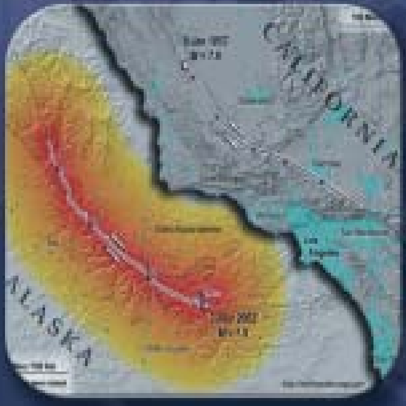
Reducing Disaster Vulnerability Through Science and Technology

National Science and Technology Council
Committee on the Environment and Natural Resources

An Interim Report of the
Subcommittee on Disaster Reduction

July 2003



sdr
subcommittee on disaster reduction

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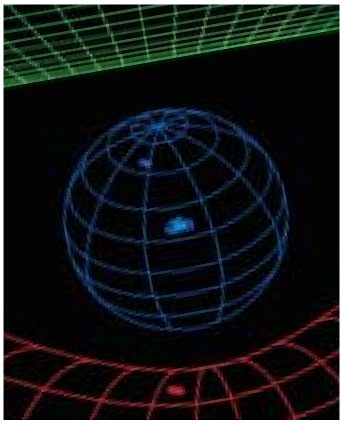


Contents

KEY TERMS

For the purposes of this paper, the following terms are defined as follows:

Disaster – the result of a hazard event involving injury or loss of human life, damage or loss of property, or disruption of economic activity

Hazard – a naturally occurring or human-made phenomenon that may result in disaster when occurring in a populated, commercial, or industrial area

Risk – the likelihood and probability of loss

All-hazards approach – an integrated hazard management strategy that incorporates planning for and consideration of all potential natural and technological hazard threats, including terrorism

Disaster risk – the chance of a hazard event occurring and resulting in disaster

Hazard event – a specific occurrence of a hazard

Hazard risk – the chance of a hazard event occurring

Natural disaster – a disaster that results from a natural hazard event

Natural hazard – a hazard that originates in natural phenomena (hurricane, earthquake, tornado, etc.)

Technological disaster – a disaster that results from a technological hazard event

Technological hazard – a hazard that originates in accidental or intentional human activity (oil spill, chemical spill, building fires, terrorism, etc.)

Executive Summary

Today, the United States and many parts of the world are at significant risk of natural and technological disaster. Escalating population growth along coastlines, fault zones, and other hazardous areas means increasing numbers of Americans live and work—often unknowingly—in harm's way. With the specter of increased technological (anthropogenic) hazards—including terrorism—modern hazards pose even more ubiquitous threats. The imperative to prepare for and protect against these threats touches every American community.

Despite these threats, advances in science and technology are improving the nation's ability to prevent hazards from becoming disasters. Scientific breakthroughs and advanced technologies are being applied to every facet of hazard risk reduction, including precision storm modeling, earthquake shake tables, and innovative mitigation and risk communication techniques. These advances mean that natural and technological hazard events no longer inevitably lead to catastrophic disaster for the communities they threaten.

Scientific and technological advances developed in the arena of natural and technological disasters also can directly benefit terrorism preparedness and response. Addressing the threats posed by terrorism requires a close look at existing and emerging hazard risk-reduction techniques and tools. A common, all-hazards approach is necessary to effectively address all disaster risks—accidental, intentional, or natural.

This report reflects the combined knowledge of the Subcommittee on Disaster Reduction (SDR) of the President's National Science and Technology Council (NSTC). Its purpose is to provide an overview of the hazard risks facing the nation, identify the common links between technological and natural hazard risk reduction, review the U.S. Government's current efforts to increase the nation's disaster resiliency through research and implementation of new tools and technologies, and identify issues and opportunities for the future.

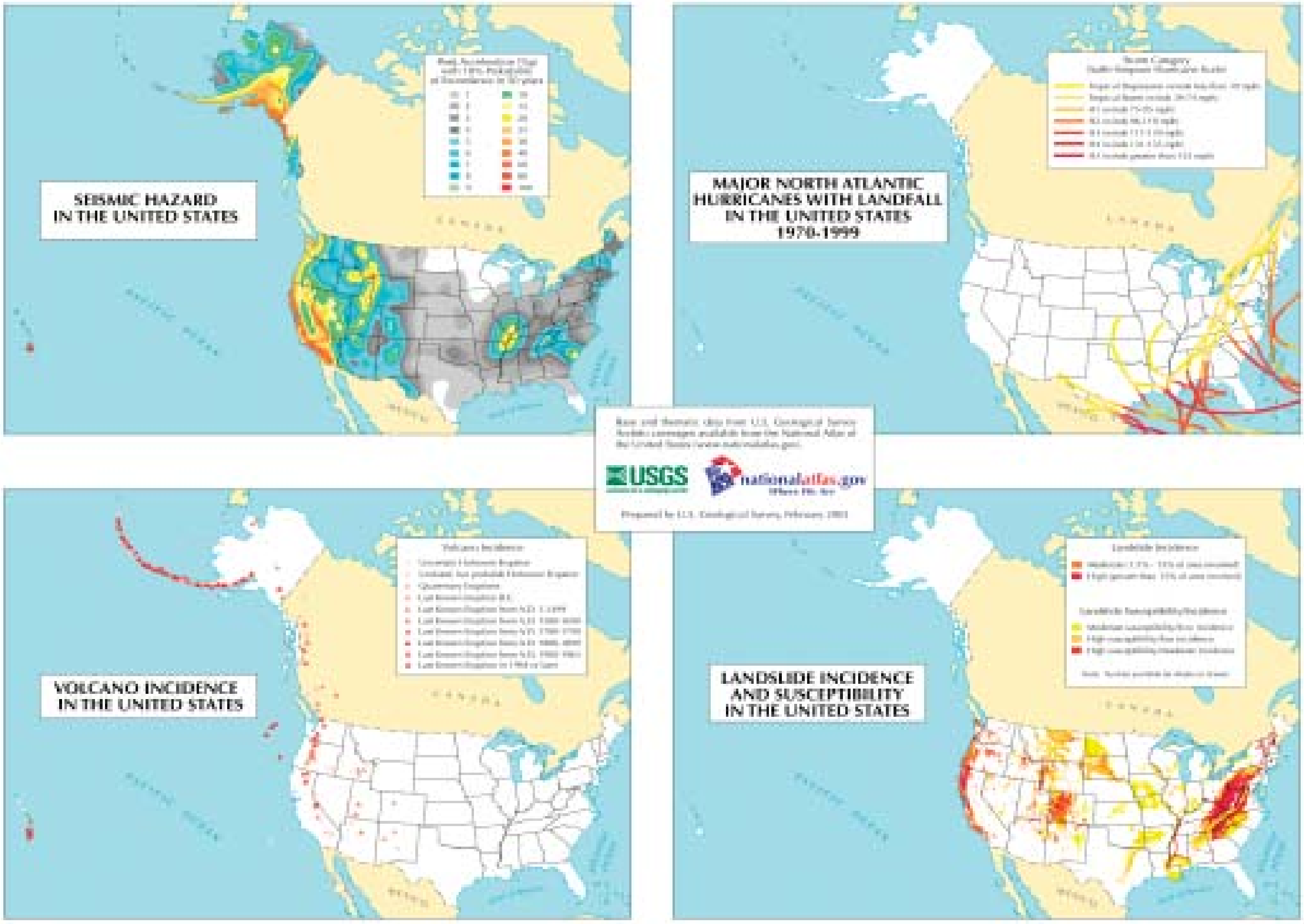
America at Risk

The extraordinary natural, climatic, and geographic diversity of the United States exposes the nation to a wide range of natural hazards. Modern industrial practices, dependency on critical infrastructures, and unforeseen interdependencies among systems make the nation further vulnerable to serious technological disasters. These factors, combined with increased population densities and property development in hazard zones, have dramatically heightened the nation's disaster risk. Although there is no system in either the private or public sectors for consistently compiling comprehensive disaster costs, conservative estimates indicate at least $20 billion annually in loss of life and property, disruption of commerce, and response and recovery costs. Section II of this report reviews the risks and costs associated with:

- Extreme weather events, including hurricanes, flooding, tornadoes, and drought
- Wildfires
- Earthquakes, volcanoes, and landslides
- Disease epidemics
- Technological disasters, including critical infrastructure threats, oil and chemical spills, and building fires.

Understanding Disaster Risk Reduction

Reducing disaster vulnerability requires increasing knowledge about the likelihood and consequences of natural and technological hazards, and empowering individuals, communities, and public agencies with that knowledge to lower risk before, and respond effectively after, hazard events. Increasing this knowledge depends on focusing science and technology investment to improve disaster resiliency at all stages of disaster management by identifying and meeting needs and closing knowledge gaps wherever possible. Techniques for



addressing traditional hazards also can be applied immediately to terrorism preparedness, mitigation, and response to improve the nation's capacity to address all hazard events.

The agencies of the SDR have identified six important areas that require continued energy and appropriate resources to meet the challenges of future hazard risk reduction for the nation:

1. Leverage existing knowledge of natural and technological hazards to address terrorism events
2. Improve hazard information data collection and prediction capability
3. Ensure the development and widespread use of improved hazard and risk assessment models and their incorporation into decision support tools and systems
4. Speed the transition from hazard research to hazard management application
5. Increase mitigation activities and incentives
6. Expand risk communication capabilities, especially public warning systems and techniques.

Current interagency and nationwide efforts to address these gaps are summarized in Section III of this report. Section IV identifies nationwide programs and international initiatives to reduce disaster vulnerability.

Development of a Strategic Science and Technology Framework for Disaster Reduction

To ensure maximum effectiveness, an all-hazards approach to disaster risk reduction must take full advantage of the nation's wealth of scientific knowledge, expertise, and advanced technologies. To that end, the member agencies of the SDR have begun a comprehensive effort to develop a long-term science and technology strategy for reducing disaster vulnerability, as discussed in Section I. The SDR's goal for this effort is the establishment of a coordinated national framework for science and technology research and application development for disaster risk reduction. By establishing this strategic framework, the SDR aims to provide clear advice to the science and technology policy community through an effective Federal architecture for analyzing and reducing national disaster risk over the long term. With the continued support and leadership of senior policymakers in the Congress and the Administration, this active national commitment to reducing disaster vulnerability through enhanced fundamental knowledge and applied science and technology will ensure that American communities can face any hazard threat with confidence and strength.

I. Strategy for the Future: A Disaster Resistant America

In light of the current array of risks, issues, opportunities, and existing programs for hazard risk reduction, the participating agencies of the Subcommittee on Disaster Reduction (SDR) have begun a comprehensive effort to develop a long-term science and technology strategy for reducing disaster vulnerability. The strategy will focus on developing a framework for coordinating and prioritizing fundamental research and applications development for hazard identification, prediction, risk assessment, mitigation, and risk communication. The goal of the effort is to take full advantage of the nation's wealth of scientific knowledge, expertise, and advanced technologies to reduce disaster vulnerability.

The creation of this framework will support identifying and prioritizing needs and gaps in hazard research and application development as well as creating an action plan to meet those needs, linked to current and future budget requirements.

The following principles guide this effort:

1. Invest in fundamental science in broad areas that show promise for meeting and extending end-user requirements
2. Where possible, emphasize the transition of scientific research and development to technology application and deployment
3. Leverage existing knowledge of natural and technological hazards to advance the achievement of homeland security goals in reducing disaster risks associated with terrorism
4. Involve partners (from local to international) to ensure that expertise and practical knowledge from the field informs the development of the framework
5. Ensure that science and technology is deployed in a manner that allows it to be absorbed and assimilated quickly at the state and local levels by drawing upon and integrating the expertise of social and behavioral scientists
6. Enhance effectiveness of existing programs through improved coordination and interagency collaboration.

A Disaster Resistant America—The creation of this framework will support identifying and prioritizing needs and gaps in hazard research and application development as well as creating an action plan for meeting those needs

Building on the issues and opportunities identified in Section III, the SDR has identified key focus areas for the development of a national science and technology framework for disaster reduction, including, but not necessarily limited to, the following:

- **Integrated Observations**. Support the efforts of the Committee on Environment and Natural Resources (CENR) and the Administration to lead the international community in implementing a comprehensive, integrated, global earth-observing system. The hazard support benefits of such a system include the improvement of remote-sensing and land/sea/air *in situ* observing systems for early hazard detection and delivery of timely, high-quality critical observation data to hazard managers. As the first step in building an integrated global observing system, the United States will host an Earth Observation Summit in Washington, DC, in 2003. The SDR will incorporate the vision identified by this summit in the development of the framework.

- **Hazard Mitigation Science and Technology**. Address the applied science and technology needs for the development of a nationwide program for improving engineering, design, and planning techniques for mitigation and promoting their widespread use, preparatory to the development of a national all-hazard mitigation plan.

- **Risk Assessment.** Expand the development and widespread use of risk assessment tools to provide communities with maximum information regarding hazard risk, to support informed decision-making with regard to development and community planning in hazard zones.

- **Risk Communication.** Develop a national risk communication plan that fully leverages advances in science and technology to expand the effectiveness of public warnings during disaster response and pre-disaster public education regarding techniques for preparedness and mitigation. This effort would include an investment in the social and behavioral science dimensions of public response to information and education campaigns, public health and emergency preparedness campaigns, and public warnings.

Throughout 2003-2004, the SDR will provide more detailed recommendations for these as well as other areas of emphasis, and will provide updates in subsequent reports.

By establishing this framework, the SDR aims to provide clear advice to the science and technology policy community through an effective Federal architecture for analyzing and reducing national disaster risk over the long term. In doing so, the SDR will provide an important pillar in the nation's overall effort to increase national security through the effective application of science and technology.

II. Disaster Risk: What's at Stake

The extraordinary natural, climatic, and geographic diversity of the United States exposes the nation to a wide range of natural hazards. Modern industrial practices, dependency on critical infrastructures, and unforeseen interdependencies among systems make the nation further vulnerable to serious technological disasters. These factors combined with increased population densities and property development in hazard zones have dramatically heightened the nation's disaster vulnerability.

Although the September 11 attacks have focused attention on the challenges of preparing communities for the threat of terrorism, the time since then has proven that the threat of natural disasters and accidental technological disasters continues. In 2002 alone, the nation's disaster management attention was taxed by more familiar but increasingly more destructive hazards, including deadly tornadoes; oil spills; building fires; large wildfires in states such as Colorado, Arizona, and Oregon; Hurricanes Lili and Isidore; a major earthquake that threatened the Alaska pipeline; and West Nile virus. Taken together, these hazards posed grave risks to human life, property, and the economy.

Although attention has been focused on the challenges of preparing communities for the threat of terrorism, the time since then has proven that the threat of natural disasters and accidental technological disasters continues.

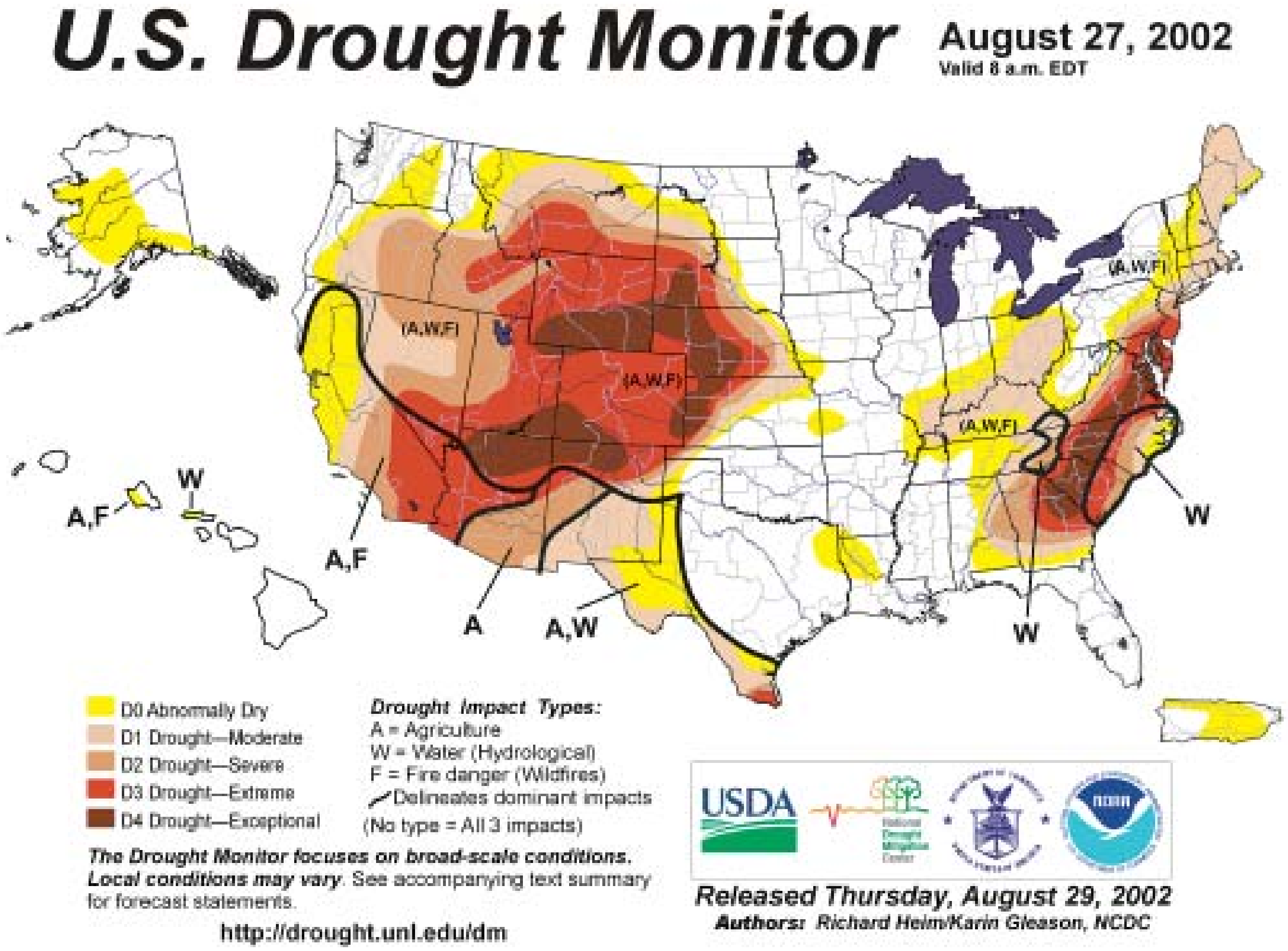
Disasters disrupt nearly every sector of U.S. society, including industry, agriculture and forestry, transportation, schools, hospitals, insurance, recreation and tourism, telecommunications, water, power, and military installations. Although there is no system in either the private or public sectors for consistently compiling comprehensive disaster costs, conservative estimates indicate at least $20 billion annually in loss of life and property, disruption of commerce, and response and recovery costs. Dramatic annual variance in disaster costs makes budgeting for disaster liability a significant challenge for industry and government. Furthermore, the strain on emergency response and reserve personnel diverts time and resources from other critical obligations, making communities more vulnerable to other threats.

Nevertheless, hazard events need not lead inevitably to costly disasters. Through careful planning and application of appropriate information and techniques, communities across the nation can be prepared to withstand hazard events through improved awareness, mitigation, preparedness, and effective public warning. It is essential that the nation continue to seek a fundamental understanding of major hazards, their causes, the changing magnitude and distribution of risk, and their prediction, as well as addressing mitigation, response, and recovery processes.

Extreme Weather

Up to $2.2 trillion of the U.S. economy are believed to be affected annually by weather and climate events.[1] Between 1980 and 2002, the U.S. endured 54 weather-related disasters in which overall damages and costs reached or exceeded $1 billion per event. Of these disasters, 45 occurred during the 1988-2002 period with total damage and related costs of nearly $200 billion for that period.[2] Extreme weather events include the following:

- **Hurricanes and Tropical Storms**. Over the last 30 years, coastal population growth and accompanying property and infrastructure system development have quadrupled. Because of this growth, Americans today are more vulnerable to hurricanes than ever before—more than 45 million people now are permanent residents of hurricane-prone coastlines.[3] This explosive population growth has increased evacuation times for the residents along the Gulf and Atlantic coasts.[4]



"By 1990, Dade and Broward Counties in south Florida were home to more people than lived in all 109 counties along the Gulf and Atlantic coasts from Texas through Virginia in 1930... It is only a matter of time before the nation experiences a $50 billion or greater storm, with multi-billion dollar losses becoming increasingly more frequent."

–C. W. Landsea and R. A. Pielke, NOAA Hurricane Research Division, cited in "A Climatology of Recent Extreme Weather and Climate Events," National Climatic Data Center, October 2000

- **Flooding.** Floods are the most frequent natural disasters—75% of Federal disaster declarations are related to flooding.[5] An increase in population and development in floodplains, along with an increase in heavy rain events during the past fifty years, have gradually increased the economic losses due to flooding.[6] Property damage from flooding totals over $5 billion in the United States each year.[7] Flooding also causes extensive damage and service disruption to the nation's transportation infrastructure, including roads, railroads, and bridges.

- **Drought.** Drought is an extremely complex and widespread natural hazard, affecting more people in the U.S. than any other natural hazard. Annual losses associated with drought have been estimated at $6–8 billion. During the summer of 2002, one-third of the country experienced drought conditions. The magnitude and complexity of drought hazards have increased in association with growing population, the shift of population to drier regions of the country, urbanization, and changes in land and water use.[8]

- **Tornadoes.** Tornadoes are more common in the United States than anywhere else in the world. In an average year, 1,000 tornadoes are reported nationwide, resulting in 70 deaths and over 1,500 injuries.[9] Fortunately, due to improved forecasting, detection, communications, and public awareness, tornado death figures continue to decline in spite of population growth. However, more tornado-related disasters were declared in the 1990s than in any other recent period, including a record of 17 declarations issued in 1998. For the decade, a total of 102 such disasters were declared at a cost of more than $1.72 billion in Federal Emergency Management Agency (FEMA) assistance.[10]

Wildfires

The extreme fire seasons of 1988, 1996, 2000, and 2002 have seen the largest areas burned by wildfires in the U.S. since the 1960s. In the summer of 2000, wildland fire burned 8.4 million acres and destroyed nearly 900 structures. The estimated Federal cost of wildfire suppression in 2000 was $1.36 billion, about twice the cost in 1996. This does not include the costs to communities in terms of structural losses or economic disruption, or the cost to local and state agencies and the Army Corps of Engineers (USACE), which also support fire suppression efforts.

In the period 2000-2002, the average area burned annually by wildfire was approximately 6.6 million acres, and scenes of wildfire engulfing thousands of acres and encroaching on residential neighborhoods have become all too familiar. Tens of millions of acres of American wildlands are still at risk of catastrophic fire due to disruptions in historic fire cycles, drought, and other factors. While programs to decrease fuel loads and hazards to communities have increased substantially and are expected to lead to decreased costs in the future, the costs of wildfire suppression and the economic damage to communities and resources are likely to grow in the near term.

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Disaster and Potential Disaster Risk Examples

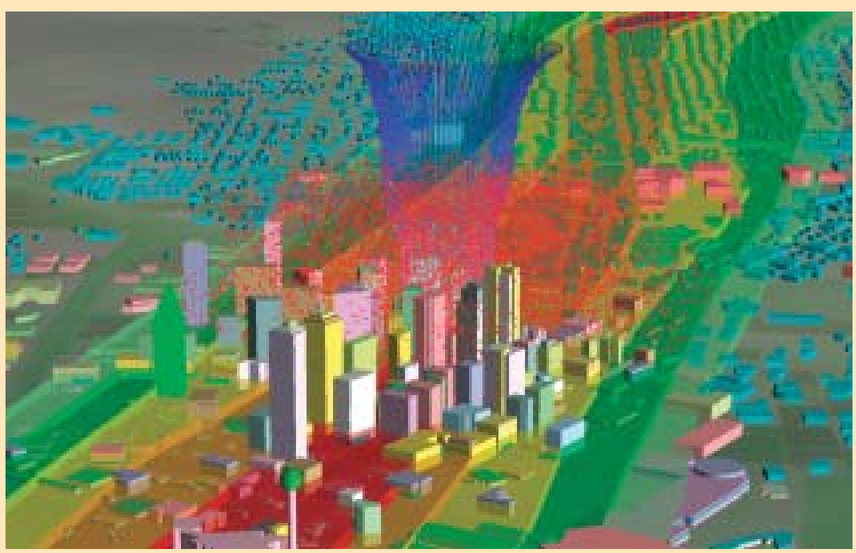
Scenario: Tornado Strikes Dallas!

THE TORNADOES THAT STRUCK the Oklahoma City area on May 3, 1999, were some of the most devastating tornadoes in U.S. history, causing over $1 billion in damage and destroying over 2,500 structures. With such a large impact, other urban areas in Tornado Alley were forced to consider their own susceptibility and preparedness. As part of the Spring 2000 severe-weather planning season, The North Central Texas Council of Governments, in cooperation with the National Weather Service in Fort Worth, engaged in a Tornado Damage Risk Assessment. The project estimated the potential impact of a major tornado outbreak to the Dallas-Fort Worth Metroplex, home to 5 million people, 1 million houses, and 60 thousand commercial structures.

Tornado damage paths from the Oklahoma outbreak were transposed across the Metroplex, and a statistical profile of each impacted area was generated. Five main scenarios were tested in which 53 of the damage paths were centered as a group over five different locations. Of the five scenarios, the lowest damage estimates (Scenario 2) approached $800 million. In the worst case (Scenario 5), 84,000 residents were affected, with damage estimates exceeding $2.8 billion.

Additionally, 50 paths of the Moore, OK, tornado—the costliest tornado in U.S. history to date—were overlaid on the Dallas area. Looking at the results of the Moore tornado 50-series test, 31 of the 50 paths would likely have produced property losses greater than $1 billion—19 would have exceeded $2 billion. Seven of the paths passed the $3 billion mark. Thirty-eight (38) of the 50 paths would have at least 10,000 structures in the path—10 having more than 30,000. More than half of the paths would have at least 45,000 people living in the impacted residential structures. A tornado of this size and magnitude entering the urban core of the Dallas-Fort Worth Metroplex would represent a grave threat to life and property.

▼ *Excerpted from "Tornado Damage Risk Assessment Dallas-Fort Worth Metroplex," North Central Texas Council of Governments/National Weather Service, Summer 2000*



Earthquake Scenario:

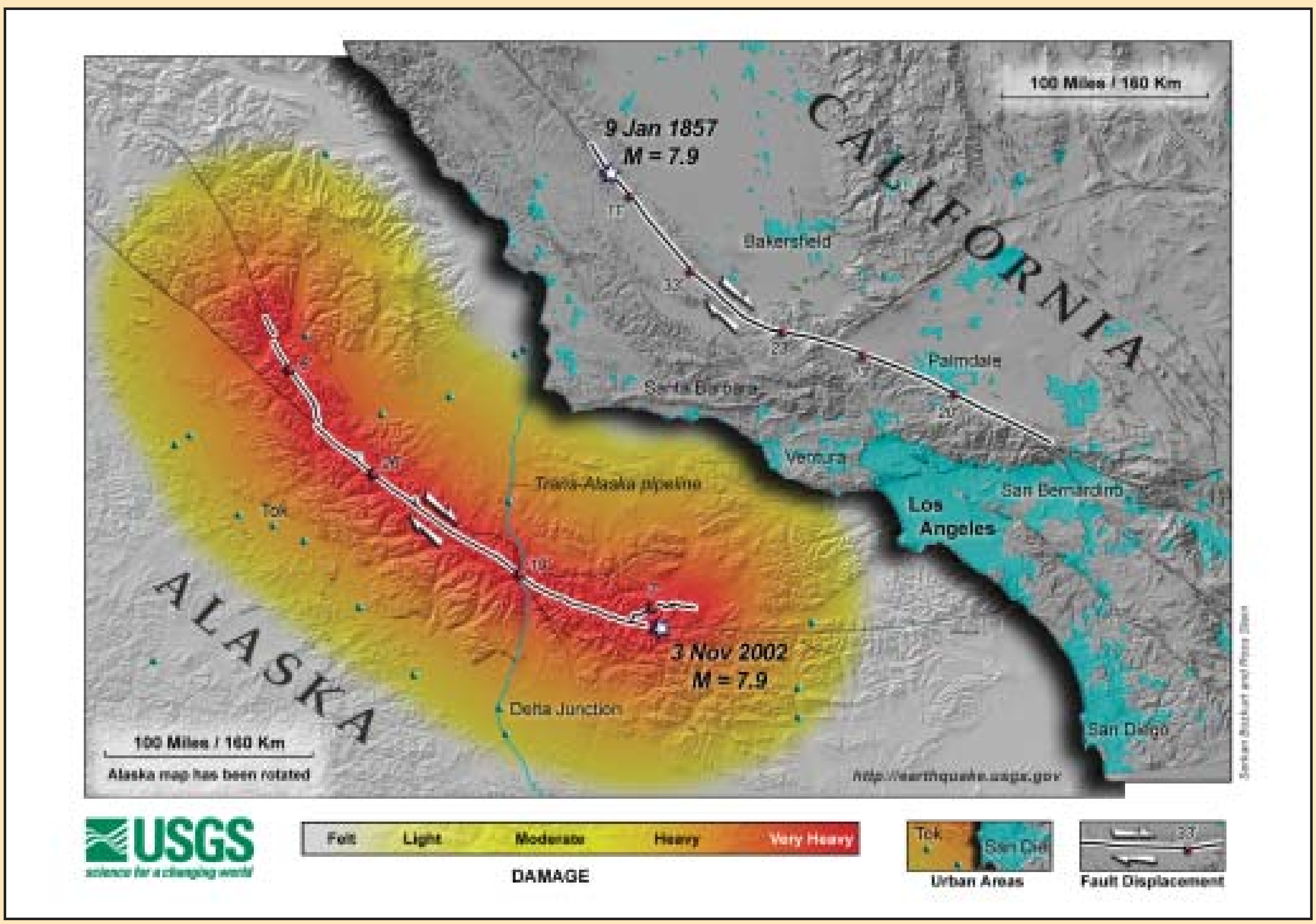
A 7.9 Earthquake Shakes California

"At each of the paleoseismic sites from Wrightwood [California] south, the elapsed time since the most recent large earthquake is significantly longer than the average time between earthquakes . . . the fault may rupture in a large earthquake of 7.6 to 7.8 magnitude in the future. Such an earthquake would be especially hazardous to the San Bernardino-Riverside urban area, which is developed right up to the fault."

Thomas Fumal, Geologist, U.S. Geological Survey

ILLUSTRATED BELOW is the geographic reach of the 7.9-magnitude earthquake that occurred on the Alaska Denali Fault in November 2002, juxtaposed with the site of the 1857 Fort Tejon, CA, earthquake of similar magnitude. The densely populated southeastern end of the fault is overdue for seismic activity. This graphic, developed by scientists at the U.S. Geological Survey, vividly demonstrates how a 7.9 earthquake along this fault line in California would have devastating effects on the highly developed areas it underlies.

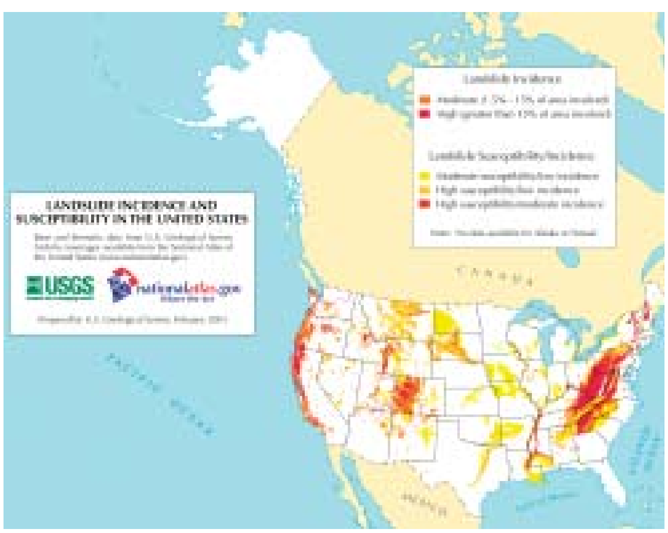
▼ *About 20 percent of the nation's 530,000 highway system bridges are potentially prone to earthquake damage.*



Earthquakes

Earthquakes are often the source of the most unpredictable and deadly natural disasters. Each year the United States experiences thousands of earthquakes with an average of seven at a magnitude of 6 or larger—large enough to cause serious damage.[11] Seventy-five million Americans in 39 states face significant risk from earthquakes.[12] Although major advances have been achieved in understanding and mitigating earthquake hazards, earthquakes remain one of the nation's most significant hazard threats. In a ranking of FEMA relief costs, for example, the cost of the Northridge, California earthquake of 1994 dwarfs all other natural disaster statistics. FEMA obligated almost $7 billion for Northridge, exceeding the relief costs of Hurricanes Georges, Andrew, Floyd, and the 1993 Midwest floods combined.[13] As the population increases, expanding urban development and construction encroach upon areas susceptible to earthquake impacts, increasing the risk to life and property resulting from earthquake hazards.[14] However, increased Federal efforts at earthquake disaster risk reduction can enhance protection of buildings even in these high-risk areas.

Close view of a volcano erupting incandescent molten lava fragments.



Hazard map prepared by the U.S. Geological Survey, February 2003, illustrating landslide incidence and susceptibility in the U.S.

Volcanoes

The United States is among the most volcanically active nations in the world, with nearly 70 active or potentially active volcanoes.[15] During the 20th century, volcanic eruptions in Washington, California, Alaska, and Hawaii devastated thousands of square miles and caused substantial economic and societal disruption and loss of life. Even with improved ability to identify hazardous areas and predict eruptions, increasing numbers of people face volcanic hazard as a potential danger.[16] Volcanic ash is also a serious danger. Ash plumes ejected into the atmosphere pose costly and potentially deadly dangers to aircraft, even when flying thousands of miles away from the eruption.[17] One Boeing 747 alone sustained $80 million in damage when it encountered ash from Mount Redoubt in Alaska.[18]

Landslides

Landslide hazards include various kinds of slope failure: slumps, slow- and fast-moving debris-flows, and rockfall, either triggered by intense rainfall or (more rarely) by earthquakes. Landslides affect every state, causing about $1-2 billion in damage and more than 25 fatalities each year in the United States;[19] they pose serious threats to critical infrastructure distribution systems, transportation, and housing, as well as to infrastructure that supports fisheries, tourism, timber harvesting, mining, and energy production. Extreme erosion and sedimentation events following high-intensity rainfall or wildfires cause additional billions of dollars of damage annually, impair quality of water supplies, and decrease soil productivity in upland areas.

Disease Epidemics

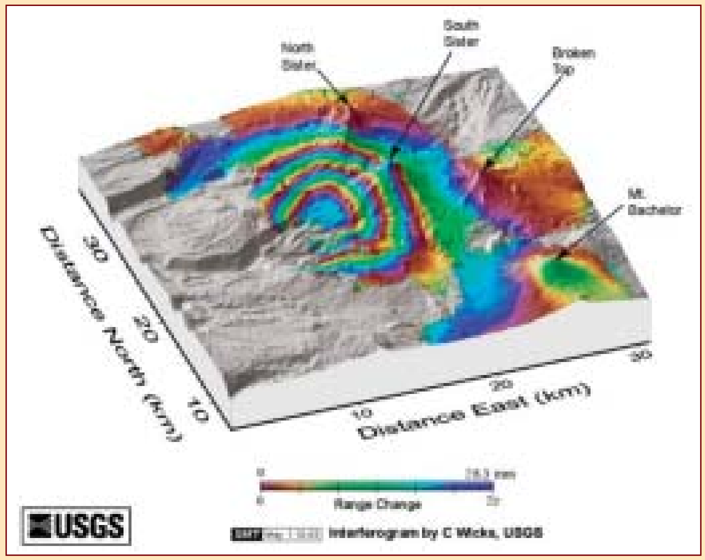
While disease outbreaks often lack the sudden onset aspect of other disaster scenarios, they may potentially present an even greater threat to the U.S. population. For example, the West Nile virus epidemic of 2002 demonstrates how such outbreaks quickly can become a public health emergency. The epidemic exposed vulnerabilities in the public health system that served as both a warning and a wake-up call for the nation. In this case, few labs in the country were equipped to detect the virus, thus delaying detection of the disease.

Potential Disaster Risk Example

The Three Sisters

THE CASCADE MOUNTAIN RANGE, which extends from northern California to the Canadian border, includes 13 active or potentially active volcanic centers, three of which lie close to rapidly growing communities and resort areas in the Pacific Northwest.[20]

Among these is the Three Sisters volcanic center in central Oregon, which produced a series of young prehistoric eruptions dating back 1,500 years. Recently, scientists from the U.S. Geological Survey and the University of Oregon-Corvallis have detected renewed activity beneath this previously quiescent volcanic center. Data from space-based, interferometric synthetic aperture radar shows that a circular area 20 km across was "uplifted" by as much as 10 cm (4 inches) in its center from 1996 to 2000.



This slow but continuous uplift is most likely caused by magma accumulation at a depth of 6.5 km in the Earth's crust. This inflation has continued at least into 2002, and whether it will soon lead to an eruption is not known. If inflation continues and shallow earthquakes start to occur, an eruption may soon follow. If inflation ceases, continued monitoring is essential to gain increased insight into the eruption cycles of this center. The U.S. Geological Survey has deployed seismic and other equipment to the area of uplift, to capture as complete a record of this intrusive event as possible.[21]

Even more significant was the lack of communication between veterinarians and human health professionals. In 2002 alone, West Nile Virus killed 241 people and hundreds of thousands of birds and mammals.[22]

The advent of SARS is a timely reminder of the urgency of disease outbreaks as a serious public health concern and the need for improved public health monitoring and safety mechanisms.[23]

Technological Disasters

Technological disasters are commonly defined as emergencies characterized by a sudden threat to lives, property, public health, or the environment, arising from a failure of critical infrastructure systems or the release, or potential release, of oil, radioactive materials, or hazardous chemicals into the air, land, or water. These emergencies may occur from transportation accidents, events at facilities that use or manufacture chemicals, or as a result of natural or man-made hazard events.[24] While these incidents are most often accidental, intentional acts of sabotage must increasingly be considered as a discrete category of technological disaster. Technological disasters include:

- **Critical Infrastructure Threats**. Critical infrastructure is defined as "the linked system of facilities and activities vital to providing services necessary to support the nation's economy and quality of life... including electrical power, medical and public health services, transportation, oil and gas production and storage, water supply, emergency services, government services, banking and finance, and telecommunications."[25] These systems are increasingly varied and complex, and are operated with increasingly sophisticated information technology systems. The integration of aging civil infrastructure systems into larger networks and the associated loss of redundancy can lead to reduced reliability and intricate interdependencies. Failure of particular components or subsystems within these critical infrastructures can incapacitate the entire system.[26] Moreover, deregulation, mergers, consolidation of resources, and downsizing have resulted in reduced reserves and capacity. In addition, too few professionals are trained in complex system management to meet future needs.

Property losses do not account for loss of productivity and impact to the environment, secondary costs such as fire safety training, or economic implications of fire safety requirements.

- **Oil and Chemical Spills and Accidents**. Almost 14,000 oil spills are reported each year in the U.S., mobilizing thousands of specially trained emergency response personnel and challenging the best-laid contingency plans. Although many spills are contained and cleaned up by the party responsible for the spill, some spills require assistance from local and state agencies, and on occasion, the Federal Government.[27] Similarly, the safe handling of industrial chemicals became a significant priority for disaster managers worldwide following the 1984 accident at Union Carbide's Bhopal, India, factory that killed more than 2,000 people.[28]
- **Building Fires**. In 1999, building fires caused $10 billion in property damages, more than 4,000 deaths (including 100 firefighters) and 100,000 injuries.[29] Property losses do not account for loss of productivity and impact to the environment, secondary costs such as fire safety training, or economic implications of fire safety requirements. The number of deaths due to fire has decreased during the past 30 years as a result of revised fire standards and codes, yet property losses remain about the same as reported in 1973, when annual property losses exceeded $11 billion.[30]

III. Understanding Disaster Risk Reduction: Issues and Opportunities

The axiom "knowledge is power" is central to disaster risk reduction. Reducing disaster vulnerability requires increasing knowledge about the presence, imminence, and consequences of natural and technological hazards, and empowering individuals, communities, and public agencies with that knowledge to lower risk before, and respond effectively after, hazard events. Increasing this knowledge depends on focusing science and technology investment to improve disaster resiliency at all stages of disaster management by identifying and meeting needs and closing knowledge gaps wherever possible.

Techniques for addressing traditional hazards also can be applied immediately to terrorism preparedness, mitigation, and response to improve the nation's capacity to address all hazard events. Developing greater national resiliency to all disasters is a central tenet of efforts to improve homeland security.

In developing the nation's all-hazards approach to disaster vulnerability reduction, no single Federal agency can provide a fully comprehensive solution. Agencies must work together to narrow program gaps through a coordinated science and applications research agenda to pursue common solutions for common problems. Forging this interagency collaboration is one of the highest priorities of the National Science and Technology Council's (NSTC's) Subcommittee on Disaster Reduction (SDR). The agencies of the SDR have identified six important areas that require continued energy and appropriate resources to meet the challenges of future hazard risk reduction for the nation:

1. Leverage existing knowledge of natural and technological hazards to address terrorism events
2. Improve hazard information data collection and prediction capability
3. Ensure the development and widespread use of improved hazard and risk assessment models and their incorporation into decision support tools and systems
4. Speed the transition from hazard research to hazard management application
5. Increase mitigation activities and incentives
6. Expand risk communication capabilities, especially public warning systems and techniques.

These areas, along with a variety of corresponding interagency programs and activities, require continued attention and appropriate resources to meet the challenges of disaster risk reduction for the nation.

1. Terrorism, Natural, and Technological Hazards – Leveraging Existing Knowledge

Protecting American communities from disasters, no matter what the source, depends on policymakers adopting an integrated, all-hazards approach to disaster risk reduction, drawing on existing knowledge from natural and accidental hazards combined with new information on risks associated with technological and terrorism events.

Dr. Kenneth Bloem of the Johns Hopkins University Center for Civilian Biodefense Studies has identified a number of parallel areas where preparing for terrorist incidents can be enhanced by decades of research in traditional disaster areas:

- Wildfires and arson
- Accidental explosions and bombs
- Floods and dam sabotage
- Chemical spills and chemical attacks
- Epidemics and biological terrorism.[31]

Planning and preparedness for one disaster may have unforeseen beneficial effects for another.

For example, the nation's experience in managing earthquake disasters is directly relevant to managing terrorist threats to the nation's buildings, transportation, and industrial infrastructure, commonly referred to as "the built environment." The widespread application of earthquake hazard reduction principles could improve the design and construction of the nation's buildings to standards that could better withstand the disastrous effects of explosive blasts.

Elements of Disaster Risk Reduction & Hazard Management

THE HAZARD RESEARCH AND MANAGEMENT COMMUNITY employs a range of terminology to describe its activities, but no definitive, comprehensive list of these terms and their definitions exists. However, hazard risk reduction and disaster management activities can be grouped largely under nine broad concepts: research and development, hazard identification, risk assessment, risk communication, prediction, mitigation, preparedness, response, and recovery. Each of these rubrics includes critical science and technology elements, and, taken together, they form the nation's toolbox for reducing vulnerability to disaster risk.

1. Disaster Process Research and Development (R&D)—the science activities dedicated to improving understanding of the underlying processes and dynamics of each type of hazard. R&D includes fundamental and applied research on geologic, meteorological, epidemiological, and fire hazards; development and application of remote sensing technologies, software models, infrastructure models, organizational and social behavior models; emergency medical techniques; and many other science disciplines applicable to all facets of disasters and disaster management.

2. Hazard Identification—determining which hazards threaten a given area. This includes understanding an area's history of hazard events and the range of severity of those events. The continuous study of the nation's active faults, seismic risks, and volcanoes are included in this category, as are efforts to understand the dynamics of hurricanes, tornadoes, floods, droughts, and other extreme weather events.

3. Risk Assessment—determining the impact of a hazard or hazard event on a given area. This includes advanced scientific modeling to estimate loss of life, threat to public health, structural damage, environmental damage, and economic disruption that could result from specific hazard event scenarios. Risk assessment takes place both before and during disaster events.

4. Risk Communication—public outreach, communication, and warning at every stage of hazard management. Risk communication includes raising public awareness and effecting behavioral change in the areas of mitigation and preparedness; the deployment of stable, reliable, and effective warning systems; and the development of effective messaging for inducing favorable community response to mitigation, preparedness, and warning communications.

5. Mitigation—sustained actions taken to reduce or eliminate the long-term risk to human life and property from hazards based on hazard identification and risk assessment. Examples of mitigation actions include planning and zoning to manage development in hazard zones, storm water management, fire fuel reduction, acquisition and relocation of flood-prone structures, seismic retrofit of bridges and buildings, installation of hurricane straps, construction of tornado safe rooms, and flood-proofing of commercial structures.

6. Prediction—predicting, detecting, and monitoring the onset of a hazard event. Federal agencies utilize weather forecast models, earthquake and volcano monitoring systems, remote sensing applications, and other scientific techniques and devices to gather as much information as possible about the what, when, and where of a potential hazard, as well as the severity of each threat.

7. Preparedness—the advance capacity to respond to the consequences of a hazard event. This means having plans in place concerning what to do and where to go if a warning is received or a hazard is observed. Communities, businesses, schools, public facilities, families, and individuals should have preparedness plans.

8. Response—the act of responding to a hazard event. Hazard response activities include evacuation, damage assessment, public health risk assessment, search and rescue, fire suppression, flood control, and emergency medical response. Each of these response activities relies heavily on information and communication technologies.

9. Recovery—activities designed to restore normalcy to the community in the aftermath of a hazard event. Recovery activities include restoring power lines, removing debris, draining floodwater, rebuilding, and providing economic assistance programs for disaster victims. As with response, the recovery process relies heavily on the availability of up-to-date data and information about the various community sectors, and on the technology to obtain and communicate that information.

2. Hazard Information Data Collection and Prediction Capability

Over the past 30 years, the United States has made significant strides in the area of hazard information collection and prediction. However, with increasing numbers of the population at risk, the demand for current and accurate hazard risk information continues to outpace its availability. Specific challenges in this arena include:

- Overcoming a lack of upstream weather observations over data-sparse oceans, and when upstream observations are available, improving the assimilation of observation data into current forecasting methods.
- Strengthening linkages between *in situ* observing systems (land/sea/air) and space-based observing systems to provide the most accurate and comprehensive assessment of potential hazards.
- Improving the accuracy of navigational charts and other geospatial tools necessary for locating and tracking dangerous oil spills and other water-borne pollutants.
- Increasing the observational base for monitoring seismic activity to improve notification and ability to forecast earthquakes and their effects.
- Improving the ability to predict structural and nonstructural response of the built environment when subjected to earthquakes, e.g., through performance-based earthquake engineering.
- Improving understanding of the phenomena of volcanic deformation, allowing the ability to distinguish with greater certainty which episodes of deformation will lead to volcanic eruptions.
- Improving observation, monitoring, and prediction capability for wildland fire, including early detection, mapping areas burned, fire severity and behavior, fire effects on atmosphere and ecosystems, potential risks to structures and communities, and post-fire recovery.
- Developing cyber-infrastructure and decision support tools to enhance response and recovery operations.

Significant benefits could accrue from improved extreme weather prediction, *such as hurricane landfall location. Greater certainty in forecasted hurricane landfall would sharply reduce the costs associated with "over-warning." The average hurricane warning for 300 miles of coastline costs about $50 million for boarding up homes and closing businesses. Scientists believe that improving landfall track forecasts by 20 percent is possible over the next several years to reduce unnecessary warnings.*

Congressional Natural Hazards Caucus Fact Sheet: Hurricanes, p. 2, http://www.agiweb.org/workgroup/hurricanes0701.pdf

Related Interagency Activities

Joint Center for Satellite Data Assimilation (JCSDA)

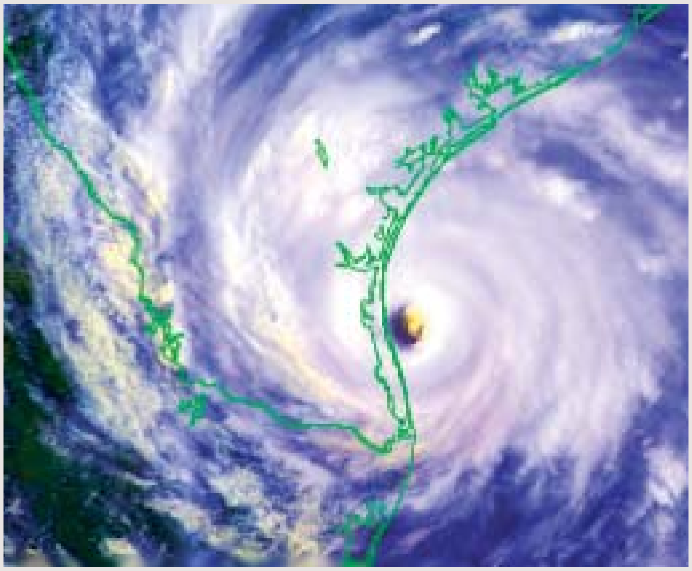
Participating Agencies: NOAA, NASA, DOD

JCSDA is a multi-agency cooperative effort to improve numerical weather prediction models, weather outlooks, and the effective use of environmental satellite data. NASA is responsible for technology development, demonstration and improved sensor capability, as well as model development for scientific use; DOD identifies military weather forecasting requirements; and NOAA identifies national weather forecasting requirements.

Integrated Earth Observation System

Participating Agencies: NOAA, NASA

Because no single country can adequately observe the complex workings of the global dynamics of the atmosphere, land, and ocean, a concerted international approach is required to implement a comprehensive, integrated, global earth-observing system. Such a system would integrate existing research and operational instruments and sensors from both fixed and moving platforms; communication links between measurement platforms, science modeling laboratories and application development centers; and computing capacity. As an important step in building such a system, the United States will host an Earth Observation Summit in Washington, DC, in 2003.



Multi-Hazard Flood Map Modernization

Participating Agencies: FEMA, USACE, USGS, TVA, USDA, NOAA

FEMA is undertaking a transformation of the nation's flood hazard maps, an essential tool for flood hazard mitigation in the United States. In FY2003, FEMA began a focused Map Modernization effort to update flood hazard data while converting the format from a paper map system to a digital one. Furthermore, the new format will provide the capability to broaden the scope of risk management from a single hazard focus to a multi-hazard focus. It is envisioned that the base maps needed for context, along with the system needed for development and distribution of flood hazard data and maps, will also support development and distribution of geospatial data of all-hazards, including those that are man-made.

EarthScope

Participating Agencies: NSF, USGS, NASA

EarthScope is an effort to apply modern observational, analytical, and telecommunications technologies to investigate the long-term structure and evolution of the North American continent and the physical processes controlling earthquakes and volcanic eruptions. When fully deployed, EarthScope's components will include modern digital seismic arrays, global positioning satellite receivers, strainmeters and new satellite radar imagery, and an observatory deep within the San Andreas Fault.

Advanced National Seismic System (ANSS)

Participating Agencies: USGS, NSF

The ANSS is a dense, nationwide network of 7,000 shaking measurement systems primarily in urban areas, both on the ground and in buildings that, when deployed, will make it possible to provide emergency response personnel with real-time earthquake information, provide engineers with information about building and site response, and provide scientists with high-quality data to understand earthquake processes and solid earth structure and dynamics. Its greatest potential lies in earthquake warning, where even a few seconds of notice could trigger automatic safety shutdowns of critical infrastructure systems such as natural gas pipelines and electrical power systems, and also signal the community to brace for an earthquake. The implementation of the ANSS is carried out in coordination with regional advisory/steering committees.

Southern California Earthquake Center (SCEC)

Participating Agencies: NSF, USGS, NASA

SCEC, headquartered at the University of Southern California, is a regionally focused consortium founded in 1991 with a mission to gather new earth science information about earthquakes in southern California, integrate knowledge into a comprehensive and predictive understanding of earthquake phenomena, and communicate this understanding to end-users and the general public in order to increase earthquake awareness, reduce economic losses, and save lives.

National Ice Center (NIC)

Participating Agencies: USN, NOAA, USCG

The NIC is a multi-agency operational center organized to provide global, regional, and tactical scale sea ice analysis and forecasts tailored to meet the requirements of U.S. national interests, including safety of maritime navigation.

Joint Fire Science Program (JFSP)

Participating Agencies: USDA Forest Service, DOI

The JFSP competitively funds research and technology transfer conducted by Federal agency scientists and their counterparts in universities and other organizations to address critical science needs in fire and fuels management. The program complements the core fire science research efforts of the Forest Service, USGS, and other agencies, and works with the Forest Service's National Fire Plan research program (see Section IV) to provide a sound scientific foundation for reducing risk to communities and natural ecosystems from wildland fire in an economically sound and socially responsible manner, while maintaining the health and productivity of forests and rangelands.

3. Development and Widespread Use of Improved Hazard and Risk Assessment Models

While data acquisition is the critical first step in improving hazard risk information, effective risk assessment modeling is the critical middle step for combining raw facts to quantify the actual risk to a community. Modeling also can be employed to predict the sociological and organizational stress of a hazard event on the general public and the emergency management community itself. The resulting information is indispensable to mitigation, preparedness, and response activities, and promulgation of new risk assessment models is a critical priority for the Government.

The creation of new risk assessment models of the flow between critical infrastructure system components for natural disasters and homeland security would lead to improved vulnerability analysis of system interdependencies. Creating new models around best practices for mitigation and preparedness, such as evacuation planning, also will lead to significant homeland security benefits.

State-of-the-art *earthquake engineering is achieved through experimental and analytical investigation of the behavior of the built environment during earthquakes and through innovative concepts such as performance-based design and consequence-based engineering.*

Related Interagency Activities

HAZUS-MH

Participating Agencies: FEMA, NOAA, NASA, USGS, USACE, Census Bureau

HAZUS-MH (multi-hazard), to be released by FEMA in 2003, is a nationally applicable standardized methodology and software program that will contain models for estimating potential losses from earthquakes, floods, and hurricane winds. Building on the original HAZUS module for earthquake hazard analysis, HAZUS-MH will use state-of-the-art geographic information system software (ArcGIS) to map and display hazards and the results of damage and economic loss estimates for buildings and infrastructure. HAZUS-MH estimates physical damage (damage to residential and commercial buildings, schools, critical facilities, and infrastructure); economic loss (lost jobs, business interruption, and repair and reconstruction costs); and social impacts (impacts to the general public, including requirements for shelters and medical aid).

Seismic Hazard Maps

Participating Agencies: USGS, FEMA, NASA

The Seismic Hazard Maps program develops national and regional maps of earthquake shaking hazards used for creating and updating the seismic design provisions of building codes used in the United States. Buildings, bridges, highways, and utilities built to meet modern seismic design provisions are better able to withstand earthquakes, which not only saves lives, but also enables critical activities to continue with less disruption. USGS scientists have been working with colleagues to revise and update the maps, which include a digital database of expected ground-shaking levels at more than 150,000 sites. The latest versions were released in November 2002.

The George E. Brown, Jr. Network for Earthquake Engineering Simulation

Participating Agencies: NSF, under the auspices of NEHRP (FEMA, NIST, USGS, NSF, NASA)

The National Science Foundation George E. Brown, Jr. Network for Earthquake Engineering Simulation (NEES), when operational in FY2005, will be a networked simulation resource of 15 geographically distributed experimental research equipment sites located at U.S. universities nationwide, including shake tables, geotechnical centrifuges, a tsunami wave basin, large-scale laboratory experimentation systems, and field experimentation and monitoring installations. NEES experimental capabilities and the national data repository will lead to new tools for modeling, simulation, and visualization of site, structural, and nonstructural response to earthquakes and tsunami effects, producing results that can be adopted into building codes and engineering practice. NEES is under construction during FY2000-FY2004 and will be operated during FY2005-FY2014 by the NEES Consortium.

Earthquake Engineering Research Centers (EERCs)

Participating Agencies: NSF, FEMA

Funded in 1997, the three EERCs (the Mid-America Earthquake (MAE) Center, headquartered at the University of Illinois at Urbana-Champaign; the Multidisciplinary Center for Earthquake Engineering Research (MCEER), headquartered at the State University on New York at Buffalo; and the Pacific Earthquake Engineering Center (PEER), headquartered at the University of California at Berkeley) have advanced the state-of-the-art in earthquake engineering through experimental and analytical investigation of the behavior of the built environment during earthquakes; through innovative concepts such as performance-based design and consequence-based engineering, which will have a significant impact on the seismic design codes and provisions for the nation; and through the goal of establishing earthquake-resilient communities. All EERCs have extensive programs that include not only basic and applied research, but also efforts in communicating the research outcomes to the appropriate stakeholders.

Volcanic Hazards Maps and Reports

Participating Agencies: USGS, NPS, USDA Forest Service, NASA, and others

The USGS, in cooperation with its scientific partners, produces maps and reports on the distribution and frequency of volcanic hazards for active and potentially active volcanoes in the U.S. These are used as a basis for land-use planning in areas surrounding the volcanoes, and have led to the implementation of specialized monitoring systems where appropriate. They have also served as the basis for public education campaigns in the Cascades, California, and Hawaii.

Coastal Erosion Modeling

Participating Agencies: USGS, USCG, NASA, NOAA

The USGS provides geologic information for understanding and predicting coastal erosion and other storm effects on the shoreline, for identifying and evaluating offshore earthquake and tsunami hazards, and for evaluating underwater landslide hazards. Cooperative efforts by USGS, NASA, and NOAA that use Light Detection and Ranging (LIDAR) mapping provide for nearly complete coverage of coastal topography. Periodic surveys to update shoreline position and condition provide an assessment of erosion and storm impacts. USGS scientists are completing a series of maps of coastal vulnerability to sea-level rise for the U.S. Atlantic, Pacific, and Gulf of Mexico coasts.

Building-Fire Assessment Tools

Participating Agencies: NIST, FBI, ATF

NIST fire researchers teach sessions on fire dynamics and computer modeling as part of NIST's leadership in the field of fire dynamics and large-scale fire experiment capabilities. In collaboration with two other Federal agencies and the International Association of Arson Investigators, NIST has filmed apartment and townhouse fire burns as a training tool for arson investigation. NIST fire scientists have assembled a 10-minute video collection of fires taken from large-scale tests conducted in NIST's fire test facilities to illustrate how fires grow from ignition to flashover. (Flashover occurs when all combustibles in a room burst into flames and the fire spreads rapidly.)

4. Speed the Transition From Hazard Research To Hazard Management Application

Among the most crucial areas of hazard risk reduction is speeding the transfer of scientific research results to real-time hazard prediction, mitigation, and response applications used daily by hazard managers. From the outset, real-world response and prediction requirements must be incorporated into the development of algorithms and other risk identification and assessment tools. Similarly, when scientists discover a tool, method, or process that has operational utility, the research community must have a mechanism to ensure that the new capability becomes part of the standard tool set available to emergency managers and planners. New capabilities and innovations must not languish in scientific laboratories but must be fast-tracked to hazard responders in the form of useful and reliable tools.

Further, to avoid problems of insularity and information-sharing failures among first responders, strong communication bridges, such as integrated databases and routine information-sharing exercises must be established among the discrete agencies engaged in disaster management, particularly those with overlapping jurisdictions.

There are numerous examples of the benefits of providing quality information to hazard managers and planners:

- Recently installed satellite receivers enable the USDA Forest Service to obtain data directly from the NASA Terra and Aqua satellites and the Advanced Very High Resolution Radiometer (AVHRR) instrument on NOAA satellites, and to distribute processed data to incident or area command centers for strategic and tactical planning. Products from this effort were extremely useful during the 2002 fire season. Direct broadcast "real-time" capability for the western states will be available in 2003. The project is scheduled for completion in 2005.
- Following the Loma Prieta earthquake in 1989, information from the northern California seismograph network was used to warn workers of numerous aftershocks as they razed the collapsed Cypress freeway viaduct in Oakland, California. USGS scientists set up a system that warned workers via radio approximately 25 seconds before the precarious structure would begin to shake from an aftershock. These warnings, made possible because radio waves travel much faster than seismic waves, were sent from detecting instruments in the aftershock area—some 50 miles away—to a receiver at the Oakland worksite. Each time the instruments detected an aftershock, the receiver sounded an alarm that enabled workers to move to safety during the danger period.[32]
- The Earthquake Analysis System Program at NASA's Jet Propulsion Laboratory (JPL) monitors and evaluates ground motion at critical JPL locations. Through this monitoring, JPL scientists can evaluate the seriousness of ground motion threatening crucial JPL systems and can transfer the data to emergency response teams within NASA.

Related Interagency Activities

National Interagency Fire Center (NIFC) Geospatial Multi-Agency Coordination Group Fire Maps (GeoMAC)

Participating Agencies: USGS, NOAA, USDA Forest Service, BLM, BIA, FWS, NPS, NASA

The NIFC in Boise, Idaho, is the nation's support center for wildland firefighting, where seven Federal agencies work together to coordinate and support wildland fire and disaster operations. NIFC has teamed with Federal firefighting agencies and private industry to form GeoMAC, which provides real-time information to assist operations personnel in prioritizing the use of wildfire suppression resources and ensuring public and firefighter safety. GeoMAC is an internet-based mapping tool that allows fire managers to access near-real-time maps of current fire locations and perimeters in the contiguous 48 states and Alaska. Fire personnel can download this information to pinpoint the affected areas.

ShakeMap

Participating Agencies: USGS, NSF

A key product of the ANSS, ShakeMap is an Internet-enabled map tool that portrays regional severity and distribution of ground shaking during earthquakes. These maps, in popular Geographic Information System (GIS) formats, enable emergency responders and utility and transportation system operators to assess areas of likely damage and allocate resources quickly. ShakeMap is now an integral component of emergency response plans in several metropolitan areas (including Los Angeles, the San Francisco Bay Area, Salt Lake City, and Seattle), and is expanding to other regions (including Anchorage, Memphis, and the northeastern United States).

Volcanic Ash Response/Volcanic Eruption Response

Participating Agencies: NOAA, USGS, FAA, USAF, NASA, other Federal, state and local entities

Effective response to volcanic ash hazards depends on rapid and seamless cooperation among several agencies: NOAA, the USGS, and the FAA, with the USAF also having a role in some areas. Ash clouds are tracked using weather and other satellites, eruptions are monitored by ground-based and satellite techniques, and the resulting data are fed to the FAA for communication to air traffic controllers, pilots, and the airline industry. An example of this highly effective collaboration is laid out in the "Alaska Interagency Operating Plan for Volcanic Ash Episodes," a formal interagency agreement with six Federal agencies plus the Alaska Division of Emergency Services as signatories. Similar plans have been prepared in anticipation of eruptions and the hazards they pose to people and property on the ground. An example is the Long Valley Response Plan, formally developed and posted on the web in collaboration with the relevant Federal and local authorities.[33]

Stream Gauging

Participating Agencies: USGS, NOAA, USACE, WBR

The USGS maintains a nationwide system of more than 7,000 stream gauges that communicate through NOAA's GOES satellites. These gauges provide accurate, timely information on water levels, which NOAA uses to issue local and regional flood warnings. Local officials also use stream-gauge data to make timely decisions about evacuating people from flood-prone areas. The ability to assess quickly and accurately the magnitude and distribution of floods and droughts improved dramatically in FY2001 with the release of the USGS WaterWatch Website. WaterWatch is a comprehensive collection of maps and graphs of current streamflow conditions for the 50 states and Puerto Rico. The new site significantly expands and enhances the previous Daily Streamflow Conditions Map that USGS pioneered in 1999 by expanding the map products to include real-time, daily, and weekly streamflow, as well as two special maps highlighting current flood and drought conditions.

Advanced Hydrologic Prediction Services (AHPS)

Participating Agencies: NOAA, USGS, USACE, WBR

NOAA's AHPS leverages observational stream gauge data provided by the USGS and other Federal agencies. These data are critical to AHPS' ability to provide river stage and flow forecasts detailing how high rivers will rise, when they will reach their peak, where flooding will occur, and how long the flood will last. Extending from the short term (hours) through the long term (months), predictions are made in a probabilistic manner to quantify the certainty in the forecasts. AHPS couples weather and climate predictions with hydrologic observations to produce river and stream forecasts which enable emergency managers and local officials to make timely, informed risk-based preparedness and response decisions.

Search and Rescue Satellite Aided Tracking (SARSAT) System

Participating Agencies: NOAA, USCG, USAF, NASA

The SARSAT System is the United States component of the international satellite search and rescue system known as Cospas-Sarsat, which seeks to protect lives and property by providing accurate, timely, and reliable distress alert and location information to search and rescue authorities. NOAA operates a series of polar-orbiting and geostationary environmental satellites that detect and locate emergency beacons carried by aircraft, vessels, and land-based users in distress anywhere in the world. These satellites, along with a network of ground stations and NOAA's U.S. Mission Control Center in Suitland, MD, operate 24-hours a day, 365 days a year to alert rescue authorities around the world whenever and wherever a distress situation occurs. In the U.S., the USCG responds to all maritime-related alerts while USAF responds to all inland distress alerts.

Disaster Averted:

The Quake That Didn't Break the Alaska Pipeline

ON NOVEMBER 3, 2002, one of the largest recorded earthquakes to strike the U.S. rocked the interior of Alaska. The magnitude 7.9 quake caused countless landslides, opened 6-foot cracks in highways, shook homes and damaged supports to the Trans-Alaska pipeline. Effects of the 3-mile-deep quake extended for thousands of miles. It triggered microearthquakes at the Geysers geothermal area in northern California and at Yellowstone National Park in Wyoming. From Seattle to New Orleans, boats were tossed about and torn from moorings. As far east as Pennsylvania and Florida, USGS instruments recorded significant changes in ground-water levels immediately following the earthquake.

The earthquake resulted from a slip on the Denali fault, one of the longest continental faults in the world, stretching over 700 km (435 miles) across Alaska and southeastward into Canada. Amazingly, very few injuries and no deaths resulted from the quake, at least in part due to its remote location: 75 miles south of Fairbanks and 175 miles north of Anchorage. Long-term research and a commitment to hazard preparedness and mitigation also played key roles. For example, USGS scientists were instrumental in ensuring that the Trans-Alaska oil pipeline was designed and built to withstand the effects of a magnitude-8.0 earthquake with up to 20 feet of movement at the pipeline. These standards were considered to be excessively conservative at the time, but proved to be on target. The earthquake ruptured the ground surface under the pipeline and, although some supports were knocked out, the pipeline did not break. The resilience of the pipeline to the fault rupture is a testament to the importance of hazard mitigation in engineering design.

Source: "Massive Alaska Earthquake Rocks the Mainland," Volcano Watch, Hawaiian Volcano Observatory, November 14, 2002, http://hvo.wr.usgs.gov/volcanowatch/

Photo by: Peter Haeussler, U.S. Geological Survey, November 7, 2002

5. Mitigation Activities and Incentives

Many communities that have experienced disasters could have been better protected if they had implemented long-term disaster-reduction measures in advance of the event. Mitigation is a forward-thinking approach that challenges the nation to take advantage of scientific advances and apply new technologies that protect businesses and communities by reducing or eliminating their long-term vulnerability to the effects of hazards. Mitigation emphasizes pre-disaster actions taken by individuals and businesses, as well as governmental and non-governmental entities. Reducing the effects of hazards through mitigation is an essential public policy tool to prevent unnecessary loss of life and property and damage to the economy.

"It's very tough to make the case to the new home buyer to pick the hurricane straps over the Jacuzzi."
–Bill Hooke, American Meteorological Society

In the past 10 years, the hazard management community has made great strides in shifting the perspective of communities from post-disaster clean-up to adopting pre-disaster mitigation strategies. However, encouraging citizens to adopt mitigation techniques, such as fire-fuel modification around homes and earthquake retrofitting, in their personal and community decision-making continues to be a great challenge. At the local level, governments still need to be persuaded to adopt hazards-conscious decision-making processes and zoning ordinances. After aviation disasters, efforts are made to ensure that the errors that contributed to or caused the event "never-again" are allowed to happen. In contrast, redevelopment in a flood plain or hazardous coastal area is still too common after devastating storms. More incentives are needed in mortgage lending and insurance practices as well as in tax policy, building codes, and zoning requirements to encourage individuals and communities to ensure hazard mitigation planning is central to community development and sustainability.

"The message of [the Denali, Alaska earthquake of 2002] is not that the U.S. has proven itself invulnerable to great earthquakes, but that when science and engineering work in concert, the country can drastically reduce earthquake damage and losses. What was done for a single pipeline in Alaska now must be undertaken for the entirety of metropolitan Los Angeles."
–Ross S. Stein, U.S. Geological Survey

Related Interagency Activities

The Tornado Safe Room Initiative

Participating Agencies: FEMA, HUD, SBA

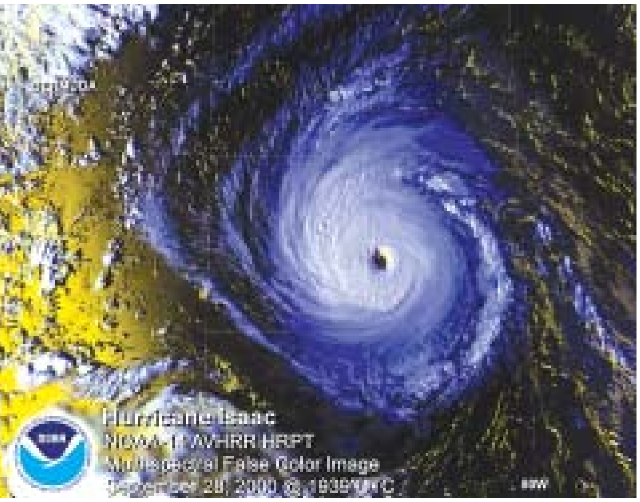
In high-risk tornado regions, residential safe rooms and mass shelters are the most effective way to provide "near absolute protection" to individuals and families. Partnering with HUD and SBA, FEMA leads a national initiative to increase construction of tornado safe rooms, implemented state by state. Through the program, FEMA has distributed over 200,000 copies of *Taking Shelter From the Storm: Building a Safe Room Inside your House* and thousands of safe rooms have been built in Tornado Alley and other tornado-prone regions.

Partnership for Advancing Technology in Housing (PATH)

Participating Agencies: HUD, FEMA, NSF, DOE

HUD's Office of Policy Development and Research coordinates the Partnership for Advancing Technology in Housing (PATH), bringing together a variety of government agencies, industry groups, and researchers to promote the use of technology to improve housing. One of PATH's major issue areas is disaster risk. In partnership with NSF, HUD funds research of new structural and construction systems that improve a home's ability to withstand extreme conditions without appreciable increases in the cost of construction. PATH, in cooperation with FEMA and DOE, is funding Oak Ridge National Laboratory and Tuskegee University to develop a construction pre-standard and computer model, as well as testing protocols, to determine the flood resistance of building materials, permitting less costly post-flood rehabilitation. Also with FEMA, PATH has funded the University of Florida for a project with a major national homebuilder to construct energy efficient wind-resistant homes. The goal of such research is to develop techniques and collect data that will allow major home insurers to reduce premiums for hurricane-resistant construction.

6. Risk Communication Capabilities, Especially Public Warning Systems and Techniques



At every stage of hazard risk management, effective communication with the public is vital to reducing disaster losses. Communications regarding mitigation and preparedness, if heeded, can transform a community's readiness to face an extreme event. Effective communication is especially critical immediately before, during, and after a hazard event to ensure the public has adequate warning and complete information to maximize public safety. Hazard managers face three principal risk communication challenges in effective warning:[34]

- **Effective Messaging.** Research has shown that individual and public risk perception is based on emotion and not fact, no matter how good the science behind the message. Warning messages must convey to an often-skeptical public that they are vulnerable, that the danger is real, and that specific measures can be taken to protect themselves and their property. Messaging must also consider the target audience and make provisions to reach high-risk populations and overcome language barriers in diverse populations.
- **Source Credibility.** Credibility is easy to lose and difficult to regain when communicating public warnings. Working with trusted sources at the national and local levels is imperative to ensure people understand and heed warnings. At the local level, local media and emergency managers are the most credible sources with the public.
- **Lack of a Comprehensive National Warning System.** Though NOAA Weather Radio has the capability to wake people at night when hazards threaten, there is no single warning system in the U.S. today that collects and disseminates all risk information. Instead, warnings tend to be compartmentalized, with at least a dozen Federal agencies having responsibility for issuing warning information for various types of hazards. There is also a need for a national lexicon of warning terms and national threat indicators that would go beyond the current color-coded system now in place for terrorism threats.[35]

Simple, low-cost risk communication techniques can often save thousands of lives. During the severe heat wave in Chicago in 1995, local media and community groups engaged in a vigorous campaign to inform the public of heat-wave sanctuaries created in public buildings. Teams of community volunteers reached out to high-risk groups like the elderly to bring them to safety and, as a result, hundreds of lives were saved. Similarly, winter deaths from carbon monoxide poisoning have dropped considerably in the Northeast through public information campaigns educating the public about keeping windows cracked during cold weather and avoiding reliance on kitchen stoves for heat.

Related Interagency Activities

StormReady Community Recognition Program (SCRP)

Participating Agencies: NOAA, FEMA

StormReady helps communities implement procedures to reduce the potential for disastrous weather-related consequences. To become recognized as StormReady, communities must complete an application and review process that demonstrates they have the technology, procedures, and education tools in place to safeguard their communities. Communities are designated StormReady by a local advisory board made up of the local Weather Service Forecast Office, and county and state emergency managers. NOAA's National Weather Service started the StormReady program in 1999 with seven communities in Oklahoma. There are now over 500 StormReady/TsunamiReady communities in 43 states.

On November 10, 2002, a powerful tornado hit the StormReady community of Van Wert, Ohio. Thanks to procedures set up by the town, 50 people were evacuated from a movie theater before the tornado ripped through it, throwing cars into the seats where people had been sitting just moments before.

National Disaster Education Coalition (NDEC)

Participating Organizations: NOAA, FEMA, USGS, and others

The NDEC is composed of national agencies and organizations that work together to develop consistent educational information for the public about disaster preparedness. The Coalition's principal publication, *Talking About Disasters: Guide for Standard Messages*, provides standardized safety messages about 13 hazards and general disaster preparedness topics.

Partnership for Public Warning (PPW)

Participating Organizations: NOAA, FEMA, USGS, and others

The PPW brings disaster-warning experts from government, business, academia, the media, and other organizations together with first responders to agree on standards, procedures, and systems for warning people at risk so that they can take actions to save lives, reduce disaster losses, and speed recovery.

May 3, 1999 one hundred lives were saved when a tornado flattened Norland Plastics in Haysville, Kansas as the plant manager ushered employees to the basement following receipt of warnings via NOAA Weather Radio.

The National Disaster Education Coalition (NDEC) principal publication, Talking About Disasters: Guide for Standard Messages, provides standardized safety messages about 13 hazards and general disaster preparedness topics.

EAST BAY MUNICIPAL UTILITY DISTRICT

Seismic Improvement Plan

Following the Loma Prieta Earthquake in 1989, East Bay Municipal Utility District in California (EBMUD) performed an in-depth evaluation of the seismic vulnerability of its water treatment plants, reservoirs, buildings, pipelines, tunnels, pumping plants, and communication facilities. The results showed that, for a magnitude seven earthquake on the Hayward Fault, 63 percent of its customers would be out of water, one-third of the reservoirs and two-thirds of the pumping plants would be out of service, 5,500 pipes could break, and four out of six water treatment plants would be out of service. It would take approximately 6 months to restore partial service, and the costs to repair damage to facilities were estimated at $245 million.

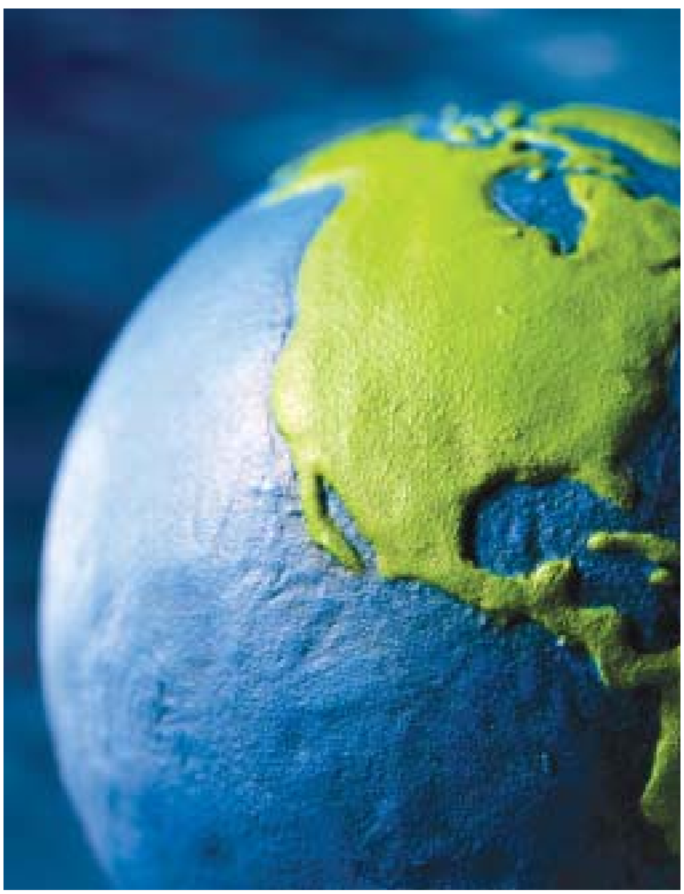
The EBMUD Board of Directors decided to take action in 1994 by approving the Seismic Improvement Program (SIP), an aggressive 10-year, $189 million capital improvement program to minimize damage to the water system, improve fire-fighting capability, and protect customers from long, disruptive water outages following a catastrophic seismic event. To date, the District has completed seismic upgrades for 21 reservoirs. EBMUD has installed shutoff valves and emergency hose connections at nine locations where water mains that cross earthquake faults are particularly vulnerable. Upgrades to at least five water treatment plants are complete and ensure they will be available and functioning after an earthquake. Since its inception, the project has saved an estimated $1.2 billion by avoiding losses due to fire, costs to rebuild the District system, lost revenue, economic impact to businesses in the region, and flood losses. SIP capital costs amount to $189 million, resulting in a cost-effectiveness ratio of six to one.

SEDGWICK COUNTY, KS

State of Kansas School Shelter Initiative

Local officials in Sedgwick County, KS, had recognized the risks of living in Tornado Alley and surveyed their public school facilities. Based on existing safety criteria, they identified the safest places in each of the schools for students to seek shelter in the event of severe weather. In two schools, due to a lack of interior areas, the hallways had been identified as the most secure locations. But on May 3, 1999, these very hallways in both schools were heavily damaged by deadly tornadoes. In one instance a tall boiler chimney collapsed into the hall. Fortunately, the storms occurred after school hours, but had students been present, injuries and deaths would have been likely. These close calls inspired Sedgwick County officials to take aggressive measures to prevent similar events in the future. Working with FEMA's Tornado Safe Room Initiative, Sedgwick County officials have implemented 24 safe room projects in local schools. When all of the projects are completed, these shelters will serve approximately 7,800 students in the area. The community will also use them as polling places, religious service facilities, and meeting locations for groups such as Boy Scouts and Girl Scouts. In Park Elementary, a shelter also serves as a cafeteria and gymnasium. Within 3 months of its completion, it had already been used three times to shelter students during high-wind events.

IV. Cooperating for Success: Integrated National and International Efforts



Successful Federal interagency cooperation is common throughout the hazard risk management community. As indicated in Section III, the member agencies of the Subcommittee on Disaster Reduction (SDR) have developed an array of valuable cooperative programs for improving the resiliency of American communities to all hazards. A number of key nationwide and international activities also deserve mention.

These concerted national and international efforts provide excellent models for new programs, because they ensure operations are coordinated and the benefits of science and technology are fully leveraged, both nationally and globally, to support effective disaster risk reduction and disaster response.

National Efforts

Federal Radiological Preparedness Coordinating Committee (FRPCC)

FEMA chairs the Federal Radiological Preparedness Coordinating Committee, whose 17 member agencies coordinate Federal activities in support of state and local emergency planning for radiological emergencies. The committee also coordinates the radiological research efforts of its member agencies to avoid duplication and to make sure that the research benefits state and local emergency planners. There are Regional Assistance Committees, with Federal agency memberships in each of the 10 Federal regions, also chaired by FEMA. The regional committees help state and local jurisdictions develop radiological emergency plans and evaluate exercises to assess the effectiveness of the emergency plans that are in place. FEMA also coordinated the development of the Federal Radiological Emergency Response Plan (FRERP), which outlines the responsibilities of Federal departments and agencies when responding to any type of peacetime radiological emergency, including transportation accidents involving radioactive materials. Revised in 1996, the FRERP details how each Federal department and agency responds operationally to specific kinds of radiological emergencies based on the location of the emergency, the potential impact on the public and environment, the size of the affected area, and the source of the radioactive material involved.

Federal Response Plan (FRP)

The FRP is an agreement of 27 signatories (26 Federal agencies and the American Red Cross) managed by FEMA that provides the mechanism for coordinating delivery of Federal assistance and resources to augment efforts of state and local governments overwhelmed by a major disaster or emergency. The FRP identifies lead and support agencies for functions such as damage assessment, emergency communications, medical assistance and support, mass sheltering and feeding, urban search and rescue, emergency power restoration, and community relations. FRP agencies arrange for equipment and supplies such as mobile kitchens, water purification units, portable toilets and showers, tents, food, water, and emergency generators. Additional FRP activities include debris clearance and opening of critical transportation routes. Under the DHS, the FRP along with other Federal government emergency response plans (National Contingency Plan, Federal Radiological Emergency Response Plan, and the Interagency Domestic Terrorism Concept of Operations Plan) are being consolidated into a single all-hazards response plan.

National Construction Safety Team (NCST)

The National Construction Safety Team Act (P.L. 107-231), signed into law on October 1, 2002, authorizes the NIST to establish post-disaster teams (interagency and private sector collaborations) to investigate building failures. The purpose of the teams is to assess building performance and emergency response and evacuation procedures in the wake of any building failure that has resulted in substantial loss of life or that posed significant potential of substantial loss of life. These authorities are modeled after those of the National Transportation Safety Board (NTSB) for investigating transportation accidents. NIST is directed to assemble the disaster investigation teams, deploy them within 48 hours following a disaster, and develop reports. The NCST will perform independent, objective, fact-finding (not fault-finding) evaluations analogous to the NTSB. The teams have priority over any other Federal investigation, except those of the NTSB or those involving criminal acts. They have specific authorities including entry and inspection, preservation of evidence, and issuance of subpoenas.

National Contingency Plan (NCP)

The National Oil and Hazardous Substances Pollution Contingency Plan, more commonly called the National Contingency Plan, or NCP, is the Federal government's blueprint for responding to both oil spills and hazardous substance releases, including those caused by or resulting in disaster. The first National Contingency Plan was developed and published in 1968 in response to a massive oil spill from the oil tanker *Torrey Canyon* off the coast of England the year before. It provided the first comprehensive system of accident reporting, spill containment, and cleanup, and established a response headquarters and national and local response teams. The Congress has broadened the scope of the National Contingency Plan over the years to include a framework for responding to hazardous substance situations. The latest revisions to the NCP were finalized in 1994, and the two principal NCP agencies are the EPA and the USCG. The EPA chairs the National Response Team (NRT), while USCG acts as vice-chair. In addition, NOAA's Office of Response and Restoration (OR&R) has responsibility for providing scientific support for oil and hazardous material spills. To support this mandate, the OR&R Hazardous Materials Response Division (HAZMAT) works with USCG to provide 24-hour scientific support to spill events. Other NRT members include DOD, FEMA, DOE, USDA, DOC, HHS, DOI, DOL, DOT, NRC, DOS, GSA, and the Department of Treasury.

National Earthquake Hazards Reduction Program (NEHRP)

NEHRP was established in 1977 to improve understanding, characterization, and prediction of earthquake hazards and vulnerabilities; improve model building codes and land use practices; reduce risks as the result of post-earthquake investigations and education; improve design and construction techniques; improve the capacity of government at all levels and of the private sector to reduce and manage earthquake risk; and accelerate the application of research results. The four principal NEHRP agencies are FEMA, the lead agency; NIST; NSF; and the USGS. NEHRP is scheduled for reauthorization in FY2003.

National Fire Plan (NFP)

The NFP supports coordinated fire management planning, preparedness and hazard reduction, fire suppression, collaboration with and assistance to communities, and rehabilitation and restoration of burned areas. Participants include the Forest Service, DOI agencies, and collaborators in state and local agencies. The NFP also supports research and development activities in fire and fuels management to develop improved science-based knowledge and tools for predicting and evaluating potential outcomes of alternative management strategies and for monitoring ecological, social, and economic impacts of wildland fire and fire and fuels management. The NFP also coordinates with the Firewise program, which works with local communities to develop and implement plans to reduce risks from wildland fire. The interagency Wildland Fire Leadership Council oversees the implementation of the NFP.

National Hurricane Program (NHP)

The NHP is a cooperative effort between Federal, state, and local governments to reduce the risk to lives and property from all hazards associated with hurricanes in the United States. The NHP, which includes FEMA, NOAA, USACE, and DOT, is dedicated to providing the 22 at-risk coastal states and territories with financial and technical assistance and support to all levels of government for hurricane mitigation, preparedness, response, and recovery. The NHP utilizes intelligent state-of-the-art hurricane evacuation tools and data allowing interactive, instantaneous decisions during hurricane events. Improvements in technology include the predicting and mapping of hurricane hazards that include inland-flooding hazards; managing state, regional, and national transportation systems; assessing the risk to buildings and infrastructure; providing safer building techniques; and increasing Internet communications. Within the NHP, USACE manages the Hurricane Evacuation Study effort nationwide together with NOAA, which also performs the basin studies (funded by FEMA) to identify the inland limits of hurricane surges.

National Landslide Hazard Mitigation Strategy

At the request of the Congress, the USGS prepared a "National Landslide Hazard Mitigation Strategy," available to the public on the Internet at http://landslides.usgs.gov. This report, which outlines a framework for reducing losses from landslide hazards, addresses concerns over the rising costs of landslide hazards facing the nation. The report delineates the essential elements of a strategy for mitigating national landslide hazards that, when implemented, would reduce the cost of landslide hazards. It includes developing new partnerships between government, academia, and the private sector to manage the hazards. The report also recommends expanding landslide research, mapping, assessment, monitoring, forecasting, information dissemination, development of mitigation tools, and emergency preparedness and response.

U.S. Climate Change Research Initiative

Climate change has important implications for disaster risk reduction, as many scientists consider it a "forcing factor" that influences the severity and frequency of extreme weather events and the spread of disease. On June 11, 2001, President George W. Bush announced the establishment of the U.S. Climate Change Research Initiative to study areas of uncertainty in climate change research and identify priority areas where investments can make a difference. The President directed the Secretary of Commerce to set priorities for additional investments in climate change research, review such investments, and improve coordination among Federal agencies. He also committed to providing resources to build climate observation systems and proposed a joint venture with the European Union (EU), Japan, and others to develop state-of-the-art climate modeling that will improve understanding of the causes and impacts of climate change.[36]

U.S. Weather Research Program (USWRP)

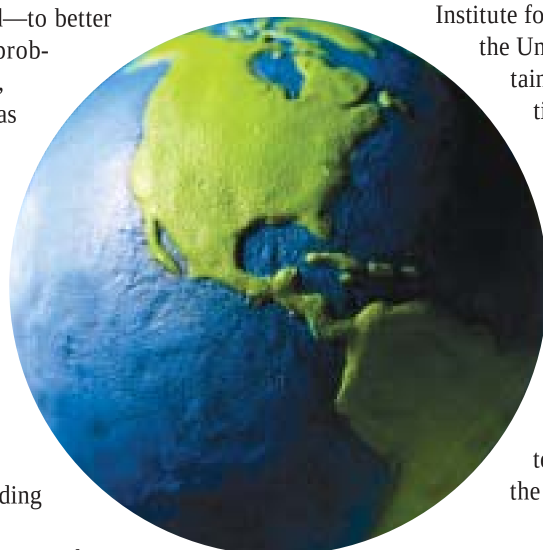
The USWRP is a partnership among seven Federal agencies and the academic and commercial communities. The overarching goal of the USWRP is to use integrated research to accelerate improvement in high-impact weather forecasting capability—in particular, improvement in forecast timing, location, and specific rainfall amounts associated with hurricane landfall and flood events that significantly affect the lives and property of U.S. inhabitants. Within the USWRP, NASA is working with NOAA and other U.S. and foreign agencies to develop advanced satellite-based sensors, including the Tropical Rain Measuring Mission (TRMM), the Geostationary Imaging Fourier Transform Spectrometer (GIFTS), and new measurements by the existing EOS platforms. Advanced temperature and moisture sounders should also contribute to improvements in national predictive capability for weather events. The USWRP includes support for the National Center for Atmospheric Research in Colorado and joint awards made by NSF/NOAA/NASA for weather research projects.

International Efforts

Providing science and technology guidance to the international disaster community is a key foreign policy goal that will save lives and property and assist other nations to become disaster-resistant. This activity also helps the U.S. Government achieve other foreign policy goals of enhancing good governance abroad, reducing the cost to the U.S. taxpayers of foreign disaster assistance, and protecting U.S. citizens and interests abroad.

Integrated Global Observing Strategy

Currently, NOAA is serving as co-chair of the Integrated Global Observing Strategy (IGOS) Partnership, an international, 14-partner entity committed to addressing observational gaps and overlaps in satellite space-based and *in situ* earth-observing systems. In this capacity NOAA is promoting the establishment of a global earth observation system—uniting the world's major satellite and surface-based systems for environmental observations of the atmosphere, oceans and land—to better understand, predict, and address global problems such as energy, water, food, climate, and sustainable economic development, as well as natural and technological disasters.



International Strategy on Disaster Reduction (ISDR)

The ISDR is a UN-sponsored effort working toward international disaster reduction by increasing public awareness; obtaining commitment from public authorities; stimulating interdisciplinary and inter-sectoral partnership and expanding risk reduction networking at all levels; and further improving the scientific knowledge of the causes of natural disasters and the effects of natural hazards and related technological and environmental disasters on societies.

International Charter: Space and Major Disasters

In July 1999, the European and French space agencies (ESA and CNES, respectively) initiated the "International Charter: Space and Major Disasters" to provide a unified system of space data acquisition and delivery to support post-disaster response. Each member agency commits resources to the Charter to support emergency response to disasters worldwide. The Canadian Space Agency (CSA) joined the Charter in October 2000, followed by NOAA and the Indian Space Research Organization (ISRO) in September 2001. USGS and NASA participate in this initiative as part of a NOAA-led team. U.S. commercial space companies have expressed interest in exploring opportunities for involvement.

The Global Seismographic Network (GSN)

GSN is a worldwide network of over 100 seismometers designed for obtaining high-quality data in digital form that can be readily accessed by users worldwide. GSN is a joint effort involving the USGS, the Incorporated Research Institutions for Seismology (a consortium of universities supported by NSF), and the Institute for Geophysics and Planetary Physics at the University of California. GSN is maintained in cooperation with many international partners who provide facilities and personnel to maintain each station.

Global Disaster Information Network (GDIN)

GDIN is an international partnership of disaster managers and other information users, focused on developing more effective means of sharing critical disaster information. The U.S. effort is led by the Department of State.

About the Subcommittee on Disaster Reduction

Chartered to promote effective strategies for reducing the nation's vulnerability to disaster risks, the Subcommittee on Disaster Reduction (SDR) leverages critical expertise and information across the Federal government, academia, and the private sector. The SDR works to ensure that national strategies for reducing disaster risks and losses are based on effective use of science and technology.

Mitigating the impacts of natural and technological disasters requires a solid science and technology foundation, the ability to rapidly transition research to applications, and efficient access to diverse information resident across a wide array of public and private entities. The SDR provides a unique Federal forum for information sharing; development of collaborative opportunities; formulation of science- and technology-based guidance for policymakers; and dialogue with the U.S. policy community to advance informed strategies for managing disaster risks.

Mission and Objectives

The SDR is charged with facilitating and promoting natural and technological disaster mitigation, preparedness, response, and recovery through:

- Coordinating national research goals and activities for Federal research related to natural and technological hazards and disasters
- Identifying and promoting opportunities for the U.S. Government to collaborate with state, local, and foreign governments; international organizations; and private/academic/industry groups
- Facilitating the identification and assessment of risks
- Providing information to the Administration and the Congress to summarize relevant resources and work across SDR agencies
- Serving as liaison to the Administration, the Congress, NGO's, and other policy development bodies
- Promoting disaster-reduction practices
- Facilitating the exploitation of dual-use systems and fusion of classified and unclassified data streams and research for disaster-reduction applications.

Membership

The SDR is constituted under the NSTC CENR. The heads of relevant agencies and departments annually designate lead representatives to the SDR. The Chair, Vice-Chair for Policy, and Vice-Chair for Science and Technology are appointed by the Committee on the Environment and Natural Resources in consultation with the member agencies and serve a 3-year term.

Subcommittee on Disaster-Reduction Partnerships

SDR facilitates a collaborative environment beyond its inter-government agency scope and has forged partnerships with other disaster-reduction and management groups nationwide. Descriptions of some of SDR's partners follow.

Natural Disaster Roundtable of the National Academies of Science

This body was created to facilitate and enhance communication and the exchange of ideas among scientists, practitioners, and policymakers to identify urgent and important issues related to the understanding and mitigation of natural disasters. Funding organizations include FEMA, USGS, NOAA, NASA, USDA, NSF, and others. Through a series of quarterly forums, groups participating in this roundtable involve the public and private sector as well as academia in certain focus areas or high priority topics.

Working Group of the U.S. Senate Natural Hazards Caucus

The U.S. Senate Natural Hazards Caucus, co-chaired by Senators John Edwards (D-NC) and Ted Stevens (R-AK), is advised by a network of professional, scientific, and engineering societies, relief organizations, higher education associations, institutions of higher learning, trade associations, and private companies that work to reduce the toll of natural hazards and to enhance the nation's ability to recover from such events. A working group organized by the American Geophysical Union and the American Geological Institute provides technical advice and information used in the development of programs of hearings for the Caucus.

Subcommittee on Disaster Reduction Agencies

Department of Agriculture - Forest Service

The Forest Service is responsible for managing and reducing risks of multiple hazards on national forests and grasslands and for cooperating with states and other landowners to reduce disaster risks and impacts on public and private lands. The largest Forest Service hazard reduction programs are currently under the interagency National Fire Plan, which addresses disaster preparedness and prevention, hazards management, and science and technology development related to wildland fire. The Forest Service also manages wildlands to reduce the risks of flooding, erosion, sedimentation, and contamination of water supplies arising from the impacts of natural and human disturbances. Major research areas include: post-fire rehabilitation and restoration; effects of road design and disturbance from logging and other activities regarding susceptibility to extreme flooding and erosion; management of riparian zones; and impacts of natural disasters, human impacts, and extreme weather events on water quality, air quality, and wildlife habitat.

Department of Commerce - National Institute of Standards and Technology (NIST)

NIST's Building and Fire Research Laboratory (BFRL) studies building materials; computer-integrated construction practices; fire science and fire safety engineering; and structural, mechanical, and environmental engineering. BFRL products include measurements and test methods, performance criteria, and technical data that support innovations by industry and are incorporated into building and fire standards and codes. BFRL operates under five goal areas: Advanced Construction Technology; Enhanced Building Performance; Fire Loss Reduction; Advanced Building Materials; and Homeland Security.

Department of Commerce - National Oceanic and Atmospheric Administration (NOAA)

NOAA conducts research and gathers data about the global oceans, atmosphere, space, and sun, and applies this knowledge to science and service that touch the lives of all Americans. NOAA is the nation's resource for weather-related research, observing systems, and environmental data and information services. With respect to natural hazards, it focuses on two critical areas to lower the impacts and costs: (1) providing the best possible warnings and information to prevent damage and permit escape during atmospheric and coastal hazard events, and (2) providing information and techniques to lower the vulnerability and increase the resiliency of people and property before and after atmospheric and coastal hazard events. Within NOAA, the National Weather Service, the National Environmental Satellite, Data & Information Service, the National Ocean Service, the National Marine and Fisheries Service, and NOAA Research play critical roles and have distinct functions that together promote, protect, and enhance the nation's economy, security, environment, and quality of life.

Department of Defense – Army Corps of Engineers (USACE)

USACE serves as DOD's lead agency with respect to hazard management and response, and coordinates with FEMA. USACE is engaged in a full range of research and development efforts, through its Engineering Research and Development Center, that contribute to a better understanding of the impacts of natural disasters and the development of management and mitigation models and techniques that focus on damage reduction, infrastructure protection, and civil emergency management.

In addition, DOD has military development programs that have direct applications to disaster reduction and management. The results of these efforts will be directly applicable to the needs of the civil community during disasters. DOD also is involved in the types of data collection, purchasing, and database development where more complete, accurate, and dynamic disaster reduction technologies are produced. DOD technologies may be leveraged and utilized in a timely fashion to enhance current capabilities and optimize Federal response to all types of emergencies affecting life, property, and economic stability.

Department of Defense - National Imagery and Mapping Agency (NIMA)

NIMA supports FEMA and Federal Response Plan disaster operations by acquiring and interpreting remote sensing and Geographic Information Systems (GIS) data, which help define the scope and scale of a disaster area. NIMA has developed and acquired a robust hardware- and software-deployable capability that ensures that NIMA analysts can support lead Federal agency requirements for crisis and consequence management and longer-term recovery. The deployable suites can support near-real-time commercial and national technical means (NTM) imagery, GIS, and a host of analytical tools. In addition, NIMA is working with FEMA to develop a capability to support FEMA's Information and Planning with on-site geospatial intelligence analysis at designated off-site Emergency Operations Centers as required.

Department of Defense - National Reconnaissance Office (NRO)

The NRO designs, builds, launches, and operates U.S. space-based reconnaissance assets, which include near-real time photoreconnaissance systems that may be used to collect scientific and environmental data as well as data on natural and man-made disasters. Photoreconnaissance assets can be used to image the U.S. and its territories and possessions.

Department of Health and Human Services – Centers for Disease Control and Prevention (CDC)

The mission of the Centers for Disease Control is to promote health and quality of life by preventing and controlling disease, injury, and disability. CDC seeks to accomplish its mission by working with partners throughout the nation and world to monitor health, detect and investigate health problems, conduct research to enhance prevention, implement prevention strategies, and foster a safe and healthful environment. In response to domestic disasters, both natural and technological, CDC plays a critical role in preventing and controlling possible disease outbreaks by working with other Federal, state, and local agencies to assess critical needs of the impacted population, establish disease surveillance, assist in the control of disease vectors, and provide epidemiologic expertise. Recent developments at CDC, including building a state of the art operations center and improving the organizational structure, have greatly enhanced the agency's ability to rapidly respond to emergencies in a comprehensive manner.

Department of Homeland Security (DHS) - Federal Emergency Management Agency (FEMA)

FEMA became part of DHS on March 1, 2003. Its mission is to lead America to prepare for, respond to, and recover from disasters. FEMA's programs span the four phases of emergency management: preparedness, mitigation, response, and recovery. FEMA helps states and localities prepare for a wide range of hazards through its preparedness, exercise, and training programs for state, tribal, and local emergency managers, and other officials.

The agency has a long history of partnering with states, tribal and local governments, the private sector, non-profit groups, and the general public to reduce or eliminate the risk to people and property from all hazards, thereby contributing to a nation of safer, stronger communities. FEMA provides disaster assistance to states, and tribal and local governments, and coordinates the provision of assistance by other Federal agencies. The agency has both broad-based and in-depth experience coordinating intergovernmental efforts.

Department of Housing and Urban Development (HUD)

HUD's mission is to provide a decent, safe, and sanitary home and suitable living environment for every American. Many of HUD's programs already include disaster mitigation components such as minimum construction standards and rules on project site selection. This includes not only the minimum property standards that apply to all HUD-assisted construction, but also special wind and snow load requirements for manufactured housing to ensure a degree of protection from hurricanes and snowstorms. There are also restrictions on constructing projects near any operation that stores, handles, or processes hazardous substances such as petroleum products or flammable chemicals. HUD has also placed some process and design requirements on assistance for construction in areas having special flood hazards. HUD's Healthy Homes program funds projects to develop moisture detection and control methods that protect residents as well as the structural integrity of building components, through the Building Research and Fire Laboratory at the National Institute for Standards and Technology.

Department of the Interior - U.S. Geological Survey (USGS)

The USGS natural hazards programs produce information and understanding that help to reduce the impact of natural hazards and disasters on human life and the economy. These programs contribute to the reduction of human and economic losses and disruptions associated with these natural hazards by:

- Defining, assessing, and monitoring potential earthquake, flood, volcano, landslide, and other hazards as the basis for loss-reduction strategies and actions by government and the private sector
- Providing analysis and real-time information and warnings for improved disaster response, for reducing losses from future disasters, and for enhanced public awareness of these natural hazards
- Expanding the fundamental knowledge of earthquake, flood, volcano, landslide, and other hazard processes for more effective risk-mitigation and disaster-response strategies.

Department of State (DOS)

The DOS leads the interagency effort on International Strategy on Disaster Reduction (ISDR) and coordinates how the U.S. votes on UN General Assembly and ECOSOC resolutions on international disaster matters. DOS works with a number of international organizations to foster better disaster reduction.

With respect to this mission, the Bureau of Oceans and Environmental Sciences is the main research arm of DOS. The Bureau of International Organizational Affairs (IO) also funds research aimed at gaining a better understanding of the systemic risks posed to society by disasters, and, along with NOAA and NASA, has stimulated research into the use of unmanned aerial vehicles for use in disaster telecommunications and remote sensing. IO also works closely with Canada through the G-7 Information Society to develop more effective knowledge management tools.

Department of Transportation (DOT)

Transportation is a critical daily lifeline for communities across the country. During disasters, transportation is essential for helping the community restore its economy. DOT's Office of Emergency Transportation (OET) in the Research and Special Programs Administration (RSPA) provides a centralized, effective program for handling transportation disasters by operating a crisis management center and performing coordinated crisis management functions for multi-modal transportation emergencies, including natural disasters, technological incidents, and major transportation accidents.

Environmental Protection Agency (EPA)

EPA's overall mission is to protect human health and to safeguard the nation's natural environment — air, water, and land. EPA is responsible for dealing with environmental emergencies that involve sudden threats to the public health or the well-being of the environment arising from the release or potential release of oil, radioactive materials, or hazardous chemicals into the air, land, or water. These emergencies may occur from transportation accidents, events at facilities that use or manufacture chemicals, or as a result of natural or man-made disaster events. In September 2002, EPA created the National Homeland Security Research Center. The Center, a part of the Office of Research and Development (ORD), manages, coordinates, and supports a wide variety of disaster-related research and technical assistance efforts. Research at the Center will focus on developing methods to clean up contaminated buildings, protecting the nation's drinking water supply, and improving risk assessment techniques.

National Aeronautics and Space Administration (NASA)

NASA's Earth Science Enterprise endeavors to understand and protect our home planet by advancing earth system science to enable improved prediction of climate, weather, and natural hazards from the vantage point of space. Through its ability to view the earth as a dynamic system, NASA makes key contributions to the science of hazard assessment and mitigation and provides essential support to the efforts of other Federal agencies charged with these responsibilities.

NASA and USGS are partners in the Landsat program, which has provided 30 years of data on land cover change. NASA and NIMA partnered in the Shuttle Radar Topography Mission which is yielding the first globally consistent topographic data set at 90m resolution. The combination of land cover and topography data makes a powerful tool for hazard assessment and response. NASA, NSF, USGS, and the Keck Foundation created the Southern California Integrated GPS Network to monitor strain and movement in the Los Angeles basin. NASA, NOAA, and DOD are long-time partners in the development and operation of the nation's weather satellite system; NASA's research systems of this decade will strengthen the operational system of the next decade. NASA and NOAA's partnership in satellite data assimilation is making substantial progress in predicting storm formation and hurricane tracks. NASA satellites are enhancing the wildfire monitoring assets of the U.S. Forest Service. Today's new generation of gravity field and ocean topography measuring systems will substantially improve sea level predictions.

NASA research and observations are providing essential tools to help the U.S. meet its disaster reduction goals for the next decade. NASA employs a systems engineering architecture approach to help its partner agencies improve their decision-support tools with Earth science information.

National Science Foundation (NSF)

The NSF is an independent agency established to promote the progress of science; to advance the national health, prosperity, and welfare; and to secure the national defense. NSF supports fundamental research and education across all fields of science and engineering, including the effects of extreme conditions on natural and constructed environments. Disaster-related projects aim to enhance fundamental understanding of the natural and social environments contributing to disasters and to promote advances in engineering analysis, design, and construction and in social sciences to improve the response and reduce the impact of natural and technological hazards. Laboratory and field experiments and monitoring projects (which include the use of advanced sensors) improve hazard event prediction and assessment of infrastructure integrity during and following major disasters. These research efforts take advantage of high-speed computers to develop models and improve simulation of natural disaster events and community response and recovery.

Additional Member Agencies:

- Department of the Interior-Bureau of Land Management
- Federal Energy Regulatory Commission
- National Guard Bureau
- United States Agency for International Development

AHPS	Advanced Hydrologic Prediction Services
ANSS	Advanced National Seismic System
ArcGIS	Geographic Information System Software
ATF	Bureau of Alcohol, Tobacco and Firearms
AVHRR	Advanced Very High Resolution Radiometer
BIA	Bureau of Indian Affairs
BFRL	Building and Fire Research Laboratory (NIST)
BLM	Bureau of Land Management
CENR	Committee on Environment and Natural Resources
CNES	Centre National d'Etudes Spatiales (French space agency)
CSA	Canadian Space Agency
DOC	Department of Commerce
DHS	Department of Homeland Security
DOD	Department of Defense
DOE	Department of Energy
DOI	Department of the Interior
DOL	Department of Labor
DOS	Department of State
DOT	Department of Transportation
EBMUD	East Bay Municipal Utility District in California
ECOSOC	United Nations Economic and Social Council
EERCs	Earthquake Engineering Research Centers
EOS	Earth Observing Systems
ESA	European Space Agency
EU	European Union
FAA	Federal Aviation Administration
FBI	Federal Bureau of Investigation
FEMA	Federal Emergency Management Agency
FRERP	Federal Radiological Emergency Response Plan
FRP	Federal Response Plan
FRPCC	Federal Radiological Preparedness Coordinating Committee
FWS	Fish and Wildlife Service
FY	Fiscal Year
GDIN	Global Disaster Information Network
GeoMAC	Geospatial Multi-Agency Coordination
GIFTS	Geostationary Imaging Fourier Transform Spectrometer
GIS	Geographic Information System
GOES	Geostationary Operational Environmental Satellite
GSA	General Services Administration
GSN	Global Seismographic Network
HAZMAT	Hazardous Materials Response Division
HAZUS-MH	A standardized multi-hazard methodology and software program
HHS	Department of Health and Human Services
HUD	Department of Housing and Urban Development
IGOS	Integrated Global Observing Strategy Partnership
IO	Bureau of International Organizational Affairs (Department of State)
ISDR	International Strategy on Disaster Reduction
ISRO	Indian Space Research Organization
JCSDA	Joint Center for Satellite Data Assimilation
JFSP	Joint Fire Science Program
JPL	Jet Propulsion Laboratory
LIDAR	Light Detection and Ranging
MAE	Mid-America Earthquake Center, University of Illinois at Urbana-Champaign

MCEER	Multidisciplinary Center for Earthquake Engineering Research
NASA	National Aeronautics and Space Administration
NCP	National Contingency Plan
NCST	National Construction Safety Team
NDEC	National Disaster Education Coalition
NEES	Network for Earthquake Engineering Simulation
NEHRP	National Earthquake Hazards Reduction Program
NFP	National Fire Plan
NGO	Non-Governmental Organization
NHP	National Hurricane Program
NIC	National Ice Center
NIFC	National Interagency Fire Center
NIMA	National Imagery and Mapping Agency
NIST	National Institute of Standards and Technology
NOAA	National Oceanic and Atmospheric Administration
NPS	National Park Service
NRC	Nuclear Regulatory Commission
NRO	National Reconnaissance Office
NRT	National Response Team
NSF	National Science Foundation
NSTC	National Science and Technology Council
NTM	National Technical Means
NTSB	National Transportation Safety Board
OET	Office of Emergency Transportation
ORD	Office of Research and Development
OR&R	Office of Response and Restoration
PATH	Partnership for Advancing Technology in Housing
PEER	Pacific Earthquake Engineering Center, University of California at Berkeley
PPW	Partnership for Public Warning
R&D	Research & Development
RSPA	Research and Special Programs Administration
SARSAT	Search and Rescue Satellite Aided Tracking System
SBA	Small Business Administration
SCEC	Southern California Earthquake Center
SCRP	StormReady Community Recognition Program
SDR	Subcommittee on Disaster Reduction
SIP	Seismic Improvement Program
TRMM	Tropical Rain Measuring Mission
TVA	Tennessee Valley Authority
UN	United Nations
USACE	U.S. Army Corps of Engineers
USAF	U.S. Air Force
USCG	U.S. Coast Guard
USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey
USN	U.S. Navy
USWRP	U.S. Weather Research Program
WBR	Water, Bureau of Reclamation

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