contingency and mitigation plans? How can delivery of information be assured through robust channels? What is the best way for the community to share new knowledge about forecasting and prediction methods? What is the most effective and efficient manner to convey best practices and lessons learned? How do we most effectively take advantage of newly unclassified data? And how can the growing community of information providers best collaborate?

In many respects, tremendous progress in developing a disaster information infrastructure has been made since the Gatlinburg Symposium.

Space remote-sensing assets—public and private, classified and unclassified—are routinely applied in DM applications. Communications technologies of every mode are exploited to deliver information to scientists, disaster managers, and the general public. Information providers are responding in growing numbers to user demands for understandable information products derived from increasingly complex sources. A disaster information infrastructure is indeed emerging. At this time, what is the best course of action needed to ensure a system that is responsive to the needs of DM?

Information Infrastructure Needs by Disaster Phase

Throughout this report, the comprehensive DM cycle has been characterized as being composed of four overlapping phases: mitigation, preparedness, response, and recovery. A disaster-related information infrastructure needs to provide balanced support to each phase of activity. Each phase imposes unique requirements on the infrastructure, since data needs change according to the disaster phase and people involved. The preparation and response phases are characterized by high timeliness and reliability needs along with highly variable volume. Mitigation and recovery phases have less urgent delivery needs and a broader audience (e.g., government, academics, builders, insurers) but often cannot accommodate long delays. In its current state of evolution, the information infrastructure has been employed primarily for purposes of preparation and recovery, though other uses are evident. For example, the scientific community increasingly relies on the Internet for access to data and scientific collaboration supporting mitigation efforts. The requirements peculiar to each phase of disaster management and the implications to information systems and components employed are discussed below.

Mitigation Phase. Mitigation activities are pervasive both during and between times of crisis. They encompass activities necessary to reduce the impacts of disasters when they occur—such as the development and promulgation of zoning ordinances and building codes—and create the critical baseline data, analysis, and modeling capability needed to prepare for, respond to, and recover from a disaster event. The scientific community, business community, DM community, and disaster information provider community share in mitigation responsibilities. For the most part, however, these activities are not time critical but do impose other burdens on an information infrastructure.

Networking requirements to support the mitigation phase have key attributes, including the need to move large quantities of data/information, broad connectivity among a diverse group of organizations, and, in contrast to response and recovery, timeliness is generally not critical. Much of the data is GIS-based risk assessment, claims history, facility/resource identification, land use/zoning, and building code information. Use of modeling/prediction tools for trend and risk analysis is important. The data are largely archive-based, so several cataloged and linked repositories offered through good search engines or directory systems should permit better access by distributed users. Data providers are responsible for data quality (timeliness and accuracy), limiting redundancy, and updating catalog/directory information.

Preparedness Phase. Preparedness activities range from development of community training and logistical support, supply, and resource systems needed for disaster response to early warning and monitoring activities preceding disasters such as hurricanes, tornadoes, tsunamis, fires, or volcanic eruptions.

Network distribution of warning data during the preparedness phase is intense, and timeliness becomes a critical factor for some types of information dissemination. Public awareness through broadcast announcements and access to disaster web pages is key. Distance learning and other training activities making use of interactive video also fit into this category. Although disaster prediction accuracy and warning lead-times are improving, storm and earthquake alerts still require wide distribution in minutes or seconds. In remote areas, for example, full national coverage is a concern being addressed for the NOAA Weather Radio system.

Response Phase. Response to disaster events is time critical. Logistical options, damage surveys, baseline maps, equipment, human resources, and funds all need to be accessible. Communications among response teams and to the general public become critical.

Rapid, reliable, configurable, controlled-access communication is vital to efficient disaster response operations. Major challenges are presented by extreme conditions of facility destruction, traffic peaks, mobile users, and sensitive data. Intense management of property and casualty status, resource information, and response priorities require special access capabilities beyond normal commercial telephone/ Internet services. The Government Emergency Telecommunications Service (GETS) and Cellular Priority Access System (CPAS) from the National Communications System, Government and commercial "fly-away" systems, and private communication organizations address many of these needs, but incompatibility, cost, and complexity are widespread concerns.

Government Emergency Telecommunications System

Today's technology, coupled with the current worldwide political climate, has made our public telecommunications systems more vulnerable to disruption by disasters. GETS is an integrated service and a cost-effective means to allow emergency officials to obtain priority access to telephone dial tone during everyday usage, an emergency, crisis, or war. GETS is managed by the Office of the Manager, National Communications System (OMNCS), to satisfy National Information Infrastructure (NII) and disaster information infrastructure needs.

GETS uses the major long-distance, local, and Government-leased networks to provide service. GETS interoperates with other Government-leased services to include the Federal Telecommunications Service (FTS-2000), the Defense Switched Network (DSN), and the Diplomatic Telecommunications Service (DTS). GETS is accessed through a simple dialing plan and a personal identification number. (http://www.gtefsd.com/gets.html)

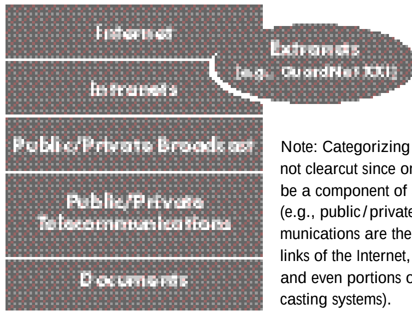
Recovery Phase. The data needs during recovery include significant onsite data collection related to rebuilding, claims processing, and documentation of lessons learned. Feedback on the mitigation process and historical databases is important to prevent the same mistakes in the future. Timeliness concerns are relaxed in favor of efficiency, and the Internet is often ideal for such transfers.

The Internet is suitable for support to the recovery and mitigation phases, but urgent and life-critical communications during the preparation and response phases call for more robust systems. Currently, this need is being met by telecommunications providers who provide limited quick-response, mobile systems (portable satellite communications, wireless systems, cellular office on wheels, etc.) during emergencies. Much progress has been made in strengthening existing communication networks to survive catastrophes, but on-call recovery capabilities will continue to be important.

Clearly, system needs for access, privacy, and bandwidth vary among disaster phases. Today's disaster information infrastructure offers an eclectic mix of component technologies to respond to diverse requirements. Systems like the Internet are increasingly employed for purposes of mitigation, preparation, and recovery. Public and private telecommunications provide for quick response and real-time communication needs. Creative applications of broadcast technologies are being explored for warning and advisory systems.

Modes of Communication

Communication plays a vital role in transferring information between sensors, experts, archives, models, and key decision-makers involved in DM. As technology changes and disaster applications evolve, information distribution methods need to adapt. Here, we discuss five modes of communication that support the interconnectivity infrastructure for disaster information management; these are shown in the figure below. The design of an information infrastructure supporting comprehensive disaster management must weigh the relative merits of each mode in satisfying its specific requirements. The characteristics of each mode are described in this context. It is noted that while these are logical building blocks they are physically interwoven. For example, the physical manifestation of an "internet" depends on the public and private telecommunications. However, fax, phone, and pager technologies—all part of telecommunications mode—are useful alternatives because they conform to different sets of standards and provide different functionality. Today's incipient disaster-related information infrastructure relies in part on all these modes of communication; the future infrastructure, however, will need to address shortcomings present in its current manifestation.



Note: Categorizing networks is not clearcut since one form may be a component of another (e.g., public/private telecommunications are the internal links of the Internet, intranets, and even portions of broadcasting systems).

The five basic modes for disseminating disaster information.

Internet. The Internet is a global network of networks enabling computers of all kinds to directly and transparently communicate and share services throughout much of the world. It constitutes a shared global resource of information, knowledge, and means of collaboration among countless diverse communities. The Internet evolved from the DoD ARPANET project in the late 1960s and later research investments of the National Science Foundation. The Internet consists of more than one million network domains in more than 90 countries. Gateways that allow at least e-mail connectivity extend this reach to 160 countries. From its start in the late 1960s, the Internet has grown from 235 connected hosts to more than 20 million computers with an estimated total of over 100 million users. Network growth continues at around 10 percent per month. Data passing through the major network access points and metropolitan area exchanges exceed 700 terabytes of Internet traffic per month.

The most common Internet services are file transfer, WWW, e-mail, and remote computer access. Other popular services include information discovery services, real-time written interactions, audio and video conferencing, directory services to discover the addresses of people, or even multicasting of audio and video programs such as Internet Talk. Key characteristics include:

Decentralized: Very loose coordination among government, private sector, and academic organizations to develop standards and manage operations. No control of content or organization; anyone can publish what they want.

Widely Deployed: Other than the telephone and TV/radio broadcasts, the Internet is available to more people than most other means of information delivery.

Best Effort Delivery: If bandwidth and end system capacity is available, delivery is made, but congestion and route failures can cause losses.

Local Control/Global Knowledge: Subject-matter experts have control over posting data; it is then available for access by a worldwide audience.

Limited Timeliness Guarantee: Current protocols do not prioritize traffic or reserve bandwidth; thus, data may be delayed due to congestion.

No Inherent Security: Access control, authentication, data integrity, and confidentiality are added as needed.

Vulnerable to (Last Mile) Disruption: While routing around network link failures is automatic, the final connection to end systems is often a single point of failure.

Intranet. An intranet is a segregated community of network nodes with strictly controlled access, typically managed by a single organization. Access to and from the Internet is provided through security firewalls. It may also be called a virtual private network (VPN). Key characteristics include:

Strict Control of Access: Usually only members of the owning organization can have access. Internally, this occurs using userids and passwords. Firewalls limit external access to only specific subnets, protocols, and applications.

Traffic Management: Since users are all from one entity, large traffic peaks can be identified and controlled more easily.

Security: Optional encryption prevents eavesdropping.

Wider Bandwidth: At a price, the net is scalable and the expeditious handling of large files on demand is enabled.

Robustness: If required, the net can be made resistant to interruption.

Extranet. An extranet is a specialized form of intranet that allows cross-organizational communications such as between a manufacturer and its suppliers. Access control may be at a finer resolution (i.e., at the directory, file, or record level). As discussed later, this type of network is highly suited to needs of the diverse DM community.

Wireless Broadcast. Broadcast includes mass media (TV, cable services [CATV], and radio) and special-purpose information systems (NOAA weather radio, EMWIN, etc.). Key characteristics include:

Broad Coverage: Warnings through public/private alert system can reach the vast majority of citizens nationwide and worldwide.

One-Way Transmission: Broadcast media are not interactive (video conferencing is considered below).

Often Wider Bandwidth.

Existing Disaster Information Broadcast Initiatives

EENET (Emergency Education Network): A satellite-based distance learning system utilized by FEMA to bring interactive training programs into virtually any community nationwide. All programming is open and is in the public domain so that any community with access to a C-band or Ku-band satellite dish, or community cablevision provider, can receive the broadcast and participate in the training programs.

CATV (Cable TV): Provide a major broadcast venue for populations at risk. The advent and proliferation of high-bandwidth cable modems, value-added services such as WebTV, and low-cost network computers suggest the cable industry as a primary information disseminator of warnings and public information for the foreseeable future.

EAS (Emergency Alert System): Follow-on to the Emergency Broadcast System (EBS); uses commercial broadcast stations to send alerts and warnings.

EMWIN (Emergency Managers Weather Information Network): A system for broadcasting a live datastream of basic weather data and providing access to stored sets of basic data for EM. EMWIN's multilayered approach disseminates the basic datastream by radio, Internet, and satellite (currently GOES 8, GOES 9, and Galaxy 4).

JBS (Joint Broadcast System): A DoD joint broadcast satellite system used to support U.S. and NATO forces in Bosnia. Traffic includes live, compressed video, imagery, intelligence reports, maps, and weather data uplinked from a central site in Washington. Receiver equipment consists of a 1m dish, a slightly modified commercial satellite TV receiver, a router, MPEG2 card, and KG94 encryptor.

Fixed Telecommunications. Fixed telecommunications include commercial and government voice, video, and data networks using cable, circuit, and packet switching. Key characteristics include:

Limited Priority Calling: GETS/TSP gives precedence for authorized priority users (military systems allow preemption of lower priority callers).

Dedicated Use Circuits: Give privacy, but do not permit cost sharing. Usually flat rate, distance-sensitive pricing.

Variable Bandwidth: Available at a price.

Documents. These include printed material, physical media (tape, floppy disks, video, etc.). Key characteristics are:

Archival Features: Information can be retained indefinitely.

Slow Delivery: Need to transport physically makes updates difficult.

Laborious to Catalog/Retrieve: Mostly sequential access and usually no on-line index.

High Capacity: Variable-volume, high-capacity media have historically been transmitted this way.

Precisely Tailored Content: Material can be focused and designed by author to meet the needs of the audience.

Capable of Reaching Large Audiences: One of the most common mechanisms for broad distribution (e.g., mass mailings, libraries, retail stores).

The interconnectivity infrastructure consists of much more than communication circuits and network hardware. Information search and browse tools, directory services, intelligent agents, and other emerging Web services are all part of matching a user's information need with a provider's data resource. Full integration among data organization, definitions, formats, and access tools is critical to efficiently making this match.

When comparing the features of the modes with the needs of providers and users of DM information, one finds that certain modes are better suited to particular scenarios and the needs of the specific disaster phase in question. For example, a researcher studying insurance claims records for recovery functions may need to plot data, layered on a dozen high-resolution images. If time is not critical and the images are over 100 MB each, transfer by 8mm tape (document) may be best because of its large capacity and archival features. But the best use of analytic expertise may be via video conferencing, which dictates use of real-time, high-bandwidth systems. On the other hand, tornado or earthquake warnings generally need lower bandwidth and wide distribution in a short time. Both broadcast and fixed telecommunications (mainly telephones) provide wide coverage, but telephones are obviously unsuitable for rapid, mass warnings. Some key characteristics of the five categories are presented in the following table.

	Document	Internet	Intranet	Wireless Broadcast	Fixed Telecommunications
Security	Strong	Limited	Strong	Limited	Limited
Congestion Control	N/A	Limited	Strong	Strong	GETS
Connectivity	N/A	Large	Controlled	Variable	Large
Bandwidth	Large	Shared	Medium to Large	Variable	Get What You Pay For
Cost	Low	Basic	Scalable Medium to High	Inexpensive	Scalable
U.S. Coverage	50–90%	20%	<1%	95%	95%
Reliability	High	Moderate	High	High	High
Interactivity	None	High	High	None	Limited

A comparison of the features of the five basic modes for disseminating disaster informtion.

Each of the five modes of dissemination has different strengths and weaknesses. These modes complement one another. This suggests a communications suite would provide the overall capabilities needed. Internet offers high interactivity and high connectivity at basic cost. Intranets offers high interactivity and bandwidth for a price. Printed materials provide large bandwidth, high coverage at low cost. Other factors such as ease of storage and multilingual facility also play a role in the information infrastructure.

Future of the Disaster Information Infrastructure

Emergence of Multimedia Networks. In this decade, data networks have emerged as an important communications tool at the disposal of the DM community. For example, FEMA has developed a TCP/IP-based intranet using point-to-point telecommunications between its headquarters and 10 regional centers. This network is used to distribute disaster-related information products from Washington, DC, to regional centers, which then convey relevant data to field officers. Video teleconferencing among limited sets of users is growing. The Internet is increasingly used to broadly convey disaster-related information.

The Internet is noted for its openness, decentralization, limited security, informal collaboration, and open standards process. Recent dramatic growth in its use is attributed to the WWW. Long before the Internet grew to millions of computers, several significant shortfalls were identified such as address space, congestion, multicast, security, and quality of service limitations. Much of the preliminary work to define solutions is being done by Internet Engineering Task Force

(IETF) working groups. The Next Generation Internet (NGI) project known as Internet 2 (I2)—a consortium of more than100 government, commercial, and academic institutions—is working to develop and deploy nationally the essential elements of NGI.

Disaster-relevant Home Pages on the Web

Numerous examples of Internet-based disaster-related capabilities exist. The following illustrate use of Internet for collaboration and communication (EIIP), data referencing (NDRD), current disaster events (Disaster Central), and weather (NOAA Weather Page).

EIIP (Emergency Information Infrastructure Partnership): An emergency lane on the information highway. The EIIP is a virtual partnership forum administered by several emergency management associations. EIIP is designed to provide a vehicle to communicate among Federal, state, local, and tribal agencies, volunteers, research community, private sector, and emergency management organizations. The EIIP works through formal meetings, telephone conferencing, and Internet chat sessions on a variety of topics related to emergency management information systems. The EIIP's goals are achieved through work groups of emergency management community volunteers who represent specific programmatic and technical topics. (http://www.emforum.org)

NDRD (Natural Disaster Reference Database): The NDRD is a bibliographic database on research, programs, and results that relate to the use of satellite remote sensing for disaster mitigation. The NDRD was compiled and abstracted from published material generated since 1981. Major sources for the contents of this database were the NASA RECON and ISI Current Contents databases. This database focuses on nexus of hazards and satellite remote sensing as well as models and studies through which these can brought together. (http://ltpwww.gsfc.nasa.gov/ndrd)

Disaster Central. Disaster Central is a real-time weather and emergency information site associated with the National Building Protection Council—a Florida not-for-profit corporation that helps find reliable ways to protect against tragedies related to international events. (http://www.promit.com/discent.htm)

NOAA Weather Page. This site is an excellent starting point for gathering current weather information and locating weather-related organizations and data. (http://www.esdim.noaa.gov/weather_page.html)

Internet uses for disaster-related applications can be categorized as follows: (1) public information announcements, (2) scientific analysis and collaboration, (3) disaster management training, and, to a lesser degree, (4) real-time disaster event management. Most Federal agencies have a website, and many websites have an area that deals with disaster functions and related data (several examples are highlighted in the box above). Additionally, hundreds of independent organizations are involved in disaster operations, weather and seismic data, DM research, and remote sensing usage. Although several efforts have attempted to build a comprehensive disaster sites, there is much work to be done to organize information, maintain currency, and support peak demand.

Even a casual survey of disaster information on the WWW shows a vast diversity of types, sources, formats, and quality. While Web graphics, search engines, and "point-and-click" links are ubiquitous, they have not ensured logical organization and reliable access to information. One of the most pressing problems is how to determine the quality of data; some independent data providers could post data of dubious quality. Some form of certification or seal of approval for critical information providers may lead to better quality control. At this time, the reputation of the provider is the only measure of quality.

Issues/Shortfalls (Where Can Investment Best Provide Benefits?). The Internet, private intranets, broadcast, documentation, and telecommunication systems are all playing a role in today's disaster information infrastructure. With the continued advance of technology, the key is identifying where investments can make the greatest difference.

Network Reliability (Timeliness, Robustness). When major disaster events occur, certain Webservers familiar to the public will inevitably receive a very high demand for current information. This may overload the data network, the servers, and other components such as firewalls. While this congestion is a frustration to those trying to get status of weather, damaged areas, etc., it can be a critical hindrance for disaster response personnel if systems are not designed to prioritize access. Priority access to and transmission over the public network is a needed but unavailable capability. Reliable information access can be affected by other events such as power failures and link failures, so access to vital information needs to be redundant. This may be achieved through mirrored Websites, fault-tolerant systems, and dual-homed communications.

Network Scalability. The ideal network provides instant access to secure, huge-bandwidth channels with minimal latency, low-usage-based prices, and simple operations. Shared bandwidth should be sized to support mixed disaster support applications (data, fax, voice, video, email, etc.) required at each site (e.g., through the use of ATM technology). Common procedures to easily change the capacity of the network connection are desired.

Directory/Catalog of Resource. Today, a clearly significant challenge is not only whether there is enough data, but obtaining the right data from the wealth of sources available. Architecture for data organization is necessary to easily index and lookup research and sensor data, people, equipment, supplies, and supporting agencies. Directory services using X.500 and LDAP are coming into limited use, but innovative application in the DM arena is lacking.

Training. Complexity accentuates the need for regular and realistic training in the use of disaster information systems and the processing of the data into information useful for decision-making. Distance learning does occur through FEMA's EENET and is a proposed element of GuardNet XXI; however, access to training using the same network as for other information exchange may reduce costs and increase user familiarity, as would use of the same system during and between times of disasters. As more organizations train more personnel, the capacity of the entire response system will shift to a higher level of performance. The response system will be able to function more efficiently, more effectively, and more responsibly given the resources and time available in a specific disaster context.

Interoperability. A recurring lesson across the DM community is that users need the right data in the right place at the right time and in the right format. A limited set of transmission methods, data interchange formats, standard products, and symbology would ease this difficulty, as well as aid in data interpretation and correlation.

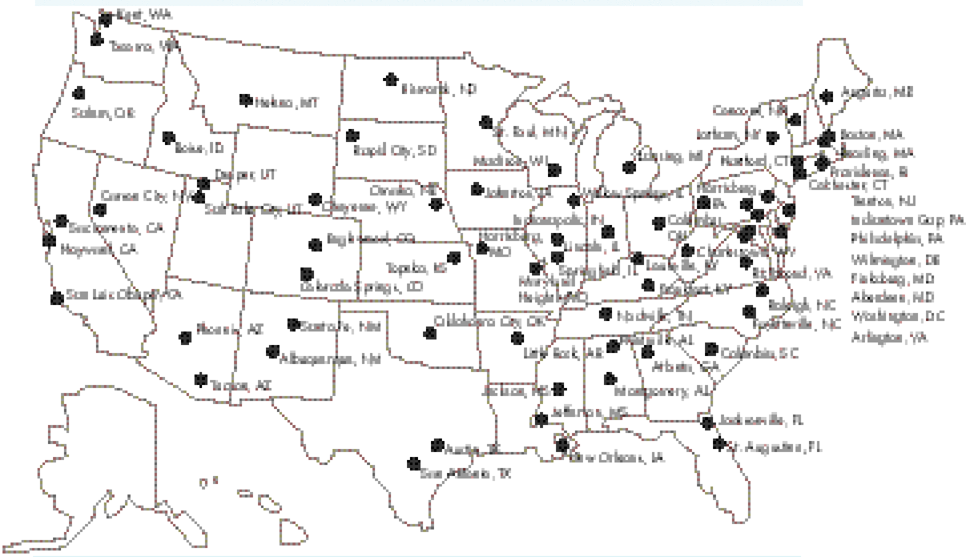
Privacy/Security. Some disaster information is very sensitive. Unconfirmed casualties or speculation on earthquake aftershocks are best protected from disclosure until officially released. Since such data is sensitive for only short periods, relatively low-grade cryptographic protection is adequate. Information covered by the Privacy Act of 1974 must also be protected. On data networks, privacy mechanisms must be matched with adequate authentication of users and access control methods to ensure one does not "lock the door and leave the window open."

Emerging Technology/Opportunities. Many exciting technology innovations are becoming available that have great potential for improving the use of information to save lives and reduce property damage. A wise balance must be struck between moving to the next technology and maintaining the state of training and interoperability among existing systems.

ATM/SONET. Asynchronous Transfer Mode/Synchronous Optical Network (ATM/SONET) is a core technology making enhanced network services feasible. ATM/SONET is the combination of cell-based switching and fiberoptic transmission technology that makes possible true global multimedia networks. Dynamic bandwidth allocation, extremely high switching and throughput speeds, and low, constant latency make mixed data, voice, and video applications economically sound and enable flexible use of bandwidth. Advanced encryption devices such as the KG-75 FASTLANE allow mixed security levels on the same circuits. There is a role for advanced networks to augment existing use of the Internet and private emergency warning systems. Over time, the merger of voice and data networks will decrease operating costs and provide improved resilience, but that has yet to be achieved. Participation in the NGI project to address the unique needs of the DM community is needed. GuardNet XXI is an illustration of an application of ATM/SONET.

GuardNet XXI—An Emerging Network

The Federal Government, and in particular the DoD, has made an enormous investment in broadband packet-switched ISDN (i.e., ATM) and SONET. The ATM infrastructure is capable of providing voice, video, and data in a cost-effective and guaranteed manner. GuardNet XXI is a National Guard virtual private network scheduled to be operating to all 50 states and to U.S. territories by December 1997. Remote training is one major application.



Locations of major ATM nodes on the GuardNet XXI system being installed by the National Guard.

GIS, Modeling, and Prediction Tools. Other exciting advances are occurring in decision support systems, including geographic information systems, modeling, and prediction systems. Modeling data and results are key components of information support to disaster managers. Weather models and risk analysis tools are making warning times better and more precise. Other DM tools are improving the ability to synthesize disaster information from multiple sources. Continued directed research in modeling, collaboration, and information fusion technology should be a priority.

Modeling and Prediction Tools

HAZUS (Hazards, U.S.) works by inputting data such as soil conditions, local geology, building stock, location, potential size of an earthquake, and economic data. In HAZUS, the input is manipulated to estimate potential losses. Eventually, flood hazard data will be imported into HAZUS so mitigation strategies can be identified for these hazards as well.

PCGRIDDS (Personal Computer-Based Gridded Interaction Display and Diagnostic System) is a software package for IBM-compatible PCs developed for use at U.S./NWS offices to support the World Area Forecast System (WAFS). NWS forecasters use it to examine computer model guidance. It includes macros useful in forecasting tornadic supercells. (http://www.noaa.gov.software/pc-gridds)

CATS (Consequences Assessment Tool Set) is a computer modeling and monitoring tool maintained by FEMA. It joins the latest communication, satellite, and weather-forecasting technologies with on-the-ground information including location of everything from vulnerable neighborhoods to potential biohazards. The system enables FEMA to predict the effect of impending disasters like hurricanes or floods and to quickly mobilize a well-coordinated and directed response after acute disasters like earthquakes. One of the most important potential advantages of being able to make accurate damage predictions is to encourage evacuation and to stage or pre-position necessary resources. (http://www.excelgov.org/inn96_20.htm)

Personal Communications Systems (PCS). Several consortiums are building worldwide systems to extend wireless communication for use anytime, anywhere at reasonable costs. Low-earth-orbit (LEO) satellite systems promise resilient voice and data service for a price that will greatly assist DM personnel working in remote and devastated areas. Higher LEO systems (big LEOs) will provide continuous coverage.

Collaboration Technologies. Electronic mail is a basic representative of a class of emerging computing technologies that support collaborative efforts. These capabilities, collectively referred to as collaboration technologies, enable dispersed project teams to coordinate their collective efforts. Shareable documents can be authored and edited.

Scientists can simultaneously review data using whiteboard software or desktop video applications. Conferences can be coordinated on-line. Training materials can be presented to students electronically.

> **Disaster Management Collaboration Initiatives**
>
> **IISIS** (Interactive Intelligent Spatial Information System): A decision support system currently under development at the University of Pittsburgh that integrates field data with stored knowledge using logical inference by the computer to produce likely consequences of planning and response actions. The system supports interorganizational learning among response organizations through a continuous process of updating information, thereby facilitating training and performance evaluation.
>
> **EPIX** (Emergency Preparedness Information Exchange): EPIX is operated by the Centre for Policy Research on Science and Technology (CPROST), Simon Fraser University, Vancouver, Canada. The purpose of EPIX is to facilitate the exchange of ideas and information among Canadian and international public and private sector organizations about the prevention of, preparation for, recovery from, and/or mitigation of risk associated with natural and sociotechnological disasters.
>
> **RIMS** (California's Response Information Management System): Coordinates and manages response to disasters and emergencies. It is a collaborative, distributed client/server system that electronically links the multiple levels of disaster management. RIMS automates the state's Standardized Emergency Management System (SEMS). RIMS is based on Lotus Notes/Domino and utilizes an intranet and the Internet for communications and interactive access at over 65 locations. RIMS applications include resource management, intelligence reporting, cost accounting, and a purchasing system. It uses various GISs to display interactive maps and photos and access geographical, political, and demographic information relevant to a disaster.

Directory Services. The growth of the Internet and the WWW has strained the ability of most users to locate and organize the vast data resources that are now a mouse click away. Just as a telephone operator cannot hope to rapidly find information manually, on-line resources need to be indexed and organized for automated access. With on-line data as the lifeblood of DM professionals, a standard method of indexing and accessing the location of data is vital. Recent developments in on-line versions of "white pages" and "411" directories have been encouraging. The Lightweight Directory Applications Protocol (LDAP) Initiative, in conjunction with the international X.500 directory standards, is on the verge of bringing a common system into general use.

Search Technologies

Intelligent Agents. Software agents are differentiated from other applications by their added dimensions of mobility, autonomy, and ability to interact independent of the user's presence. The additional element of intelligence requires the capability for adaptive reasoning. Access to knowledge will be transformed by information technology in general and specifically by intelligent agents. However, some users may only be satisfied to allow agents to carry out the boring and routine tasks, keeping important decisions within the domain of decision support systems with which people interact.

LDAP (Lightweight Directory Access Protocol) is an Internet Engineering Task Force (IETF) specification to retrieve and manage directory information. LDAP is, like X.500, both an information model and a protocol. The major difference is that LDAP is simpler and is designed to run over TCP/IP. X.500 defines a global directory structure much as the Hypertext Transfer Protocol (HTTP) and Hypertext Markup Language (HTML) define and implement the global hypertext web. An X.500 or LDAP client may peruse the global directory just as a web browser peruses the global Web. Additionally, with the help of X.500 gateways, a web browser can peruse both.

Next Steps

A disaster-related information infrastructure exists today. It comprises a collection of largely independent data systems and communication methods that have grown as a direct result of the DM community taking advantage of emerging information technology. In what direction should this nascent capability be steered? As we discuss the future of the infrastructure, certain design principles emerge that can guide us. The opening premise of this chapter asserted that the system's knowledge, interconnectivity, and integration infrastructure must be considered in an integrated architecture using modern technologies. New technologies offer opportunities to address shortcomings of current best practices and advance development of the appropriate information infrastructure. Any strategy to intervene should embrace those opportunities. This realization forms the first design principle of any envisioned next-generation information infrastructure: *build on the existing knowledge base and associated interconnectivity*.

We also recognize that the needs associated with each disaster phase vary in time from the point of view of security, bandwidth, reliability, and other system-related parameters. Each phase, however, depends on much of the same knowledge base and is often dependent on another phase to deliver needed baseline data and derived information. That knowledge base resides throughout the nation in public and private archives best suited to its management. The value of organizing the virtual knowledge base to benefit users working in all phases leads to the need to *integrate and organize information for all phases of disaster management.*

Development of a comprehensive knowledge base must be accomplished through recognizing that priorities vary from phase to phase based on urgency. It is not necessarily the case that a single mode of communication is optimal for all needs. An integrated virtual knowledge base will need to be interfaced with an assortment of communication options. The infrastructure must therefore *ensure connectivity is matched to needed information flow throughout the network.*

Today's disaster information infrastructure depends on certain technological systems, such as the Internet, that fall short of satisfying the broad spectrum of challenges associated with disaster information management, so it is critical that the next generation *incorporate provisions for capturing emerging technologies.*

Obstacles to the next-generation disaster information infrastructure are not technological. In fact, it is the technology itself that enables advances. But why intervene at all? Is there really a need to? Why not allow current momentum simply to carry us forward? The fundamental shortcoming of today's strategy is that it is not fully coordinated and is reliant on individual best practices alone. This strategy should not necessarily be frowned on, as individual creativity discovers new pathways. But only when individual best efforts are integrated as a whole can a robust, integrated, virtual network for cooperative exchange of timely, relevant information be used during all phases of DM to save lives and reduce economic loss.

Today's information infrastructure supporting disaster management may be characterized as a knowledge and interconnectivity infrastructure that has paid too little attention to its integration infrastructure. It is the result of an uncoordinated bottom-up approach that leaves shortfalls relative to information accessibility, security, quality, timeliness, and a range of other factors important to EM. Technological opportunities are continuing to enable positive advances. However, institutional and organizational barriers will inhibit development of a fully integrated capability until all stakeholders are brought together to address the system as a whole.

Chapter 5

Moving to a Disaster Information Network (DIN) for the Future

Background

The Disaster Information Task Force established a process to capture findings and recommendations related to development of a DM network capability. This information was needed to determine whether a network of this kind was feasible and/or which elements of its potential development might be redundant.

The first step in this process was to canvas the Federal-level DM user community on their "actionable" needs. "Actionable," in this case, is defined as the type of data and/or information that will enable disaster managers to make intelligent decisions rather than burden them with sophisticated technologies. A document entitled "A Synthesis of User Requirements for GDIN Working Group Evaluation (SURGE)" was prepared to capture the polled results. Additional information sources, including the original Government Applications Task Force (GATF) survey and the FEMA-sponsored Frequently Asked Questions (FAQs) derived from operational users, were analyzed to refine the results.

These materials were then analyzed, and key themes or "findings" began to emerge. The nine separate DITF working groups subsequently reviewed the findings for content and completeness. In parallel, a conceptual approach was created to specify the various stages of information management that a GDIN-like capability would be designed to exploit.

The major stages are requirements analysis, data collection, data exploitation, product generation, decision support, and dissemination. For GDIN to provide comprehensive disaster management functionality, it was determined that each of these stages would need to be closely examined in order to decide what was feasible. A template was created to capture these various information stages, and the nine working groups were tasked with filling out the template for the various disaster events under their purview. The survey results were vetted once more, and the results were presented at the GDIN Workshop held on July 23–26, 1997.

> *A Global Disaster Information Network is feasible and has no technological barriers.*

Findings

The Disaster Information Task Force identified a variety of technical challenges. As the DITF proceeded, however, it became evident that development of a DM network, as originally envisioned, was in fact feasible. In order to create such a capability, it was clear that it would need to proceed iteratively basis. The first step would be to centralize Federal-level capabilities, then phase in a national structure (i.e., state, local, private), and, finally, develop a means to operate globally. The 12 technical and programmatic challenges that need to be considered as GDIN progresses are shown below along with their associated needs.

Disaster Management Information

Finding	Need
Information Complexity	Understandable information products from complex data sources
Use of Networks	Uniform modes of access for all sources and types of information
Information Awareness	Easy ways to find out what exists and where to get it
Timely Delivery	Efficient information retrieval, especially during an emergency
Point of Action Data and Information	Information vital for deciding on specific actions
Scalable and Flexible Information	Methods that accommodate multi-scale data and widely varying knowledge and experiences of users
Standardization/ Harmonization	Access to data sets compatible with user tools
Quality	Ways to determine quality and reliability of data and information
Security	Access to open, restricted, and secret information as appropriate
Policy	Interagency policies that enhance the flow of information
Organization	A structure that will accommodate system development and management
Life Cycle Information	Seamless flow of information between the four disaster stages

Each of these findings is vitally important and, if not adequately addressed in each development stage, will hamper eventual system operation. It is important, therefore, to cover each of them in turn.

Information Complexity. The increasing variety of information sources and associated analysis methodologies present a major challenge to the DM community. For instance, it is often difficult to assemble GIS-ready information from distributed data sources such as imagery and digital map products. As new data sets are introduced, the learning curve gets steeper. In other words, information management will grow in sophistication in relation to introduced sensors and computing technologies. Disaster managers will face increasingly complicated decisions in the use of data/information, so they will need effective training and decision support tools to guide them.

Use of Networks. In addition to information complexity, disaster information management faces a similarly increasing non-uniform and inconsistent use of network-based communications and collaboration technologies. The challenge is in choosing the right communications capability for a given use within the various stages of DM. These communications capabilities tend to dissipate in the absence of disaster, so it is important that uniform procedures are in place as information, such as GIS data layers, is passed from laboratories to emergency operation centers to field personnel. The communications procedures need to be familiar, since there is little time for training or introducing new capabilities during a crisis situation. Catalog procedures for capturing and centralizing relevant information, such as lessons learned from previous events, were found to be of vital importance to disaster managers. For instance, Web technologies for posting end-item descriptions in a catalog structure could prove to be a valuable contribution in knowledge sharing.

Information Awareness. This finding logically follows the previous two since it is difficult to know which capabilities are available to support the DM community. The complex analytical and communications tools emerging are revolutionizing the information gathering process. The challenge is knowing what is there and how to get it. There are no centralized data/information banks to which managers can turn to and access actionable products. The WWW, for example, has hundreds of sites where disaster-related information is available. A cataloging, or hierarchical, procedure needs to be implemented to point users to pertinent information sources rather than forcing them to sift through irrelevant material. Disaster managers need to have a mechanism that will allow them to perform their functions more efficiently. Access to information such as new satellite imagery, research results, after action reports, and relevant simulation models would greatly enhance their operational capabilities.

Timely Delivery. In addition to knowing what is available, timely delivery of products and information is often critical to the DM community. It may be especially problematic in the early response phases of a disaster. The proper coordination of the flow of disaster-related information is a vital component of system management, and incident commanders must have open channels to ensure timely information delivery. As the DITF survey discovered, there is currently no consistent resource tracking and ordering process for all resources used in the field and supported by the Emergency Support Team (EST). It was determined that a "one-stop shopping center" needs to be designed for integrated logistics support (resource tracking) and for providing a means to timely delivery of products.

Point of Action Data and Information. There is a significant need for "point of action" information and communications. In other words, data and information for particular areas of interest, tailored to specific events, need to be made available. For example, in situ communication links and GPS access would ensure that local needs are addressed in times of crisis. In a disaster situation, normal procedures are hampered. When communications and positional accuracy are threatened, we need to ensure that these technologies are operational and accessible. A means to provide rapid alert, warning, and special instructions to those living in areas of risk needs to be established.

Scalable and Flexible Information. The disaster information management community needs an ability to accommodate multilevel throughput compatible with disparate user technologies and cultural capacities. Given disaster crises require voice, various sensor outputs, images, full motion video, and data files which must be communicated in a timely and coherent manner. The system will need to be accessible by various users, including state and local emergency operations centers and all other jurisdictions. The major system development challenge, therefore, will be to provide what appears to the user as a seamless array of information products actually derived from unconnected sources. The effective merging of these sources into a common user framework will be no small task.

Standardization/Harmonization. This is similar to the previous finding but stands alone, reflecting the importance of uniform products to the DM community. The need to produce standard protocols is essential in a crisis situation. Even varying map symbology can greatly disrupt operational procedures. The development of a common information procedure, which can be broadly adapted within the DM community, is clearly desirable. It is unrealistic to assume that standard procedures will be applied in the near future; there are simply too many unique products in existence. Land use classifications, for example, differ greatly among the various sources, and no single system development could hope to solve this complex problem. The idiosyncratic methodologies could be linked, however, in order for the disaster manager to make the wisest decision when faced with disparate data and information. A central taxonomy or hierarchy would need to be developed in order to achieve this goal.

Quality. There is a growing reliance on data and information of questionable quality. The end user assumes that the information that has been passed to them is reliable, which may not always be true. Quality problems come into play in each step of product generation. The data may have been miscalibrated, the imagery merge may have been offset, and the model algorithm may need to be modified for a given situation. Each misstep compounds the problem, and the disaster manager may be left with products that cannot be used. The most accurate capabilities need to be introduced in each operational step, and a means to trace this accuracy (e.g., metadata) needs to be incorporated into any system development. The "garbage in, garbage out" adage states the problem at hand.

Security. There are security barriers that hamper the flow of classified information. Disaster information management often requires access to such information either because it is unavailable from open sources or because it cannot be delivered through other means in a timely manner. A secure, robust interlinking system is desirable. Such a system would need to be designed to support the effective connectivity of multi-level secure platforms. A technology will need to be developed that does not violate standing security procedures but gets the appropriate information into the right hands.

Policy. The previous findings have dealt with technical challenges. A major challenge outside of the technical realm deals with creation of an environment where there is an open sharing of all-source data and information. Current policies relative to sharing of data, communications, product development, and information access often act to constrain the flow of information. For example, lessons learned from previous disaster events are often restricted due to agency sensitivities. Furthermore, products that have been derived from National Technical Means have a limited distribution due to policies that preclude their timely release. Such policy barriers need to be addressed in order to allow more open access to critical information. The policies will need to grow with the system.

Organization. A variety of agencies at the Federal level are involved in disaster management activities. The need for interagency cooperation cannot be overlooked. Currently, cooperation is handled largely in an ad hoc manner, particularly in times of crises. An appropriate organization will need to be identified to develop a DM system. The challenge will be to create a team that fosters cooperation rather than threatens it. This organization will need effective communication and feedback channels so that it can learn and grow with experience. Public–private participation, essential to creating an effective, efficient, enduring DM network, must be enabled through charter of a formal, legal entity.

Life Cycle Information. Disaster information management has traditionally been conducted in an insular environment. Interaction between individuals involved in the four stages of disaster—mitigation, preparation, response, and recovery—is often minimal. Accordingly, the products that are generated to support the various phases are non-uniform in nature. A comprehensive approach—one in which a seamless flow of information products can be provided—is desirable. The products used in the response stage should ideally feed back into the mitigation cycle so that changes can be incorporated and common methodologies shared.

Foundation for Addressing Needs

Building on the Internet Paradigm. The rapid development of communication capabilities, as exemplified by the rapid growth of the Internet and the WWW, is providing a new paradigm for interactive collaborations. First, the system has an open architecture that is available to all, and it has fostered interactions and collaborations on an unprecedented scale. It has made the data/information that already exists readily available, and a rapidly growing number of sites are putting their historical and current data/information on line. This provides improved access for the hundreds of global, Federal, state, local, public, and private agencies focused on the issues associated with disaster management.

Worldwide, increasing numbers of people have access and are learning how to use this information infrastructure. Finally, the inherent decentralization provides great leverage. While this new paradigm is a good model for GDIN, there are some inherent limitations to this approach.

Decentralization works against integration and coherence and results in little control over the quality of data/information available to the disaster manager. In addition, the current capabilities of the Internet and the WWW make it difficult to prioritize messages, users, and bandwidth to guarantee access for disaster managers in times of crisis. Finally, security is weak. It is important for the GDIN to take the best that this paradigm has to offer and incorporate improvements to overcome the shortfalls to this particular user community.

Building on New Technologies. Just as the Internet and the WWW have provided a new paradigm for communications, the explosive growth of new technologies provides unprecedented new opportunities and capabilities for the disaster manager. Collaborative technologies for virtual meetings, fora, and training classes are growing rapidly. In addition, GIS, modeling, predictive tools, and visualization techniques have rapidly grown in the last decade. Further, there have been significant improvements in the ways we organize and access data. Technologies to turn on radios, TVs, and other devices to transmit warnings, as well as new "push" approaches to broadcasting images and text to computers, hold significant promise for the disaster manager. Network technologies such as ATM and Next Generation Internet (NGI) are addressing priority access problems.

Building on Existing Investments. In addition to the obvious investments and progress made within the private sector, GDIN can also capitalize on the applicable resources of Federal, state, local, public, and private entities involved in disaster management. For example, GuardNet XXI is an example of a Federal/state intranet partnership that might be used to make the disaster information network more robust. Finally, significant U.S. investment has been made in numerous technologies that, at modest cost, can be directed to the needs of the disaster manager.

Vision for a Future Disaster Information Network

A complete disaster information infrastructure is composed of three essential elements: knowledge, interconnectivity, and integration. Through the course of this report, we have recognized the emergence in the last decade of a nascent DIN. A family of information providers is responding to user needs through new collection and analysis techniques. A variety of technologies are employed to enable information sharing, communications, and collaboration. New technologies are emerging that expand our potential, and users are reassessing their needs in light of these new capabilities. The technical foundation for a complete disaster information network is in place. It is evident today that *a robust, integrated, virtual network for cooperative exchange of timely, relevant information used during all phases of disaster management to save lives and reduce economic loss* is feasible. Development of a national perspective is the essential first step toward DIN implementation; this vision can then be extended globally. The key to achieving this vision, and to address the shortfalls of today's emerging capabilities, is to take a broad perspective, integrating best practices and coordinating our national efforts in response to the needs of all public and private stakeholders.

Fundamental Need to Involve Stakeholders

The purpose of a Disaster Information Network is to reduce losses from disasters by providing timely and accurate information to anyone who can use it to (1) decide on appropriate actions to take in order to mitigate disasters, (2) prepare for them, or (3) improve response and recovery. Effective design and implementation of such a system needs to be grounded in a detailed understanding of what information is available and how different users need to access it. It involves much more than market research because the basic issue is one of building consensus on needs and approaches in the provider, disseminator, and user communities. Much of the implementation will need to be done in the very decentralized paradigm of Internet and WWW by many different people and organizations. The problem is not one of organizing a top-down business but rather bottom-up teams and information exchanges that cut across many businesses, organizations, disciplines, etc.

Another purpose of a Disaster Information Network is to enhance communication among stakeholders through discussions over the network and exchange of ideas via newsletters, bulletin boards, and virtual or standard meetings. Specialists should be able to find each other and team up to resolve critical issues. The problem is one of enhancing connectivity and encouraging teamwork. Many professional organizations have such goals, and disasters cut across all professions.

The Federal Government has lead responsibility for disasters. Response to major disasters is led by FEMA with help from many agencies as outlined in the Federal Response Plan. Agencies such as NOAA and USGS have legislative mandates to issue predictions and warnings. Many agencies manage lands or facilities such as dams or power grids that are subject to disasters but that also can be managed to mitigate disasters. Other agencies such as NSF, NIST, USGS, NASA, EPA, Centers for Disease Control (CDC), and NOAAperform research on disaster reduction. Others such as FAAand FCC regulate industries strongly affected by disasters. Coordinating disaster information just within the Federal Government is a major task demanding new approaches.

The primary responsibility for disaster management, however, is local—at the city and county levels and then at the state level. Thus the need for coordination extends through all levels of government.

Non-government entities complete the spectrum of players with fundamental, critical roles in disaster management activities. Private industry, insurers, and providers of lifeline services such as telecommunications, gas, electricity, etc., have heavy investments at risk in the event of disasters. They also expend significant resources for disaster mitigation, preparation, response, and recovery. Non-government organizations (NGOs) created to support all phases of disaster management provide critical resources and support to the emergency management process. Given this spectrum of players, and the important role of each, a fundamental need in developing an effective disaster information network is finding new ways to foster consensus and enhance coordination, cooperation, and teamwork by involving representatives of all stakeholders in a meaningful way.

One approach to this goal, grounded in the key responsibilities of several Federal agencies, is to choose a single Federal agency to lead the effort, supported by some type of interagency task force or working group and a Federal Advisory Committee, perhaps with subcommittees involving non-Federal stakeholders. This provides clear responsibility for leadership, budgeting, and Federal control but reduced commitment from all of the other agencies and restricts the role of private sector and NGO stakeholders. In addition, if the lead agency stumbles, the others have little power to move forward.

Another possibility is to have an interagency Integrated Program Office (IPO) with strong participation from other agencies and coordinated by a Federal Advisory Committee. This provides more buy-in for each active agency and promotes cooperation among representatives from different agencies who would be collocated and working together. However, responsibility for budgets and program is likely to fall primarily to the host agency within the current structures for budget management. The role of private sector and NGOs in this context is again limited.

One way to spread the responsibility for program and budget across key agencies is to involve high-level agency representatives in an Executive Committee to oversee the IPO or other form of interagency group.

Another approach is to move toward some type of corporate entity, chartered as a public–private partnership, that provides for equality of representation for all stakeholders. Since disaster management is primarily a local issue, this public–private partnership approach would empower local groups—the primary users. It would reduce Federal control to that of an advisory body but would still leave all final decisions regarding Federal agency activities to the specific agencies. There are several examples of such partnerships. One that provides a model closest to what we envision as a potential coordinating body for a Disaster Information Network is the Intelligent Transportation

Society of America (ITS America). ITS America serves as a bridge between private industry, public interests, and Federal agencies responsible for transportation policy.

A public–private partnership for disaster information would necessarily differ in a variety of ways from ITS America. It would have to coordinate with and accept funds from many Federal agencies. It would draw many of its participants from local and state organizations that might depend on supplemental funds for travel to national meetings or committee meetings. It would have to bring together a much broader mix of businesses as supporting members.

Intelligent Transportation Society of America

ITS America was formed in 1991 with funds and authorizing language added by Congress to the U.S. Department of Transportation (DOT) appropriations bill. It also grew out of several committees within related professional and trade organizations. ITS America has more than 1,000 member organizations—50 percent from private industry, and 50 percent from academia, Federal, state, and local governments, and consumer and public interest groups. There are 20 state chapters. Approximately 3,500 individuals, including 800 employees of DOT, participate regularly in volunteer committee activities. The 49-member Board of Directors is also an official Utilized Federal Advisory Committee that provides advice to DOT. Technical activities are coordinated and advanced by the 54-member Coordinating Council that oversees 23 technical committees and task forces. The Articles of Incorporation limit the scope of ITS America to such things as (1) providing a forum for discussing, planning, coordinating, and developing programs and activities; (2) fostering, promoting, and coordinating research; (3) advising Federal, state, local, and private entities; (4) generating standards; (5) public education; (6) fostering international cooperation; and (7) activities related to development and implementation of intelligent transportation systems. ITS America currently has a staff of approximately 50 and a budget of $10 million, less than 30 percent of which is paid by the Federal Government.

We believe some type of public–private partnership organizational structure would best meet the need to develop a Disaster Information Network. It would reduce the amount of Federal funds required and enhance participation and ownership. This partnership could operate in cooperation with a Federal IPO, or a temporary Federal IPO could be established quickly to begin work on Federal problems while the partnership is formed. Membership in this public–private partnership must include people from Federal, state, and local governments, businesses, nonprofit organizations, universities, and other organizations that provide or use disaster information or information access tools.

Chapter 6

Recommendations and Action Plan

During the course of the DITF deliberations, the assessment and findings provided by the DM experts and the technologists led to a set of compelling recommendations in four major topic areas: policy, organization, implementation, and a phased approach. These four topics represent next steps that can be accomplished in the near future and at a modest cost. They take advantage of the current and emerging national efforts and capabilities and appear likely to help the DM community improve its capabilities through all phases of the DM cycle.

Policy and Organization

It is important to note that the technologies identified are strongly biased toward what can be done now, based on the needs of the DM community. The DITF is not recommending a new technology development program, but rather the capture of existing and emerging technologies for use by the DM community. Thus, the recommended approach is designed to help solve the current problems of the disaster manager with emphasis on mitigation and preparedness. Finally, as will be discussed, the DITF strongly recommends a three-phased approach. This phased approach from Federal to national to global capitalizes on evolving capability and delivers incremental capacity each year.

Policy. The DITF determined that it is important for agency leadership to formulate a policy environment that (1) fosters cooperation through integrated strategic planning and coordination of disaster information budget initiatives, (2) improves capability, and (3) promotes public–private partnerships. Institutional commitment and specific policies are needed.

Recommendations

- Execute an Executive Order (EO) or Presidential Decision Directive (PDD) to implement GDIN.
- Construct a policy environment fostering cooperation and promoting public–private partnerships.
- Form robust policies and sustainable procedures for utilization of classified data and derived products.
- Encourage mitigation investment versus use of supplemental budget recovery dollars.

Action Plan

1. Issue an EO or PDD to implement the recommendations to establish a GDIN.
2. Establish an environment for enhanced interagency cooperation and data sharing. Agencies shall initiate discussions to coordinate DM information budget initiatives for FY99, FY00, and outyears.
3. The DCI and DoD, working closely with the Civil Applications Committee, will examine and implement policies and procedures for sustainable and timely utilization of classified data and derived products for all phases of the DM cycle.

Organization. The existing U.S. community of Federal disaster management organizations must be more tightly coupled in a cooperative effort. The NDIN must provide such an environment. In addition, the DITF recognized the need for a more cohesive organization of Federal, state, and private capabilities for disaster management. As a result, the NDIN must include all stakeholders as willing participants. This requires a formal public–private corporate entity to make effective use of public–private resources and capture their potential synergies.

Recommendations

- Establish an Executive Committee (EC) to oversee DIN activities.
- The EC will establish an Integrated Program Office (IPO) to address Federal-level challenges.
- The EC will create a public–private partnership (PPP) for long-term support of GDIN.
- Leadership of the EC and IPO should be from different departments to strengthen interagency cooperation and teamwork.

Action Plan

1. Establish an interagency Executive Committee to oversee disaster information network activities.
2. The EC will create an Integrated Program Office to begin work immediately to address Federal-level challenges.
3. The EC will create a framework that involves public and private stakeholders in a partnership (PPP) to determine and implement the long-term GDIN support organization.

Executive Committee DIN Activities

The Executive Committee will lead the development of a disaster information network by:

- Determining, in consultation with public and private stakeholders, the long-term GDIN support organization.
- Forming and overseeing activities of an Integrated Program Office in integrating Federal-level efforts for NDIN.
- Fostering integrated strategic planning and budgeting for Federal disaster information-related initiatives.

IPO GDIN Activities

The IPO will initiate the development of GDIN under the auspices of the EC by:

- Creating a Strategic Plan for Federal coordination.
- Developing a logical arrangement for Federally provided observational data, information, models, tools, and related resources.
- Developing a strategy for integrating Federal intranets, including GuardNet XXI, in order to provide a more robust NDIN.
- Forming a plan of action, under DOS leadership, to move NDIN to GDIN and working with the PPP to implement GDIN.
- Establishing and conducting a directed technology program.

Public–Private Partnership Activities

The Public–Private Partnership will:

- Create a strategic plan for the NDIN and GDIN phases.
- Stimulate and enhance private sector participation.
- Improve state and local utilization of Federal capabilities.
- Act as a catalyst and coordinator for precipitating ideas and actions to improve disaster information systems.
- Build consensus among public and private stakeholders at Federal, state, and local levels.
- Facilitate interaction among providers, disseminators, and users through meetings, newsletters, journals, training sessions, and exercises.
- Maintain a structure for providing advice from a broad constituency.
- Accept funds from public and private sources.

Implementation

Information Access. The NDIN and the GDIN should use the existing knowledge base and associated infrastructure as a foundation. The overall system is too complex for central design, which would also risk existing capabilities. A major requirement is a consistent, logical organization of information throughout the network, so that it can be expeditiously accessed in a standard way. This access to information can be enhanced by common network standards and procedures, including consistent information/data catalogs and Federal knowledge base structure. The DITF recommendation is in response to findings concerning information complexity, network use, information awareness, and standards.

Recommendation

- Enhance access to information through a network-accessible virtual knowledge base.

Action Plan

To enhance access to information, the IPO and PPP will formulate a logical arrangement of data, information, models, tools, and other resources available to users through an integrated information network. This will be accomplished through a phased approach by:

1. Creating a virtual point of access on the Internet to existing Federal disaster information.
2. Expanding Federal capability to include state, local, and private resources (providing a virtual single point of access for national-level information—a clearinghouse for tools, models, simulations, and decision support capabilities and full on-line collaboration capability to enhance user/provider interaction).
3. Introducing global extension and enhancements to NDIN that emphasize mitigation and preparedness.

Connectivity. Connectivity must be matched to user and information provider needs to access and share information in an effective way. There are five key components to connectivity: Internet, intranet, broadcast, telecommunications, and documentation. The recommendations of the DITF focused on the first three. Connectivity performance can be improved by the NDIN intranet, by more inclusive broadcast capability, and by refining Internet practices. The Internet, while broadly available, is unable to meet all the needs of the community. Specifically, it is not inherently secure, has no timeliness guarantees, and is subject to congestion and disruption. While an intranet such as GuardNet is able to overcome these shortfalls, it has its own shortcomings in that it is access limited. Therefore, NDIN and GDIN will be designed to take advantage of the best that the two nets have to offer. To enhance connectivity, the IPO and PPP must take measures to ensure the disaster information network is robust and secure when necessary and that disaster information is available to disaster managers when needed. This recommendation is in response to the following findings on required characteristics: timeliness, point of action, scalability and flexibility, security, and quality.

Recommendation

- Enhance connectivity by developing a robust, secure, and available communications infrastructure.

Action Plan

1. The IPO will establish an action plan for a DM communications network addressing needs for robustness, access, security, priority, and bandwidth (e.g., GuardNet XXI of the National Guard).
2. The IPO and PPP will initiate use of a robust system prototype (e.g., GuardNet) for Federal-level disaster-related communications system.
3. The PPP will implement an operational, robust, national-level disaster information network. The PPP and IPO will be closely integrated.

Directed Technology. New technology developments must be anticipated and captured by the NDIN and GDIN as they emerge. Research and development support must be arranged from the research community, both academic and private. The following recommendation is in response to the findings concerning information complexity, network use, information awareness, and quality.

Recommendation

- Conduct a directed technology program to integrate new and emerging tools.

Action Plan

The IPO and PPP will conduct a directed technology program to integrate new and emerging tools and technologies (models, simulation, data fusion) for use by disaster managers. First, the IPO will survey the needs for directed technologies related to disaster information and will develop a plan and a call for proposals. Then, the directed technology plan will be implemented by the funding of high-quality proposals with emphasis on mitigation and preparedness. Finally, the directed technology efforts will be evaluated and integrated into NDIN, and a follow-on proposal opportunity will be provided.

Demonstration. Technological advances have made practical the creation of a national disaster information network. This national network can evolve from existing capabilities by improving infrastructure and by including state and private entities in the network. These efforts need to be user focused and emphasize user/provider interfaces; open, restricted, and classified communications and connectivity; interoperability; public and private sector data, information, and analysis; and decision-making tools. In addition, it is important to support distributed training and exercises in all phases of the DM cycle employing all of the technologies to be incorporated. This recommendation is in response to the findings on information complexity and life cycle information.

Recommendation

- Conduct formal exercises to demonstrate the DIN and stimulate training in its use.

Action Plan

The IPO and PPP will conduct formal exercises to stimulate training and to demonstrate the integration of enhanced information access, connectivity, and directed technology efforts. This will be accomplished by first developing a demonstration plan with integrated metrics for a Federal-level disaster information network. The network is to be constructed while simultaneously developing a plan for a training and outreach program. Then, a demonstration of the Federal-level disaster information network and a plan for an NDIN will be created. In addition, a prototype training and outreach program will be initiated. Finally, the national-level disaster information system will be demonstrated, and the operational training and outreach program for DM will be implemented.

Phased Approach: The Global Extension

The complexity of forming disaster information networks at the Federal or national level is indicative of what might be expected globally. Moreover, the natural evolution of such a system is through tying together subnets into larger nets. For these and many other reasons, it is advisable for the GDIN to grow from NDINs. Thus, the GDIN is likely to evolve from the interconnecting of national networks.

Recommendation

- Implement GDIN based upon the NDIN framework.

Action Plan

The EC will request the Department of State to lead the effort to determine requirements for the global extension of NDIN and to provide leadership for development of the global disaster information network, building on national efforts. This will be accomplished by first developing a global action plan, then initiating global outreach efforts, and finally demonstrating global interoperability.

Analysis of the Ratio of Costs to Benefits

According to OSTP, the total U.S. losses to all natural disasters have averaged $54 billion per year over the last 5 years (Padovani, 1997). According to the Red Cross, the total global losses from all natural disasters have averaged $444 billion per year over the last 5 years, making the U.S. loss about one-ninth of the global loss (International Federation of Red Cross and Red Crescent Societies, 1996 World Disaster Report). The Munich Re Insurance Corp has estimated total global loss due to all natural disasters at about $50 billion per year over the last 5 years. Disparity in the estimates occurs because of reporting system shortcomings, not because of errors or variations in number of disasters reported. Generally, it is believed that disaster losses are under-reported. Using the above as a base, KPMG Peat Marwick LLP (1997) prepared a detailed benefit-cost analysis of the NDIN with the following observations and assumptions:

- The recommended Federal investment will be $50 million over 3 years.
- The projected operating and maintenance costs for the network will be $10 million per year thereafter and will be paid by two-thirds Federal and one-third non-Federal sources.
- The expected total loss reduction from all mitigation applied to all hazards is 40 percent (Burton et al., 1993).
- Total economic loss typically exceeds property loss by 10 percent (W. J. Petak and A. A. Atkisson, 1982).
- The Federal share of total loss (i.e., Government cost) is 20 percent (Padovani, 1997), and it is reasoned that the Federal share of the benefit, therefore, is also 20 percent. The total benefit of GDIN is 5–10 percent of the maximum possible reduction of 40 percent; that

is 2–4 percent (Corps of Engineers, 1997). The full benefit of GDIN will be realized linearly over a 3-year period, independent of disaster location.

- The estimated benefit of NDIN does not overlap with the benefits of other mitigation measures and assumes that the maximum possible mitigation reduction is realized.
- The total benefit to the Government will be entirely in the reduction of Federal relief money required.
- It is estimated that the user cost of implementing GDIN-related mitigation measures will be 5–10 percent (Corps of Engineers, 1997) of the total benefit regardless where the disaster occurs.
- It is estimated that the Federal share of the user costs is 20 percent, which will be redirected from discretionary funds.

From these observations and assumptions and choosing the most conservative values, Peat Marwick concluded that the ratio of benefits of an NDIN to its costs over 10 years would be in the range of 12 to 25 for Federal benefits and 15 to 31 for national benefits. The approximate annual value of savings due to GDIN is $1 billion for the above annual costs and assumptions.

In Summary

- There are few technological barriers to GDIN—we are technology enabled.
- Institutional commitment and policy foundation are critical to success.
- A formal corporate form of public–private partnership is needed to maximize the potential of GDIN.
- We can start now, building on current Federal capabilities.

Chapter 7

Global Considerations

The United States has vital commercial, humanitarian, and political interests in disaster prone countries, some of which have minimal early warning or mitigation tools. Therefore, establishing the Global Disaster Information Network (GDIN) on an international basis is essential to U.S. foreign policy and national security. GDIN must be effective, cost-conscious, and interoperable and must link existing national, commercial, multilateral, and bilateral systems. It would provide an incentive for improvement local disaster management capability. It should also be a general disaster management tool that fuses operational data from specialized systems and provides a reliable two-way communications link to disaster prone regions, especially those with poor communication networks. In short, GDIN will significantly increase the value of existing systems by providing additional sources of reliable operational information. Also, by developing communication links to areas that do not have reliable early warning and mitigation systems, GDIN's international phase will provide significant added value to the status quo.

While information alone will not solve all problems, effective information exchange between international partners will also improve the Federal Government's emergency preparedness and response by providing smoother links to foreign sources. Such an exchange will also save money otherwise spent on international relief (now hundreds of millions of dollars annually), will strengthen the economic position of American firms, and will contribute to political stability in fragile nations.

Global Phase

With the agreement of the GDIN Steering Committee, and building on ReliefWeb (a United Nations program that makes available disaster information on the Internet) and other emergency information projects, the Department of State will lead an interagency team on the DITF to plan the global phase and facilitate discussions on foreign policy, commercial, and national security issues. All relevant agencies have been invited to participate. No changes in agency charters are anticipated, and all work will be conducted using existing resources. To meet the needs of the Federal Government, the team decided to begin planning the global phase now, even though implementation must be phased in, perhaps through demonstration projects. The reasoning was that the global phase must take into account existing bilateral and multilateral arrangements in order to strengthen the disaster management capabilities of the partners within the network and to enhance local capacity. Conversely, it would imperil success to wait until domestic implementation to plan the global phase or to design the global system without international involvement.

A report on the international team's recommendations and findings will be presented to the GDIN Steering Committee in February 1998. In considering GDIN's potential budgetary implications, the team is looking for appropriate international partners willing to leverage resources to the partners'mutual advantage. The team has therefore begun to engage representatives from the G7, the European Community, UN departments and specialized agencies, other governments, and the non-government organization (NGO) community. These discussions also address how to handle information deemed sensitive by the partners and how to accommodate international partners with varying levels of access to technology.

GDIN International Goals

The international phase of GDIN has a number of goals:

- Enable an effective interoperable network of early warning, mitigation, and response systems of value to all nations—a suite of technical solutions, including an Internet-based collection of current, reliable, and essential disaster information. A range of technological solutions will actually be needed by GDIN, since in many countries access to sophisticated communication technology is limited. Such a suite of solutions should be robust enough to pass information quickly to the lowest levels.
- Enable a quick response system linking U.S. and foreign commercial and government satellites and other remote sensing tools.
- Foster increased information sharing between governments, NGOs, and international organizations and develop methods of handling sensitive information (e.g., derived products).
- Take advantage of, enhance, and support current disaster relief efforts and international public–private partnerships to reduce loss of life and property beyond what is currently being done.
- Foster global information standards to ensure that those who need to make decisions can quickly access information. In addition, the global model should be robust enough to handle some variation in standards while the transition to global standards takes place.
- Encourage governments, NGOs, international organizations, and educational institutions to require that disaster managers comply with international standards.

Priorities

As a Federal Government initiative, GDIN's first priority is to serve U.S. interests; therefore its first phase (NDIN) concentrates on the U.S. Its second phase will extend the information network globally. This phase will incorporate international partnerships to facilitate and enhance the global sharing of information necessary to implement the GDIN. Potential partners will be reluctant to provide access to their assets unless the network also serves their interests, so we need a "global package" to address the vital needs of both communities. International agreements should reasonably bound the project to keep GDIN cost effective.

GDIN's first step should enhance efforts to support U.S. Embassies and U.S. commercial missions abroad. We also need to improve how we support ongoing multilateral efforts in which the U.S. has vital interests (e.g., complex humanitarian relief operations). These interactions will sometimes involve significant international cooperation. Taken together, they should increase the viability of U.S. commercial, foreign policy, and national security interests and should potentially reduce the U.S. contribution to international relief costs. In addition, insofar as international cooperation is involved, such interactions will also form a proof of concept to potential partners interested in the global phase.

The U.S. also needs to extend the existing partnerships with foreign national and bilateral systems, the UN, and private organizations. Optimizing resources and developing common approaches to problems may reduce the need for additional satellites and remote sensing equipment and should measurably increase the amount of shared information. For this reason, representatives from potential international partners have already been brought into the discussions. That will enhance international acceptance and speed implementation.

To insure that team options are acceptable to the international community, the U.S. International Informatics Committee cleared the creation of a "meeting of experts" at the U.S. Department of State in January 1998. Attendees will examine options for a draft GDIN international model and explore various management options and the possibility of multilateral funding.

GDIN International Model

In order to plan the rescue of some refugees in Zaire in December 1996, the U.S. was asked for imagery of a volcano that had erupted. Local relief workers needed to locate the lava flows. By the following day, the U.S. State Department faxed a derived map showing the volcano's active vents and lava flows. This success pointed to a serious problem in ad hoc systems. If the State Department officer who received the call for help had not been available, or if the U.S. had not found a source for the information, a rescue attempt might have been seriously delayed even if Russian, private, or other data sources were available. A worldwide system through which alerts are quickly shared in an emergency does not exist. In a similar vein, the lack of such a system hinders mitigation efforts.

To correct this problem, the team has been exploring phasing in the international GDIN by establishing a special network of regional operation centers to provide mitigation, early warning, and response from a wide range of information sources (illustrated below). These centers would be staffed around the clock by disaster and communications experts. Each center would build appropriate communications links to private and government clients within their region of operations involving a wide range of practical technologies, such as fax, ISDN, and e-mail. The linkage effort will be critical, since an essential element of the job must be to send information from outside the region to the people most in need within the disaster. These operation centers would have high-speed links to a "ring" of existing bilateral, national, and multilateral systems, private remote sensing centers, and specialized disaster centers such as the WMO drought center in Harare, Zimbabwe, or the Asian Disaster Preparedness Center in Bangkok, Thailand.

Some nations—Japan and Italy are examples—have robust national systems that will require little reconfiguring to join the ring, but many countries do not yet have an effective national system. This is why the centers, as defined in this model, would also need to develop effective supporting coalitions of local natural disaster organizations, both private and public, to channel information to and from the GDIN. Although some countries in the operational area may have limited communication capability, the operation centers would be capable of handling high volume data and image exchange, perhaps even employing Internet II technology. It may be necessary to institute a set of cooperating memorandums of understanding (MOUs) under the GDIN umbrella to allow the operation centers to use the high-speed links to alert each member of the ring (such as the American NDIN or National Disaster Information Network). In turn, ring members should be able to receive the alert at any time of day or night. That system would then respond with the right product if available.

At least in the early stages of the project, the operation centers probably would not develop products on their own or manage disasters. However, they should be staffed by professional disaster managers so that the centers can "package" requests for help. Packaging is a key requirement and another reason for regional centers, which will serve as a “virtual network” of nodes far from the disaster scene. Disaster professionals in the centers must therefore develop trust with disaster managers in their regions so that, when a crisis occurs, they can easily discuss the problem with the managers on the scene. Based on this understanding, the center can then package the request for help to partners on the ring. The partners can then quickly respond with the right information in a format most appropriate for the disaster manager. For example, in a situation like the volcano in Zaire, a clear black- and-white map that could be faxed was the best product—rather than imagery, which was requested.

Possible model for international portion of GDIN showing relationship between regional operation centers and a ring of partners.

The reverse situation also speaks to the need for a regional approach. Members of the ring will often see natural disaster threats before they hit their targets. Even if the target has its own satellite assets, the ability to draw from additional remote sensors is always invaluable. The set of proposed MOUs would obligate the ring to pass their information in an appropriate format to the regional GDIN operation center nearest the disaster. The disaster professional at the center would then examine the information to ensure it is in a format that can be used by the disaster managers in the field.

No decision has been made on this model, which needs to be explored at the January 1998 meeting of experts. However, some experts are of the view that before building a worldwide network of operation centers, GDIN should establish proof-of-concept demonstration centers in disaster-prone regions to such as Africa or Asia. Phasing in will allow for design flaws to be correctly easily and at low cost. Such a procedure will also allow the system to build local trust, a key element, as well as develop the evidence needed to garner international financial support from the World Bank and others. If that option is picked, the demonstration centers should be simple models that do not go beyond the tasks outlined in this paper. However, once GDIN matures, donors should have the option of adding modules to specific centers as needed. For example, various donors may wish to provide a center with specialized hurricane or oil spill experts.

GDIN must use political care when choosing the location of regional centers. A number of locations have been suggested and will be explored in January. The January meeting will also explore the modalities and practical obligations that might be imposed under the MOUs. The main point is to develop a simple model that can interface with what will be a wide disparity of systems, each of which has its own methods of handling alerts and sharing information. The team does foresee that the information technology envisaged for the NDIN will eventually extend worldwide and be intricately connected to and accessible by GDIN's numerous operation centers. Nevertheless, both political and economic constraints will cause this growth to be slow in some parts of the world, which may argue for building demonstration regional operation centers now. Thus, NDIN and GDIN are symbiotic parts that grow together in cooperation, giving each other strength.

Possible GDIN Management Packages

Potential partners from disaster management agencies and organizations around the world will want a role in GDIN's management before committing to it. For that reason, a team of representatives from governments, the UN, industry, and NGOs should coordinate GDIN's international development. Rather than propose only one specific management model, the team explored four options with potential partners, starting in August 1997. Each option, as described below, has pros and cons. These will continue to be explored in the January meeting of experts.

UN Option: Making GDIN a UN project would plug it into an organization with offices in every country and into existing emergency systems. Many member nations already look to the UN for disaster assistance and to share vital information. In addition, we would expect each UN element (e.g., UNHCR, UNDP) to share information. On the negative side, unless GDIN is operated along the lines of Relief Web, the U.S. might lose significant control, as developing nations could drive the project's agenda into expensive areas of minimal value to the U.S. A solution might be to place GDIN under the auspices of the United Nation's Interagency Standing Committee. This committee—which has a reputation for pragmatism—is managed by relief professionals from governments, operation agencies, and NGOs. Another solution might be to place GDIN under the UN Emergency Relief Coordinator (ERC), who already has a major emergency information mandate.

International Federation of Red Cross and Red Crescent (IFRC): Giving GDIN's leadership to the IFRC has several advantages. The IFRC has a worldwide organization with a reputation for neutrality and high technology skills. In addition, an IFRC project would probably not be treated as a potential threat by weak governments, as might a UN or G7 effort. However, for the IFRC to retain its neutrality, the U.S. and other nations would lose nearly all control yet have to continue funding the project.

Separate System: Creating a separate international organization, a nonprofit public–private partnership, or managing GDIN through a system of bilateral arrangements would allow us to limit GDIN's functions to areas of value to us and limit the partners to those with common goals. However, GDIN has no proven value, so a separate entity might not gain UN or G7 mandates right away, but the other options associate GDIN with known organizations. To resolve that problem, the guiding body would need representatives from donor governments, UN operational agencies, the G7, Russia, and UN regional bodies. Since ReliefWeb has proven its value, it may, in fact, take this option after the new UN reform effort has been completed. It may be more effective as a private NGO and might even agree to merge with GDIN.

G7-GEMINI: Making GDIN a primary GEMINI initiative could improve G7 cooperation on natural and technological disaster relief. The members are of the same mindset and on an equal technological level. In addition, although GEMINI originated with the Brussels 1995 G7 Economic Ministers meeting, it is intended to include all nations, even those outside the G7. GEMINI's goal is to foster the development of national systems and link them in a global network. As such, GEMINI's goals are congruent with GDIN. GEMINI, however, is only in the conceptual phase, and its membership's commitment to address the developing world's needs is uncertain. Due to the U.S. Government's commercial, foreign policy, humanitarian, and national security interests in that portion of the world, addressing those needs as a key goal will be essential if this option is chosen.

Possible GDIN Partners

Many potential partners exist—regardless where GDIN resides. Irrespective of which entity manages the system, success suggests partnering with existing bilateral and multilateral programs. The pros and cons will be fully explored in the January 1998 meeting and in the paper due in February. A few possible partners are: Reliefweb, U.S. Japan Nuclear Accident Partnership, FEMA bilateral protocol with EMERICOM, China, International NGO Community, IDNDR, NATO, and ASEAN.

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Appendix A

Federal Disaster Information Centers

Advanced System Center (ASC), USGS: A facility in Reston, Virginia, that provides special facilities for member agencies of the Civil Applications Committee (CAC) to integrated classified data into unclassified programs.

Alaska Volcano Observatory (AVO), DOI/USGS, UAF/GI, ADGGS: Fairbanks and Anchorage, Alaska. Monitors and studies Alaska's hazardous volcanoes to predict and record volcanic activity and to implement public safety measures. *URL:* http:// www.avo.alaska.edu

Aviation Weather Center (AWC): Kansas City, Missouri. Enhances aviation safety by issuing warnings, forecasts, and analyses of hazardous weather to aircraft in flight and to the aviation community. The center also forecasts weather conditions affecting domestic and international aviation interests out to two days. The AWC is one of nine centers within the National Centers for Environmental Prediction (NCEP). *URL:* http://www.awc-kc.noaa.gov

Cascades Volcano Observatory (CVO), DOI/USGS: Vancouver, Washington. Provides accurate and timely information pertinent to the assessment, warning, and mitigation of natural hazards (volcanoes, earthquakes, landslides, and debris flows) and performs research into the effects of geologic or hydrologic processes on the landscape (e.g., volcanic gases on the atmosphere, increased sediment transport on streams). *URL:* http://vulcan.wr.usgs.gov

Climate Prediction Center (CPC): Washington DC. Maintains a continuous watch on short-term climate fluctuations to diagnose and predict them. Assists agencies both inside and outside the Federal Government in coping with climate-related problems such as food supply, energy allocation, and water resources. The CPC is one of nine centers within the NCEP. *URL:* http://nic.fb4.noaa.gov

Cold Region Research and Engineering Laboratory, (DOD/USACE): Hanover, New Hampshire. Provides research on solving technical problems that develop in cold regions, especially those related to construction, transport, and military operations. CRREL provides this information to defense services, civilian agencies of the Federal Government, and to state agencies, municipalities, and private industry. *URL:* http://www.crrel.usace.army.mil

Emergency Operations Center, DoD/U.S. Army Corps of Engineers. EOCs provide command and control for emergency operations, which include advance measures, flood response, and post-flood recovery as well as activities to save lives and protect improved property. Additionally, FEMA is supported during disaster response under Public Law 93-288, including the Federal Response Plan. EOCs support the Commanding General U.S. Forces Command and commanders outside CONUS for mobilization, deployment, and sustainment of U.S. forces during contingencies.

Environmental Modeling Center (EMC): Camp Springs, Maryland. Improves numerical weather, marine, and climate predictions at the NCEP through research in data assimilation and modeling. The EMC develops, improves, and monitors data assimilation systems and models of the atmosphere, ocean, and coupled system using advanced methods developed internally as well as cooperatively with scientists from universities, NOAA laboratories and other Government agencies, and the international scientific community. The EMC is one of nine centers within the NCEP. *URL:* http://nic.fb4.noaa.gov:8000

Earth Resources Observation Systems (EROS) Data Center, (EDC), DOI/USGS: Sioux Falls, South Dakota. Handles data collection and distribution of images from satellites and aircraft. The EDC holds the three decades of land-surface phenomena information within the National Satellite Land Remote Sensing Data Archive. The EDC also acts as the Distributed Active Archive Center, or DAAC, for land processes on behalf of NASA's Mission to Planet Earth.
URL: http://edcwww.cr.usgs.gov/eros-home.html

FEMA National Mapping and Analysis Center and Regional Offices, FEMA: Washington, DC. Maintains baseline disaster management data and develops integrated products distributed to regional offices, which further assimilate local information for emergency management purposes. *URL:* http://www.fema.gov/msc

Hawaiian Volcano Observatory (HVO), DOI/USGS: Hawaii National Park, Hawaii. Monitors and studies Hawaii's hazardous volcanoes to predict and record eruptive activity and to implement public safety measures. *URL:* http://hvo.wr.usgs.gov

Hydrometeorological Prediction Center (HPC): Camp Springs, Maryland. Provides basic hydrometeorological analysis and forecasts for National Weather Service field offices and the entire meteorological community. HPC meteorologists are experts in quantitative precipitation forecasting and numerical model interpretation. Products provided by the HPC include surface analyses, outlooks for heavy rain and snow, and weather forecasts through 5 days. The HPC is one of nine centers within the NCEP. *URL:* http://www.ncep.noaa.gov/HPC

Mapping Applications Center (MAC), DOI/USGS: Reston, Virginia. Serves as the U.S. Government's leading civilian organization devoted to developing maps and geospatial data based on high altitude photographs, earth orbiting satellite images, and other technologically advanced and unconventional sources. *URL:* http://www-nMDusgs.gov/mac

Marine Prediction Center (MPC): Issues marine warnings and guidance in text and graphical format for maritime users. Quality controls marine observations globally from ship, buoy, and automated marine observations for gross errors prior to being assimilated into computer model guidance. The MPC is one of nine centers within the NCEP. *URL:* http://www.ncep.noaa.gov/MPC

Mid-Continent Mapping Center (MCMC), DOI/USGS: Rolla, Missouri. Operates as a major field production facility in the National Mapping Division of the U.S. Geological Survey. Produces paper and digital maps. An Earth Science Information Center (ESIC), where walk-in and phone orders for USGS products are processed, is also part of the mapping center. *URL:* http://pluto.er.usgs.gov/xindex.html

National Centers for Environmental Prediction (NCEP), DOC/NOAA/NWS: Washington, DC. Provides worldwide weather forecast guidance products. This agency is the starting point for all weather forecasts. It is the parent center for Tropical Prediction Center (TPC) and National Hurricane Center (NHC). *URL:* http://www.ncep.noaa.gov

National Climatic Data Center (NCDC), DOC/NOAA: Asheville, North Carolina. Supports programs involving remotely sensed and in situ information on meteorology and climate. NCDC operates World Data Center-A (WDC-A) for Meteorology under the auspices of the National Academy of Sciences, with the responsibility of gathering data on global climate and weather. *URL:* http://demo1.eis.noaa.gov/nesdis/nesdis_ncdc.html

National Earthquake Information Center (NEIC), DOI/USGS: Golden, Colorado. Determines earthquake locations following occurrence, alerts appropriate entities, archives earthquake information, and performs active research to improve earthquake detection.
URL: http://wwwneic.cr.usgs.gov

National Hurricane Center (NHC), Tropical Prediction Center (TPC), DOC/NOAA/NWS: Miami, Florida. NHC and its parent center, TPC, maintain a continuous watch on tropical cyclones over the Atlantic, Caribbean, Gulf of Mexico and the Eastern Pacific (from 15 May through November 30); they prepare and distribute hurricane watches and warnings, as well as marine and military advisories; conduct research to evaluate and improve hurricane forecasting techniques; and are involved in public awareness programs. The TPC is one of nine centers within the NCEP. *URL:* http://www.nhc.noaa.gov

National Imagery and Mapping Agency (NIMA) Disaster Support Center: Washington, DC. Provides products derived from classified assets to U.S. Government agencies.
URL: http://www.nima.mil

National Interagency Fire Center (NIFC), DOI (BLM, FWS, NPS, BIA, OAS), USDA (USFS), DOC (NOAA/NWS): Boise, Idaho. Serves as primary U.S. logistical support center for wildfire suppression; also serves as a focal point for wildfire information and technology. *URL:* http://www.nifc.gov

National Response Center (NRC), DOT/USCG: Washington, DC. Serves as the sole national point of contact for reporting all oil, chemical, radiological, biological, and etiological discharges into the environment anywhere in the United States and its territories; sends alerts to appropriate entities; and serves as the communications and operations center for the National Response Team (NRT). *URL:* http://www.dot.gov/dotinfo/uscg/hq/nrc

National Severe Storms Laboratory (NSSL), DOC/NOAA/NWS: Norman, Oklahoma. Enhances national capabilities to provide accurate and timely forecasts and warnings of hazardous weather events (e.g., blizzards, ice storms, flash floods, tornadoes, lightning) through research into weather processes, research in forecasting and warning techniques, and development of operational applications and transfer of technology. *URL:* http://www.nssl.noaa.gov

National Storm Prediction Center (SPC): Norman, Oklahoma. SPC monitors hourly and forecasts severe and non-severe thunderstorms, tornadoes, winter storms, extreme winds, heavy rain, and other hazardous weather phenomena across the continental United States. Its parent agency is the National Centers for Environmental Prediction (DOC/NOAA/NWS). *URL:* http://www.nssl.noaa.gov/~spc

National Weather Service (NWS), DOC/NOAA: Silver Spring, Maryland. Serves to protect the life and property of U.S. citizens from natural disasters by issuing warnings and forecasts for hurricanes, tornadoes, floods, winter and summer storms, and all manner of severe or extreme weather. *URL:* http://www.noaa.gov/nws/nws.html

Pacific Disaster Center (PDC), DoD, Kihei, Maui, Hawaii. The PDC is a Federal center designed to provide world-class information support to Federal, state, and local disaster managers in mitigation, preparedness, response, and recovery for disasters within the Pacific region. The PDC is being developed under the auspices of the DoD with the goal of transitioning the operation to an appropriate Federal civil agency at the full operational capability milestone. *URL:* http://www.pdc.org

Pacific Tsunami Warning Center (PTWC), DOC/NOAA/NWS: Ewa Beach, Oahu, Hawaii. Serves as operational center of the Pacific Tsunami Warning System (PTWS), providing Pacific basin tsunami watches, warnings, and information/education services to the disaster preparedness community and the general public.

Rocky Mountain Mapping Center, DOI/USGS: Denver, Colorado. Produces and develops map products and conducts research, concentrating activities in western United States. Facility is responsible for distributing more than 100,000 map-related products of the United States Geological Survey (USGS) and other Federal agencies. *URL:* http://avsrvr-1.cr.usgs.gov

Volcano Systems Center (VSC), University of Washington and USGS: Seattle, Washington. Formed to integrate research across disciplines to understand the role of volcanic systems in geological evolution. *URL:* http://www.vsc.washington.edu

West Coast/Alaska Tsunami Warning Center (WC/ATWC), DOC/NOAA/NWS: Palmer, Alaska. Serves as the Tsunami Warning Center for Alaska, British Columbia, Washington, Oregon, and California; provides timely tsunami warnings, watches, advisories, and information/education services to the disaster preparedness community and the general public. *URL:* http://www.alaska.net/~atwc

Appendix B

Important Disaster-Related Websites

General Sites

The National Communications System (NCS) Emergency Response Link (ERLink) Program
URL: http://www.ncs.gov/~nc-pp/html/erlink.htm

Federal Emergency Management Agency (FEMA). The FEMA Global Emergency Management System is an online database with links to internet sites related to emergency management. *URL:* http://www.fema.gov
URL: http://www.fema.gov/home/GEMS

HazardNet: An International Decade for Natural Disaster Reduction (IDNDR) Demonstration Project
*URL:*http://hoshi.cic.sfu.ca/~hazard

The Natural Disaster Reference Database (NDRD)
URL: http://ltpwww.gsfc.nasa.gov/ndrd/disaster

Subcommittee on Natural Disaster Reduction (SNDR)
URL: http://www.usgs.gov/sndr/information.html

GDIN Homepage *URL:* http://www.gdin.tasc.com

Emergency Information Infrastructure Partnership
URL: http://www.emforum.org

U.S. Geological Survey Hazards Page
URL: http://www.usgs.gov/themes/hazard.html

Earthquakes

U.S. Geological Survey earthquake information
URL: http://www.usgs.gov/themes/earthqk.html

National Earthquake Information Center (NEIC) and World Data Center A for Seismology
URL: http://www.neic.cr.usgs.gov

Cascadia Region Earthquake Workgroup (Cascadia is between northwestern California and the southernmost tip of the Queen Charlotte of Canada.) *URL:* http://www.geophys.washington.edu/CREW/indext.html

Southern California Earthquake Center
URL: http://www.scecdc.scec.org/

The Pacific Northwest Seismograph Network, earthquake information *URL:* http://www.geophys.washington.edu/SEIS/fingerquake.html

U.S. Geological Survey site on current earthquakes in Northern California *URL:* http://quake.wr.usgs.gov/QUAKES/CURRENT/latest/index.html

U.S. Geological Survey site on current earthquakes in Southern California *URL:* http://www-socal.wr.usgs.gov/

Floods

U.S. Army Corps of Engineers *URL:* http://www.usace.army.mil/inet/locations/bdry-pages

U.S. Geological Survey flood information *URL:* http://www.usgs.gov/themes/flood.html

Hurricanes and Coastal Storms

U.S. Geological Survey Site on Coastal Storms *URL:* http://www.usgs.gov/themes/coast.html

NOAA's National Hurricane Center, Tropical Prediction Center *URL:* http://www.nhc.noaa.gov/index.html

Atlantic Tropical Weather Center *URL:* http://banzai.neosoft.com/citylink/blake/tropical.html

FEMA Tropical Storm Watch *URL:* http://www.fema.gov/fema/trop.htm

Naval Pacific Meteorology and Oceanography Center West Joint Typhoon Warning Center *URL:* http://www.npmocw.navy.mil/npmocw/prods/jtwc.html

Landslides

U.S. Geological Survey Landslide page *URL:* http://www.usgs.gov/themes/landslid.html

A report on GIS-based techniques for mapping landslide hazards *URL:* http://deis158.deis.unibo.it/gis/chapt1.htm

Inventory map of landslides triggered by the 1994 Northridge, California Earthquake *URL:* http://gldage.cr.usgs.gov/html_files/ofr95-213/TABLE.HTML

Tsunamis

Tsunamis: an interactive, on-line, Tsunami information resource *URL:* http://www.geophys.washington.edu/tsunami/welcome.html

West Coast & Alaska Tsunami Warning Center Home Page
URL: http://www.alaska.net/~atwc

National Geophysical Data Center (NGDC), Boulder, Colorado, Tsunami Data
URL: http://www.ngdc.noaa.gov/seg/hazard/tsu.html

FEMAfact sheet on tsunamis
URL: http://www.fema.gov/fema/tsunamif.html

Volcanoes

U.S. Geological Survey page on volcanoes
URL: http://www.usgs.gov/themes/volcano.html

Cascades Volcano Observatory
URL: http://vulcan.wr.usgs.gov/home.html

Alaska Volcano Observatory
URL: http://www.avo.alaska.edu/

Hawaiian Volcano Observatory
URL: http://hvo.wr.usgs.gov/

Volcano Systems Center, University of Washington
URL: http://www.vsc.washington.edu/

Wildfires

Fact sheet on wildfires from the Biological Resources Division of the U.S. Geological Survey
URL: http://www.nbs.gov/pr/factsheet/firerr.html

Fact sheet on the role of fire in forest ecosystems from the Midcontinent Ecological Science Center (MESC), Biological Resources Division, U.S. Geological Survey, and the University of Arizona's Laboratory of Tree-Ring Research.
URL: http://www.mesc.nbs.gov/rbriefs/past-fires.html

Appendix C

Abbreviations and Acronyms

ADGGS	The Alaska Division of Geological and Geophysical Surveys
AID	Agency for International Development
ATM	Asynchronous Transfer Mode
ASC	Advanced Systems Center (USGS)
ARPANET	Advanced Research Projects Agency Network
ATWC	Alaska Tsunami Warning Center
AVC	Alaska Volcano Center
AVHRR	Advanced Very High Resolution Radiometer
AVO	Alaska Volcano Observatory
BIA	Bureau of Indian Affairs
BLM	Bureau of Land Management
CAC	Civil Applications Committee
CASI	Compact Airborne Spectrometer
CATS	Consequences Assessment Tool Set
CATV	Cable Television
CDC	Centers for Disease Control
CENR	Committee on Environment and Natural Resources
COE	Corps of Engineers
CPAS	Cellular Priority Access System
CPROST	Centre for Policy Research on Science and Technology
CRS	Congressional Research Service
CVO	Cascades Volcano Observatory
DAAC	Distributed Active Archive Center
DCI	Director of Central Intelligence
DEM	Digital Elevation Model
DFO	Disaster Field Office
DII	Disaster Information Infrastructure
DISA	Defense Information Systems Agency

DISN	Defense Information Systems Network
DITF	Disaster Information Task Force
DM	Disaster Management
DMS	Defense Message System
DMSP	Defense Meteorological Satellite Program
DOC	Department of Commerce
DoD	Department of Defense
DOI	Department of the Interior
DOMS	Director of Military Support
DOS	Department of State
DSN	Defense Switched Network
DSWA	Defense Special Weapons Agency
DTS	Diplomatic Telecommunications Service

EAS	Emergency Alert System
EBS	Emergency Broadcast System
EC	Executive Committee
EDC	Earth Resources Observation Systems Data Center
EENET	Emergency Education Network
EII	Emergency Information Infrastructure
EIIP	Emergency Information Infrastructure Partnership
EM	Emergency Management
E-mail	Electronic Mail
EMC	Environmental Modeling Center
EMI	Emergency Management Institute
EMWIN	Emergency Management Weather Information Network
EO	Executive Order
EOC	Emergency Operations Center
EOP	Emergency Operations Center
EPA	Environmental Protection Agency
EPIX	Emergency Preparedness Information Exchange
ERIM	Environmental Research Institute of Michigan
ERLink	Emergency Response Link
EROS	Earth Resources Observation Systems
ERTS	Earth Resources Technology Satellite
ESF	Emergency Support Functions
ESIC	Earth Science Information Center

EST	Eastern Standard Time
EU	European Union
FAQ	Frequently Asked Questions
FCC	Federal Communications Commission
FEMA	Federal Emergency Management Administration
FERC	Federal Energy Regulatory Commission
FRP	Federal Response Plan
FTP	File Transfer Protocol
FWS	Fish and Wildlife Service
GATF	Government Applications Task Force
GDIN	Global Disaster Information Network
GEMINI	Global Emergency Management Information Network Initiative
GETS	Government Emergency Telephone Service
GIS	Geographic Information System
GOES	Geostationary Operational Environmental Satellite
GPS	Global Positioning System
HA	Humanitarian Assistance
HAZUS	Hazards, U.S.
HPC	Hand-Held Personal Computer; Hydrometeorological Prediction Center
HVO	Hawaiian Volcano Observatory
HYDICE	Hyperspectral Digital Imagery Collection Equipment
IDN	Integrated Digital Network
IDNDR	International Decade for Natural Disaster Reduction
IDP	Imagery Derived Products
IETF	Internet Engineering Task Force
IFRC	International Federation of Red Cross
IFSAR	Interferometric Synthetic Aperture Radar
IJC	International Joint Commission
IISIS	Interactive Intelligent Spatial Information System
IPO	Integrated Program Office
IR	Infrared
ISDN	Integrated Services Digital Network
ISI	Institute of Scientific Information

ITC	Independent Telephone Company
JBS	Joint Broadcast System
LDAP	Lightweight Directory Applications Protocol
LEO	Low Earth Orbit
LS	Landsat
LWIR	Long-Wavelength Infrared
MAC	Mapping Applications Center
MCMC	Mid-Continent Mapping Center
MOU	Memorandum of Understanding
MPC	Marine Prediction Center
MSS	Multispectral Scanner
NAPA	National Academy of Public Administration
NASA	National Aeronautics and Space Administration
NCAP	National Civil Application Program
NCCEM	National Coordinating Council on Emergency Management
NCEP	National Centers for Environmental Prediction
NCS	National Communications System
NDIN	National Disaster Information Network
NDRD	Natural Disaster Reference Database
NDIS	National Disaster Information Systems
NEIC	National Earthquake Information Center
NEMIS	National Emergency Management Information System
NERIN	National Emergency Response Information Network
NGDC	National Geophysical Data Center
NGI	Next Generation Internet
NGO	Non-Government Organization
NHC	National Hurricane Center
NHRAIC	National Hazards Research and Applications Information Center
NIFC	National Interagency Fire Center
NII	National Information Infrastructure
NIMA	National Imagery and Mapping Agency
NIST	National Institute of Standards and Technology
NI/USR	National Institute for Urban Search and Rescue

NOAA	National Oceanic and Atmospheric Administration
NPS	National Park Service
NRC	National Research Council; National Response Center
NRCS	National Resources Conservation Service
NRT	National Response Team
NSEP	National Security/Emergency Preparedness
NSF	National Science Foundation
NSSL	National Severe Storms Laboratory
NTM	National Technical Means
NWS	National Weather Service
OAS	Organization of American States
OFDA	Office of Foreign Disaster Assistance
OMNCS	Office of the Manager, National Communications System
OSD	Office of the Secretary of Defense
OSTP	Office of Science and Technology Policy
PCGRIDDS	Personal Computer-Based Gridded Interactive Display and Diagnostic System
PCS	Personal Communications System
PDC	Pacific Disaster Center
PDD	Presidential Decision Directive
PLRB	Property Loss Research Bureau
PPP	Public–Private Partnership
PTWC	Pacific Tsunami Warning Center
PVO	Private Volunteer Organization
R&R	Response and Recovery
RIMS	Response Information Management System
SAIC	Scientific Applications International Company
SALEMDUG	State and Local Emergency Managers Data Users Group
SEA WIFS	Sea-Viewing Wide-Field-of-View Sensor
SEMS	Standardized Emergency Management System
SIPRNet	Secure Internet Protocol Router Network
SITREP	Situation Report
SNDR	U.S. Subcommittee on Natural Disaster Reduction

SONET	Synchronous Optical Network
SPC	Storm Prediction Center
SURGE	Synthesis of User Requirements for GDIN Working Group Evaluation
SWIR	Short-Wavelength Infrared
TCP/IP	Transmission Control Protocol/Internet Protocol
TM	Thematic Mapper
TPC	Tropical Prediction Center
TSP	Telecommunications Service Priority
UAF/GI	University of Alaska Fairbanks/Geophysical Institute
UAV	Unmanned Airborne Vehicle
UK	United Kingdom
UN	United Nations
UNDP	UN Development Programme
URL	Uniform Resource Locator
U.S.	United States
USBR	U.S. Bureau of Reclamation
USCG	U.S. Coast Guard
USDA	U.S. Department of Agriculture
USERID	User Identification
USFS	U.S. Forest Service
USG	U.S. Government
USGS/ASC	U.S. Geological Survey/Advanced Systems Center
VPN	Virtual Private Network
WAFS	World Area Forecast System
WC/ATWC	West Coast/Alaska Tsunami Warning Center
WDC	Western Disaster Center; World Data Center
WMO	World Meteorological Organization (UN)
WWW	World Wide Web

The GDIN Vision

A robust, integrated, virtual network for cooperative exchange of timely, relevant information used during all phases of disaster management to save lives and reduce economic loss.