

TR NEWS

features articles on innovative and timely research and development activities in all modes of transportation. Brief news items of interest to the transportation community are also included, along with profiles of transportation professionals, meeting announcements, summaries of new publications, and news of Transportation Research Board activities.

TR News is produced by the Transportation Research Board Publications Office

Javy Awan, Editor and Publications Director
Christopher R. D'Amore, Assistant Editor
Jennifer J. Weeks, Photo Researcher
Juanita Green, Production Manager
Michelle Wandres, Graphic Designer

TR News Editorial Board

Neil F. Hawks, Chairman
Walter J. Diewald
Christopher J. Hedges
Frederick D. Hejl
Mark R. Norman
Stephan A. Parker
Barbara L. Post
A. Robert Raab

Transportation Research Board

Robert E. Skinner, Jr., Executive Director
Suzanne B. Schneider, Associate Executive
Director
Mark R. Norman, Director,
Technical Activities
Stephen R. Godwin, Director,
Studies and Special Programs
Michael P. LaPlante, Director,
Administration and Finance
Christopher W. Jenks, Director,
Cooperative Research Programs
Neil F. Hawks, Director, SHRP 2

TR News (ISSN 0738-6826) is issued bimonthly by the Transportation Research Board, National Research Council, 500 Fifth Street, NW, Washington, DC 20001. Internet address: www.TRB.org.

Editorial Correspondence: By mail to the Publications Office, Transportation Research Board, 500 Fifth Street, NW, Washington, DC 20001, by telephone 202-334-2972, by fax 202-334-3495, or by e-mail jawan@nas.edu.

Subscriptions: North America: 1 year \$55; single issue \$9.50. Overseas: 1 year \$75; single issue \$13.50. Inquiries or communications concerning new subscriptions, subscription problems, or single-copy sales should be addressed to the Business Office at the address below, or telephone 202-334-3216, fax 202-334-2519. Periodicals postage paid at Washington, D.C.

Postmaster: Send changes of address to *TR News*, Transportation Research Board, 500 Fifth Street, NW, Washington, DC 20001.

Notice: The opinions expressed in articles appearing in *TR News* are those of the authors and do not necessarily reflect the views of the Transportation Research Board. The Transportation Research Board and *TR News* do not endorse products or manufacturers. Trade and manufacturers' names appear in an article only because they are considered essential to its object.

Printed in the United States of America.

Copyright © 2007 Transportation Research Board. All rights reserved.

26 Risk Management for Multimodal Transportation Infrastructure: Interactive Tool Nears Completion

Michael C. Smith, Stephen C. Lockwood, Kevin Duffy, and Haskell Garon

A soon-to-be-released guide, including software and a data base, will assist decision makers in identifying cost-effective countermeasures to reduce the risks to transportation assets, including risks from natural disasters and from intentional harm, such as terrorism. The developers provide an overview of the guide, with insights into the practical approach taken.

28 Developing Guidance for Emergency Response Planning at the State Level

Douglas Ham, Annabelle Boyd, Stephen C. Lockwood, and Kevin Duffy

30 Tools for Improving Evacuations: Federal Highway Administration Develops Primers and Training

Laurel J. Radow and Kimberly C. Vasconez

After reviewing studies and after-action reports of recent hurricane seasons, the Federal Highway Administration concluded that basic guides, checklist templates, and best practices could contribute to the improvement of evacuation planning and capacity building by local, state, and regional authorities. The authors report on the progress, results, and related initiatives.

32 Professional Capacity Building for Transportation Security: Initiatives, Objectives, and Research Needs

John Boiney

SPECIAL INSERT

Disaster Time Line: Major Focusing Events and U.S. Outcomes (1978–2006)

Claire B. Rubin, Irmak Renda-Tanali, and William R. Cumming

A special pull-out chart links milestone domestic natural disasters and events with policy outcomes, such as major reports and documents, executive directives, and federal actions, strategies, and organizational changes.

ALSO IN THIS ISSUE:

34 Profiles

Airport executive James M. Crites and state transportation official David S. Ekern

36 TRB Highlights

Cooperative Research Programs News, 36

37 News Briefs

Public transit benefits, posting freeway trip times, and taxicab accessibility in Europe

38 Bookshelf

40 Calendar

COMING NEXT ISSUE

In the July–August *TR News*, two actively involved leaders draw a profile of the European Conference of Transport Research Institutes, which signed a memorandum of understanding with TRB in January 2006 for information exchanges and joint activities. Also described is the success of Europe's COST project of international



Pavement signage at a pedestrian crossing in Salt Lake City, Utah.

cooperative scientific and technical research—including transportation research. Other features present practical approaches to improve the communication skills of engineers, plus a summary of the award-winning research recommendations on pedestrian safety at unsignalized intersections, and more.

INTRODUCTION

Improving Disaster Preparedness and Response Through Practice-Oriented Research

Transportation is critical in preparing for, responding to, and recovering from a manmade or a natural disaster. With the creation of the Department of Homeland Security (DHS) in response to the events of September 11, 2001 (9/11), and again after Hurricane Katrina in August 2005, transportation agencies and organizations have taken on many initiatives, directives, and mandates. The Homeland Security Strategy and Legislation, along with Presidential Directives through the National Incident Management System, the National Response Plan, the National Infrastructure Protection Plan, and the National Preparedness Goal, have been the primary sources of these requests.

The transportation community has responded by researching and developing new systems, processes, and technologies to improve safety and security. Shortly after 9/11, the Transportation Research Board's (TRB's) Cooperative Research Programs initiated an \$8 million effort that has conducted more than 50 research, development, and technology projects. National Cooperative Highway Research Program Project 20-59, Surface Transportation Security Research, is generating a wealth of information and ready-to-use practice tools to assist transportation agencies and organizations in planning and responding to incidents—including tornadoes, earthquakes, traffic accidents, and terrorist attacks. TRB and the National Academies regularly post information, updates, and links about security-related research products at www.TRB.org/NASecurityProducts and www.TRB.org/SecurityPubs.

Continued all-hazards research—addressing issues in emer-

gency management and homeland security—is essential for producing technological and system enhancements that secure and maintain the quality of life in a changing world. TRB standing committees, such as the Critical Transportation Infrastructure Protection Committee, are involved in outreach to organizations such as the U.S. Department of Transportation, DHS, the Transportation Security Administration, the American Association of State Highway and Transportation Officials, the American Public Transportation Association, and others. The goal is to identify, prioritize, and communicate important topics for research and for practical synthesis studies in the areas of transportation security, emergency management, and infrastructure protection. The articles in this issue offer a brief and select—but wide-ranging—overview.

—Jeffrey L. Western
*Manager, Employee Security and Infrastructure Protection
Wisconsin Department of Transportation
Chair, TRB Critical Transportation
Infrastructure Protection Committee
Chair, NCHRP Project Panel on Guide to Risk Management of
Multimodal Transportation Infrastructure*

EDITOR'S NOTE: Appreciation is expressed to Stephan A. Parker, Senior Program Officer, TRB, for his efforts in developing this issue of *TR News*.



Remnants of the I-90 bridge (left) in Bay St. Louis, Mississippi, after Hurricane Katrina in August 2005, and the new bridge nearing completion in spring 2007.

PHOTO: HORNBLLOWER MARINE SERVICES

PHOTO: HORNBLLOWER MARINE SERVICES

Capabilities-Based Planning for the National Preparedness System

PATRICIA MALAK

The author is Chief, Policy Analysis, with the National Preparedness Directorate, Federal Emergency Management Agency, Department of Homeland Security, Washington, D.C.

This article is adapted from the introduction to the Target Capabilities List, Federal Emergency Management Agency, Department of Homeland Security, May 2006.



PHOTO: FEMA



PHOTO: FEMA



PHOTO: FEMA

(Above left:) A mobile medical unit of the federally coordinated National Disaster Medical System located off Route 23, Louisiana, October 2005.

(Above right:) Members of the Federal Emergency Management Agency's Disaster Medical Assistance Team successfully transport a Hurricane Katrina victim to safety.

(Below:) A temporary housing facility for disaster victims, D'Iberville, Mississippi, December 2005.

The Department of Homeland Security (DHS) is responsible for strengthening national preparedness to prevent and respond to threatened or actual domestic terrorist attacks, major disasters, and other emergencies.¹ DHS has developed a national preparedness goal that adopts a capabilities-based planning approach:

- ◆ Capabilities provide the means to accomplish a mission or function through the performance of critical tasks under specified conditions and standards.
- ◆ Capabilities-based planning provides capabilities suitable for a wide range of threats and hazards, working within an economic framework that necessitates prioritization and choice.

In developing a national preparedness goal, DHS addressed three fundamental questions:

- ◆ How prepared do we need to be?

- ◆ How prepared are we?
- ◆ How do we prioritize efforts to close the gap?

The target capabilities list (TCL) describes the capabilities required to prepare the nation for major all-hazards events (see box, page 5). The list identifies 37 capabilities related to the four missions of homeland security: prevent, protect, respond, and recover. The TCL provides a guide for developing a national network of capabilities that will be available when needed.

National Preparedness Goal

A presidential directive charged DHS to establish a National Preparedness System, a common and unified approach to strengthen the preparedness of the United States.¹ The national preparedness goal,

¹ Homeland Security Presidential Directive 8: National Preparedness, December 17, 2003.

which provides the foundation for the system, is for

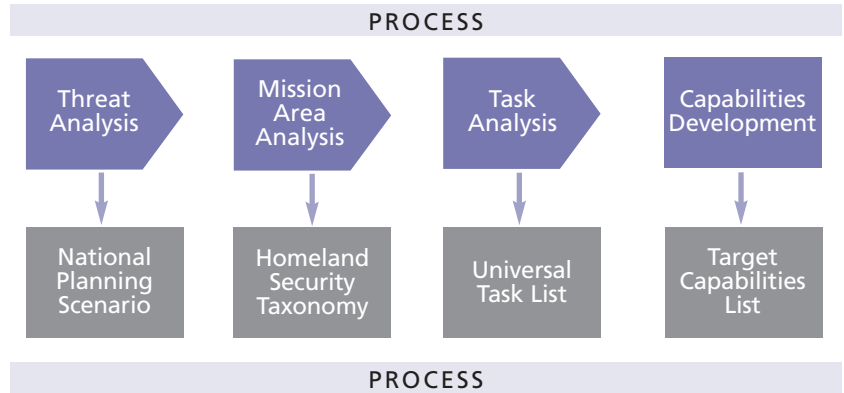
...a nation prepared with coordinated capabilities to prevent, protect against, respond to, and recover from all hazards in a way that balances risk with resources.²

Preparedness for major events assumes a coordinated and shared response that involves all levels of government, the private sector, nongovernmental organizations, and citizens. The national preparedness goal adopted a capabilities-based planning approach to identify, achieve, and sustain risk-based target levels of capability. The goal emphasizes a collaborative, regional approach to capabilities-based planning.

Capabilities Development

Answering the three questions for the national preparedness goal requires identifying the threats and then determining what must be done to prevent, protect against, respond to, and recover from those threats. Figure 1 illustrates this process.

² National Preparedness Goal (draft), May 2007.



National Planning Scenarios

An interagency working group, led by the Homeland Security Council and DHS, undertook a threat analysis to address the first question, “How prepared do we need to be?” and developed a set of 15 national planning scenarios (see box, page 6). The scenarios define the range, scope, magnitude, and complexity of a representative set of major incidents for which the nation should prepare. The range of possible scenarios assists in addressing the uncertainty in planning and avoids focusing on any one

FIGURE 1 Capabilities Planning Process and Tools

Target Capabilities List, Phase 1

Common Capabilities

- Planning
- Communications
- Community preparedness and participation
- Risk management

Prevention Mission Capabilities

- Information gathering and recognition of indicators and warning
- Intelligence analysis and production
- Information sharing and dissemination
- Law enforcement investigation and operations
- Chemical, biological, radiological–nuclear, and explosive detection

Protection Mission Capabilities

- Critical infrastructure protection
- Food and agriculture safety and defense
- Epidemiological surveillance and investigation
- Public health laboratory testing

Response Mission Capabilities

- On-site incident management
- Emergency operations center management
- Critical resource logistics and distribution

- Volunteer management and donations
- Responder safety and health
- Public safety and security
- Animal health emergency support
- Environmental health
- Explosive device response operations
- Firefighting operations and support
- Weapons of mass destruction and hazardous materials response and decontamination
- Citizen evacuation and shelter-in-place
- Isolation and quarantine
- Search and rescue (land-based)
- Emergency public information and warning
- Triage and prehospital treatment
- Medical surge
- Medical supplies management and distribution
- Mass prophylaxis
- Mass care: sheltering, feeding, and related services
- Fatality management

Recovery Mission Capabilities

- Structural damage assessment
- Restoration of lifelines
- Economic and community recovery

TR NEWS

NUMBER 250

MAY-JUNE 2007

ALL-HAZARDS PREPAREDNESS, RESPONSE, AND RECOVERY

3 INTRODUCTION

Improving Disaster Preparedness and Response Through Practice-Oriented Research

Jeffrey L. Western

The transportation community is engaged in all-hazards research, developing new systems, processes, and technologies to improve emergency management and homeland security, generating ready-to-use practice tools for responding to incidents that affect the transportation infrastructure—such as tornadoes, earthquakes, traffic accidents, and terrorist attacks.

4 Capabilities-Based Planning for the National Preparedness System

Patricia Malak

The Department of Homeland Security is working toward the goal of “a nation prepared with coordinated capabilities to prevent, protect against, respond to, and recover from all hazards in a way that balances risk with resources.” This article describes the capabilities-based planning approach to regional and national preparedness.

9 Restoring the National Response System: Fixing the Flaws Exposed by Hurricane Katrina

John R. Harrald

Learning from the emergency management failures during and after Hurricane Katrina, according to this author, can help to build a creative, agile national response system that coordinates federal resources to support state and local governments, so that communities and citizens can recover from even the most catastrophic events.

14 Conceptualizing and Measuring Resilience: A Key to Disaster Loss Reduction

Kathleen Tierney and Michel Bruneau

A multidisciplinary research project has examined ways to improve resilience, which can be measured by the functionality of an infrastructure system after a disaster and also by the time it takes for a system to return to previous levels of performance. Two project leaders present the components and dimensions of resilience and the implications for disaster response strategies.

16 Improving Resilience with Remote Sensing Technologies

Ronald T. Eguchi and Beverley J. Adams

18 The Prague Subway's New Flood Protection System: Lessons from the Disaster of 2002

Tomas Jilek, Antonin Fedorko, and Jiří Šubrt

In August 2002, the waters of the Vltava River surged far above the highest levels recorded in more than 100 years, overcoming established protections and flooding the city of Prague. Floodwaters overwhelmed 17 stations and 12 miles of tunnels in the city's subway system. Three transit officials present the lessons learned and the new protections now in place.

23 Sea-Based Emergency Response Planning: A Proven but Overlooked Strategy

Joseph Scanlon

Although major destructive incidents on land often have received maritime response, waterborne rescue missions usually are not part of a larger plan. The author points to several historic and recent events—including the September 11 terrorist attack on New York, the Indian Ocean tsunami, and Hurricane Katrina—that demonstrate the advantages and effectiveness of water-based response.



3



9



23



COVER: A helicopter drops a sandbag above a levee damaged during Hurricane Katrina, September 2005. (Photo: Reuters)

threat, hazard, or set of conditions.

The scenarios describe incidents that would cause injuries and deaths in the hundreds or thousands, major property damage, and the displacement of large numbers of people. The national planning scenarios help in defining the tasks that must be performed in large-scale incidents, as well as the capabilities required to perform the tasks.

All-Hazards Taxonomy

The homeland security all-hazards taxonomy (see Figure 2) derives from a mission analysis of homeland security requirements. The objectives and functions were identified from an analysis of the homeland security strategy, legislative mandates, presidential directives, and other homeland security doctrine, as well as input from practitioners. The taxonomy helps to define the major functional areas to address in supporting the missions and to develop and organize the universal task list (UTL) and the TCL.

Universal Task List

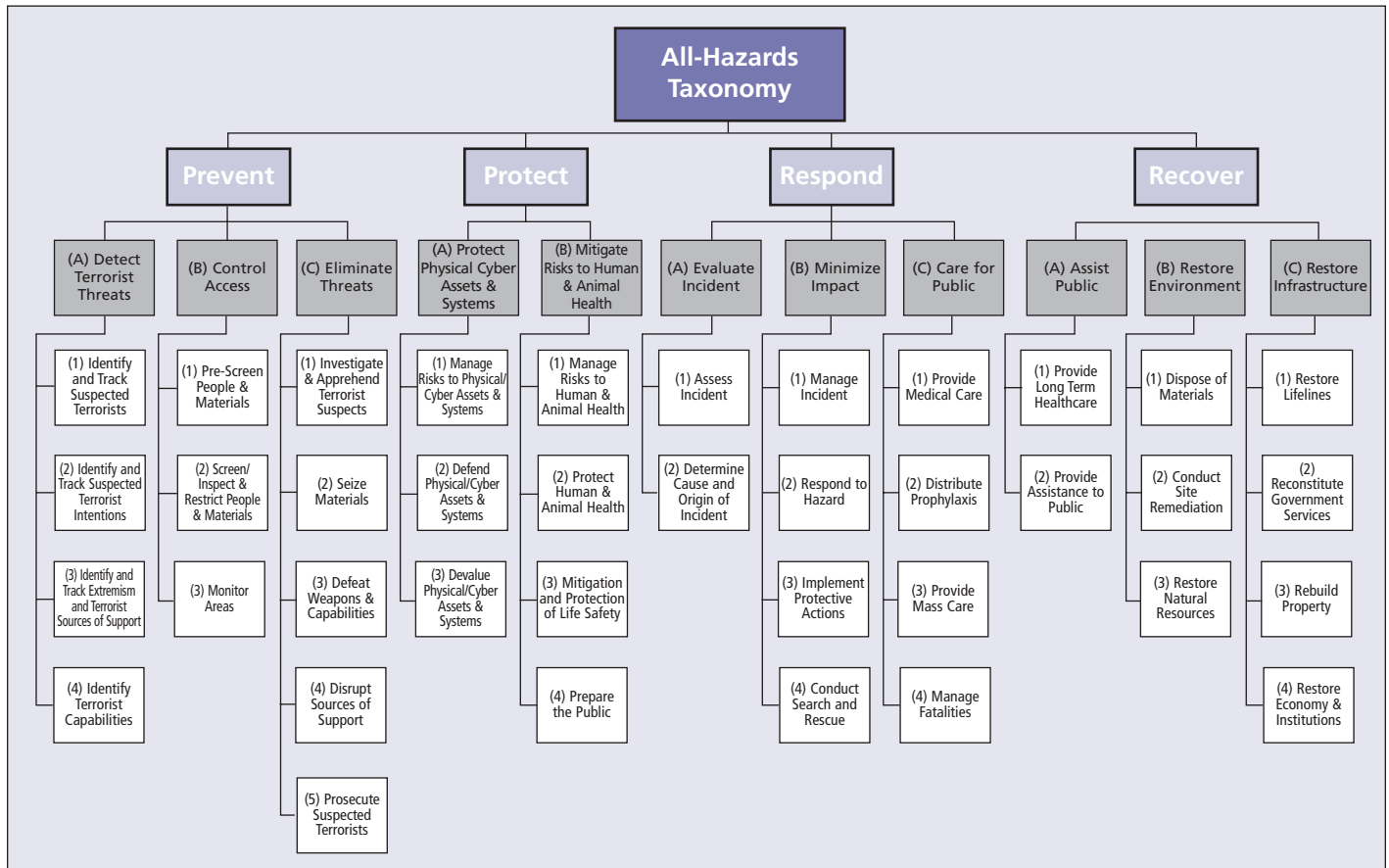
Building the right mix of capabilities for the full range of major events requires understanding which tasks need to be performed, how well, and how quickly. Developed with broad stakeholder support, the UTL

National Planning Scenarios

1. Improvised nuclear device
2. Aerosol anthrax
3. Pandemic influenza
4. Plague
5. Blister agent
6. Toxic industrial chemical
7. Nerve agent
8. Chlorine tank explosion
9. Major earthquake
10. Major hurricane
11. Radiological dispersal device
12. Improvised explosive device
13. Food contamination
14. Foreign animal disease
15. Cyberattack

comprises tasks to prevent, protect against, respond to, and recover from large-scale events such as those in the national planning scenarios. The UTL constitutes a library of tasks, organized according to the all-hazards taxonomy. Through capability-based planning, federal, state, local, and tribal entities—with appropriate private-sector support—identify the tasks that

FIGURE 2 Homeland Security All-Hazards Taxonomy



apply to them to ensure their own preparedness.

The UTL does not identify who will perform each task or how it should be performed—that is the responsibility of the implementing entities. No single jurisdiction or agency, however, is expected to perform every task; instead, subsets of tasks are selected based on roles, missions, and functions.

Target Capabilities List

The TCL describes the capabilities needed to perform the tasks identified in the UTL. It is a guide to developing a national network of capabilities that will be available when and where they are needed to prevent, protect against, respond to, and recover from major events.

As was demonstrated with the terrorist attacks of September 11, 2001, and more recently with Hurricane Katrina, major events—man-made or natural—quickly exceed the capacity of a single local jurisdiction. Preparation therefore requires a national view to estimate the type, amount, and placement of capabilities across the country. The TCL identifies the national preparedness roles of government and nongovernmental organizations, the private sector, and citizens.

The capabilities were defined through a consensus approach, involving all stakeholders. Additional capabilities are in development (see box, this page). A capability summary includes the following:

- ◆ **Definition and outcome**—the scope of the capability and the results or effects to be achieved;
- ◆ **Preparedness activities, critical tasks, and measures**—the plans, procedures, agreements, authorizations, training, and exercises to be completed before a demand arises;
- ◆ **Performance activities, critical tasks, and measures**—actions to be taken in response to a demand, including the quantitative and qualitative measures for assessing the achievement of a task or a capability outcome;
- ◆ **Capability elements**—the resources needed to perform the critical tasks at the required level; and
- ◆ **National target levels and assignment of roles**—the level of capability needed nationally and the role of local, state, and federal governments, as well as nongovernmental organizations, the private sector, and citizens, in achieving the national targets.

Using the Target Capabilities List

Users address the remaining two questions, “How prepared are we?” and “How do we prioritize to close the gap?” through the preparedness cycle, a series of activities that includes making assessments, developing strategy, planning, identifying and filling resource gaps, training, conducting exercises, and implement-

Target Capabilities Under Development

Prevention Mission Capabilities

- Identification and tracking of suspected terrorists*
- Identification and tracking of terrorist motivations*
- Determination and tracking of terrorist support*
- Recognition and tracking of extremism*
- Determination of terrorist ability to execute threats*
- Defeat weapons*
- Border control
- Transportation screening
- Infrastructure and facility access screening
- Credentialing for identity and background verification
- Interdiction and seizure of materials
- Interdiction and seizure of terrorist assets
- Denial of access to materials which may be weaponized
- Prosecution of suspects

Protection Mission Capabilities

- Defense and devaluation of physical assets and systems
- Defense and devaluation of cyber assets and systems
- Environmental monitoring
- Natural hazard monitoring
- Mitigation and life safety protection
- Infectious disease control

Response Mission Capabilities

- Incident scene investigation
- Water rescue
- Functional and medical sheltering
- Tactical operations

Recovery Mission Capabilities

- Postsurge healthcare services
- Long-term assistance of affected persons
- Resettlement of affected persons
- Debris and hazardous waste management
- Site remediation
- Natural resource restoration
- Reconstitution of government services
- Restoration of economy and institutions

* Capabilities addressed by the National Implementation Plan developed by the intelligence community.

ing corrective actions. DHS is developing implementation tools based on the TCL to help decision makers and managers at all levels to define preparedness needs, build needed capabilities, and assess levels of preparedness.

Assessing Preparedness

The TCL provides a basis for assessing preparedness. The national planning scenarios and the TCL offer a common perspective on the levels of readiness to per-



PHOTO: BOBBY NASH, USCG

U.S. Coast Guard Cutter *Spencer*, dispatched from Norfolk, Virginia, at anchor in the Mississippi River near the heart of downtown New Orleans, September 1, 2005, to aid in relief efforts for Hurricane Katrina.

form critical tasks and for identifying and addressing any gaps or deficiencies.

The assessments should inform decision making at all levels. Policy makers need information about the status of the capabilities under their responsibility, to make better decisions about resources and investments and to establish priorities. Assessments can help emergency managers and planners address deficiencies, identify alternative sources for capabilities—for example, from mutual aid or contracts with the private sector—and determine which capabilities should be tested through exercises.

DHS is developing the National Preparedness System to support capabilities-based planning and to assess capabilities across all levels of government. The system will enable users to conduct a self-assessment based on the TCL that takes into account information from exercises, onsite validations, peer reviews, and monitoring.

Strategies and Investments

States and urban areas have developed homeland security strategies that provide a blueprint for comprehensive, enterprisewide planning. The strategy should address gaps and deficiencies in capabilities, establishing priorities for available resources, including those from local, state, and federal sources. Because the national planning scenarios and the TCL focus on major incidents, which exceed the capacity of any single jurisdiction, collaboration within an expanded regional area and with nongovernmental and private-sector organizations should be an integral part of the strategy to address gaps and deficiencies.

Planning

In addition to strategic planning, the TCL informs the development of operational plans to implement the capabilities required for specific incidents or threats. The critical tasks and measures and the related resources identified in the TCL guide the development and revision of plans, procedures, protocols, systems, and agreements. Most decisions during an event should have been made in advance through effective planning. Major events require a shared response across levels of government, jurisdictions, disciplines, and the private sector.

Training

Training programs should be reviewed and modified to ensure that participants are prepared to perform the critical tasks at the required level of proficiency. States are developing multiyear training and exercise plans to build and assess capabilities. The training should impart the knowledge, skills, and abilities to perform the critical tasks and should be completed before being tested through exercises. The plans

should address the training needs of participants from nongovernmental organizations, the private sector, volunteers, and citizens.

Testing Through Exercises

Exercises test and validate preparedness. The Homeland Security Exercise and Evaluation Program (HSEEP) establishes a common design, performance, and evaluation methodology for exercises at all levels of government and the private sector. The HSEEP exercises are designed to demonstrate capability levels and to assess the performance of critical tasks and the achievement of outcomes.

The exercise design process includes the following steps:

- ◆ Identify the priority capabilities for improvement;
- ◆ Select corresponding tasks for assessment;
- ◆ Define the exercise objectives according to capabilities, tasks, and jurisdiction needs; and
- ◆ Create a jurisdiction-specific scenario to meet the exercise objectives.

HSEEP includes common evaluation tools based on the critical tasks and measures from the TCL to encourage consistency and quality of data collection and information, support qualitative and quantitative exercise analysis and assessment, and increase usability. HSEEP also defines a standard after-action report and a format for an improvement plan. The exercising entities develop the improvement plan, which outlines specific actions and a timeline to enhance the capabilities.

Refinements in Progress

The TCL is a major step in defining preparedness and capabilities. Many hundreds of stakeholders from a range of disciplines, levels of government, nongovernmental organizations, and the private sector developed the list, setting aside jurisdictional or organizational perspectives to define capabilities for the nation, along with the roles that every jurisdiction, state, federal agency, organization, and citizen play in a shared response.

Standards and guidelines that already were in place were retained—but standards and guidelines were not available for many of the capabilities. Much of the information in the TCL, therefore, is based on the best judgment and expertise of the working groups, the reviewers, and commenters.

The TCL is a living document that will continue to be enhanced and refined through lessons from application and real-world experience. Comments from stakeholders are welcome and encouraged.

Restoring the National Response System

Fixing the Flaws Exposed by Hurricane Katrina

JOHN R. HARRALD

The author is Director, Institute for Crisis, Disaster, and Risk Management, George Washington University, Washington, D.C. He is the Executive Editor of the Journal of Homeland Security and Emergency Management (www.bepress.org/jhsem), and is a member of the National Research Council's Disaster Roundtable Steering Committee. This article is adapted from his testimony, Hurricane Katrina: Recommendations for Reform, before the Senate Homeland Security Government Affairs Committee, March 8, 2006.

The United States failed in preparing for and responding to the catastrophic impacts of Hurricane Katrina and the flooding of New Orleans in August 2005. Although progress is being made, the nation today is only marginally better prepared to deal with a catastrophic event than it was then. A failure to restore and reenergize the national response and recovery capability will lead to more tragic outcomes.

Millions of Americans are as vulnerable today as the citizens of the Gulf Coast were on August 29, 2005. The United States remains vulnerable not only to hurricanes but to other natural hazards such

as earthquakes; to public health crises such as pandemic flu; and to terrorist attacks.

Catastrophic events have two characteristics that in turn affect preparation and planning:

◆ **The initial and most severe impacts are local.** Citizens, communities, and state and local governments therefore should have primary roles in preparing for and minimizing the impacts of catastrophic events.

◆ **The scale, scope, and impact differ qualitatively from those of major disasters.** The scale, scope, and impact necessitate federal involvement. Although legislation has defined the emergency man-



PHOTO: FEMA

Emergency operations personnel monitor Hurricane Katrina in a Federal Emergency Management Agency operations center, Clanton, Alabama.

agement role of the federal government clearly and adequately, the systems and the capabilities necessary to fulfill that role have not yet been created.

Federal Response Role

The response role of the federal government is to provide resources and leadership to support state and local governments, not to assert command and control over the actions of the hundreds of organizations and the thousands of individuals responding to an extreme event. A multiorganizational response to a complex, catastrophic event is not like a military combat operation—such a comparison is inappropriate, inaccurate, and misleading.

Creating a National Response System based on the National Response Plan and the National Incident Management System (NIMS) requires capacity, capability, and competence:

◆ **Capacity:** Does the federal government have

adequate personnel and materiel resources available or immediately accessible to meet the needs caused by a catastrophic event?

◆ **Capability:** Can the federal government rapidly mobilize and organize enough skilled personnel, deploy people supported with adequate resources to the places in need, and coordinate their actions?

◆ **Competence:** Can the federal government provide the leadership, management, decision making, and awareness necessary to manage the response to a catastrophic event?

Lessons from Katrina

Hurricane Katrina was a cruel auditor of the National Response System and showed that the answer to all three questions was no. Ten general lessons can be extracted from a study of the failed response to Hurricane Katrina:

1. **Infrastructure is critical.** Hurricane Katrina totally destroyed physical and communication infrastructure. Everyone in New Orleans and other affected areas required assistance. Response forces that were not self-sufficient were severely constrained.

2. **Size matters.** The scope and complexity of the event and the scale of the postevent needs overwhelmed the response system.

3. **Competence and leadership count.** Individuals at critical nodes of the system did not have the ability to make decisions and to take actions. Moreover, they did not have the experience to anticipate or to communicate an appropriate sense of urgency.

4. **Information is key to agility.** Technology did not support awareness of the situation for a distributed network of decision making. Decision makers were unable to process information that was incomplete or conflicting.

5. **Communications is more than interoperability.** Responders were not able to transmit information within the affected area or between the affected area and key decision nodes.

6. **Coordination must be seamless.** Massive mobilization requires effective coordination with the Department of Defense, nongovernment organizations, state and local governments, and other governments. This coordination did not occur.

7. **Doctrine must be understood and followed.** Many key leaders and participants had little understanding of the provisions of the National Response Plan or the protocols of the NIMS.

8. **Logistics cannot fail.** The federal, state, and local governments have to be able to move thou-

Boats carried inland by Hurricane Katrina floodwaters block a southern Louisiana roadway.



PHOTO: FEMA



Photo: Nixolino Candiani, USCG

U.S. Coast Guard officer, part of a helicopter rescue crew sent from Clearwater, Florida, searches for survivors after Hurricane Katrina in New Orleans, August 2005.

sands of people and large amounts of materiel effectively and efficiently but could not deliver during and immediately after Hurricane Katrina.

9. **Resilience is a key design concept.** Physical and organizational systems must be robust or easily recoverable and must be designed to avoid catastrophic failure.

10. **It is not over until it is over.** The transition to recovery and the adequate funding of recovery cannot be ad hoc—but the post-Hurricane Katrina response was. Preplanning and a focus on recovery are essential during response.

System in Transition

Was the implementation of a National Response System—the National Response Plan and the NIMS—after September 11, 2001 (9/11), part of the solution or part of the problem during the response to Hurricane Katrina? The adoption of the National Response Plan and the NIMS produced intended and unintended consequences. Hurricane Katrina struck while the nation was in transition to a new and more complex response framework.

The response to the hurricanes of 2004 was the last major effort under the framework of the Federal Response Plan, which was still in effect under the Interim National Response Plan. The final National Response Plan was signed in December 2004, and all federal agencies were directed to comply with the NIMS during 2005.

The new system brought a significant change in the way that the nation prepares for and responds to extreme events. The system was now more closed and bureaucratic and was less capable of the cre-

ative, agile response necessary to deal with the unexpected consequences of extreme events.

The new National Response System is a relatively closed system (Figure 1), restricting access to those trained and certified in the NIMS, and impeding the inclusion of the local volunteers, the enabled victims, and the emergent groups that historically have played a large role in the response to disasters. The National Response Plan and the NIMS have set up an artificial barrier between the formal and informal response systems with a complexity of doctrine, process, and language.

FIGURE 1 The National Response System: Is It a Closed System?

A system consists of interrelated components that work together to accomplish a common goal. What is the system's boundary? The National Response System excludes critical groups. (Source: Lauren Fernandez)

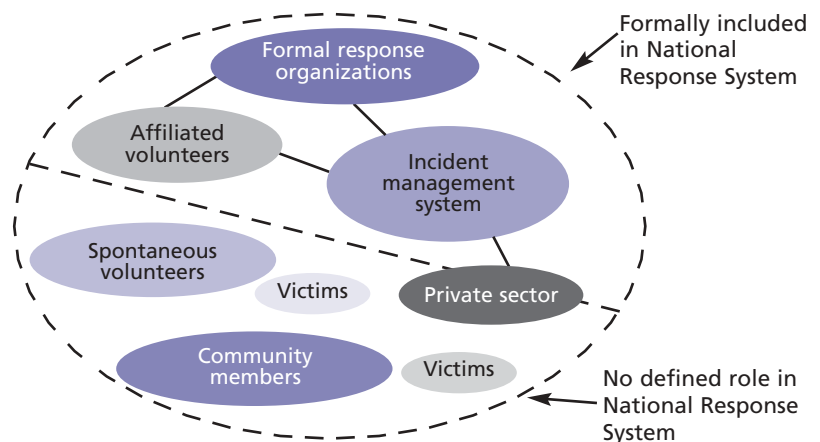




PHOTO: KYIE NIEW, USCG

U.S. Coast Guard officer prepares to hoist children from their rooftop into a rescue helicopter in New Orleans after Hurricane Katrina.

The development of doctrine and structure after 9/11 was a continuation of a 30-year trend. Since the 1970s, the U.S. emergency management community has increased its ability to structure and manage a large response through improved plans and through the adoption of an incident command system. The National Response System, created and directed by the Department of Homeland Security, is a result.

At the same time, social scientists and other disaster researchers have documented and described nonstructural elements—such as improvisation, adaptability, and creativity—that are critical to coordination, collaboration, and communication and to successful problem solving. The two approaches are not in opposition but form orthogonal dimensions of discipline and agility that must be achieved. The post-9/11 evolution of the National Response System has focused on building discipline in a closed organizational system and has neglected the preservation of an open system with agile attributes, which has characterized historically successful response efforts.

The evolution of the National Response System continues, presenting opportunities to correct obvious problems. The National Response Plan and the NIMS are under revision, the Federal Emergency Management Agency (FEMA) has been restructured and strengthened, and millions of dollars have been allocated for preparedness and planning for response to catastrophic events.

Intended and Unintended Outcomes

The restructuring of the National Response System inevitably produced intended and unintended outcomes. Both became apparent during the response to Hurricane Katrina. Intended outcomes included the following:

1. One structure and doctrine was provided for all organizations. (Some federal agencies and key state and local organizations, however, had not yet implemented the structure and doctrine.)
2. System discipline increased through training and credentialing. (The insistence on NIMS compliance and on proper credentials, however, was a problem for volunteer organizations.)
3. The federal government created new positions of authority and new mechanisms for coordination. The Department of Homeland Security secretary became the cabinet officer responsible for all incident management; the primary federal official (PFO) became the lead presence on scene; and the Homeland Security Operations Center became

the primary information coordinator for the federal government. (The authority of the PFO, however, was not clearly specified in the National Response Plan, nor was it understood by state officials.)

4. The process of obtaining Department of Defense resources was modified. The Northern Command, or NORTHCOM, became the key coordinating command for military assistance.

The restructuring of the National Response System also produced unintended consequences that proved critical during the response to Hurricane Katrina:

1. The detailed doctrine in the NRP and the specification of structure and process in the NIMS reduced the agility, creativity, and flexibility of the system and increased the bureaucracy.

2. The NIMS structure implied but did not define a flow of information that would assure a common awareness of the situation at all levels of the decision network—such as the Joint Field Office, National Response Coordination Center, Homeland Security Operations Center, and the White House.

3. The new structure increased the layers between operational and political leaders. The director of FEMA formerly held a cabinet rank with direct access to the President; the position now was three levels removed in a complex departmental structure. The federal coordinating officer in the Joint Field Office had to communicate through the PFO, the National Response Coordination Center, the Homeland Security Operations Center, and the Department of Homeland Security secretary to pass time-sensitive information to the White House.

4. The PFO became the key on-scene decision maker. The intent of the National Response Plan was that the PFO would be a coordinating official, and that decision making would reside with the federal coordinating officer. As the representative of the President, however, the PFO clearly would be viewed as a leader, not a coordinator.

5. The Department of Homeland Security and the Department of Defense had undertaken parallel planning and preparedness efforts. The boundary between homeland defense and homeland security was not clear. The procedures for engaging NORTHCOM and using Department of Defense assets that were under control of the Department of Homeland Security were not clearly defined.

Actions Based on Needs

To build adequate capacity and appropriate capabilities, planners should address potential scenarios

for catastrophic events. The planning should be based on needs, not on doctrine. More strategies, plans, and coordinating mechanisms will not help in understanding the task. The catastrophic planning scenarios developed by FEMA and the Department of Homeland Security provide a good starting point but must be used to determine the range of needs that could result from a catastrophic event.

Analysis of these scenarios will generate specific questions, such as the following:

- ◆ Can the medical system deal with tens of thousands of seriously injured people after a catastrophic earthquake?
- ◆ What is the best way to provide temporary and long-term shelter and housing for hundreds of thousands of people whose homes have been destroyed by a natural disaster?
- ◆ How can hundreds of thousands of people and businesses be evacuated and relocated from a major urban center after a dirty bomb attack, and how will the people be sheltered and fed?
- ◆ When are state and local emergency management forces overwhelmed, and how does the federal government intervene to rebuild, but not replace, local capabilities?

Defining these kinds of needs may generate creative solutions that increase the roles of private-sector, nongovernment, and volunteer organizations. Improving ways to mobilize local volunteers may be more effective than expanding the federal civilian or military bureaucracy. The goals should rely on an understanding of the needs to determine the investment, planning, acquisition, coordination, and training that will be required.

Response and Recovery Measures

Policy makers should take the following actions to ensure that the United States can develop the national capacity, capability, and competence to respond to and recover from extreme events:

1. Ensure that the federal leaders who direct emergency management have the required professional knowledge and skills. Preparing for and managing through catastrophic events are among the most important functions of the federal government.
2. Focus on supporting agility, creativity, and improvisation in response, instead of on developing doctrine and structure. Response relies on past experience and on scenario-based planning to address the next event, which will pose unanticipated challenges. The response must be agile

enough to recognize and to manage the unexpected.

3. Bring states and local governments back into appropriate roles in the national emergency management system. Bring the private sector into the planning and preparedness process. Modify the top-down approach to include bottom-up direction, information, and guidance.

4. Ensure that the NIMS is an open system. A military command-and-control system is capable only of directing the resources under its control; the NIMS must be capable of coordinating the actions of hundreds of organizations and hundreds of thousands of individuals.

5. Increase the resilience to extreme events. Response must do more than provide emergency support to disaster victims—it also must reduce vulnerability and recover economic and social systems.

6. Identify what is needed and build the capability to achieve it. Reorganization does not solve problems. Use Department of Defense resources as appropriate, but retain civilian leadership of emergency management.

7. Support emergency management education and training as a national, not a federal, issue. Programs—such as the FEMA higher education initiative—that reach people in state, local, corporate, and nongovernment organizations are essential.

8. Provide an independent, nongovernment review of the preparations for, the response to, and the recovery from Hurricane Katrina. This review should not cast blame but identify and address systemic problems in the National Response System.

Coordinating for Recovery

Should emergency management responsibilities remain in the Department of Homeland Security, or should an independent FEMA be created? Either alternative could work or could fail, depending on the leadership and support provided.

If the function remains in the Department of Homeland Security, the responsibilities for implementing and integrating comprehensive emergency management must be assigned to the highest levels of the department. Before recreating an independent emergency management agency, policy makers should examine the historical shortcomings and limitations of FEMA, as well as its successes. Learning from the failures of Hurricane Katrina can help to build a National Response System that coordinates all the resources of the federal government to support state and local governments, so that communities and citizens can recover from even the most catastrophic events.



A hazmat instructor briefs emergency response personnel for a chemical spill cleanup exercise. Hazmat teams that responded to toxic contamination situations during Hurricanes Katrina and Rita received similar training.

Conceptualizing and Measuring Resilience

A Key to Disaster Loss Reduction

KATHLEEN TIERNEY AND MICHEL BRUNEAU

Tierney is Professor of Sociology and Director of the Natural Hazards Research Center, Institute of Behavioral Science, University of Colorado, Boulder. Bruneau is Director, Multidisciplinary Center for Earthquake Engineering Research, and Professor of Civil, Structural, and Environmental Engineering, University at Buffalo.

In recent years, particularly after the catastrophe of Hurricane Katrina in August 2005, resilience has gained prominence as a topic in the field of disaster research, supplanting the concept of disaster resistance.

◆ Disaster resistance emphasizes the importance of predisaster mitigation measures that enhance the performance of structures, infrastructure elements, and institutions in reducing losses from a disaster.

◆ Resilience reflects a concern for improving the capacity of physical and human systems to respond to and recover from extreme events.

For the past seven years, researchers affiliated with the Multidisciplinary Center for Earthquake Engineering Research (MCEER), sponsored by the National Science Foundation and headquartered at the University at Buffalo, have collaborated on stud-

ies to conceptualize and measure disaster resilience. The resilience-related projects have involved researchers from a range of disciplines, including civil, structural, and lifeline engineering; sociology, economics, and regional science; policy research; and decision science. The goals of the multiyear effort were to define disaster resilience, develop measures appropriate for assessing resilience, and then demonstrate the utility of the concept through empirical research.

To develop a framework, the MCEER research team drew on various literatures and research traditions that have focused on resilience and related concepts, including ecology, economics, engineering, organizational research, and psychology. The literature revealed consistent cross-disciplinary treatments in which resilience was viewed as both inherent strength and the ability to be flexible and adaptable after environmental shocks and disruptive events.



Photo: NOAA

Hurricane Katrina made landfall near Bay St. Louis, Mississippi, at the mouth of the Pearl River, during high tide, causing a storm tide approximately 30 feet deep, and toppling segments of the I-90 bridge.

R4 Framework

MCEER researchers defined disaster resilience as

...the ability of social units (e.g., organizations, communities) to mitigate hazards, contain the effects of disasters when they occur, and carry out recovery activities in ways that minimize social disruption and mitigate the effects of future disasters. (1)

Critical infrastructure systems—including transportation and utility lifeline systems—play an essential role in communitywide disaster mitigation, response, and recovery and therefore are high-priority targets for resilience enhancement.

Resilient systems reduce the probabilities of failure; the consequences of failure—such as deaths and injuries, physical damage, and negative economic and social effects; and the time for recovery. Resilience can be measured by the functionality of an infrastructure system after a disaster and also by the time it takes for a system to return to pre-disaster levels of performance.

Figure 1 plots the quality or functionality and the performance of infrastructure after a 50 percent loss. The “resilience triangle” in the figure represents the loss of functionality from damage and disruption, as well as the pattern of restoration and recovery over time.

Resilience-enhancing measures aim at reducing the size of the resilience triangle through strategies that improve the infrastructure’s functionality and performance (the vertical axis in the figure) and that decrease the time to full recovery (the horizontal axis). For example, mitigation measures can improve both infrastructure performance and time to recovery. The time to recovery can be shortened by improving measures to restore and replace damaged infrastructure.

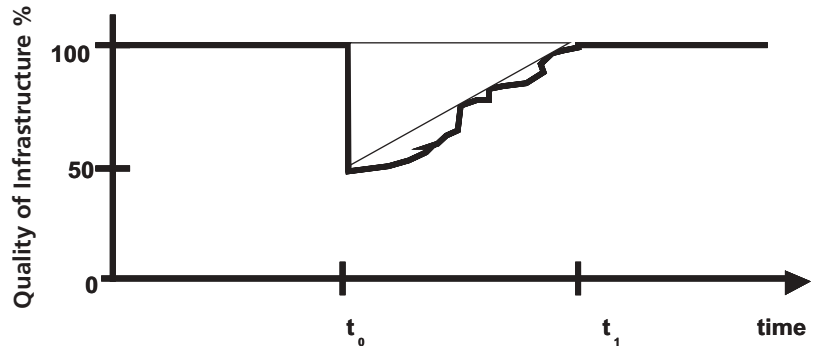
In examining the attributes and determinants of resilience, MCEER investigators developed the R4 framework of resilience:

◆ **Robustness**—the ability of systems, system elements, and other units of analysis to withstand disaster forces without significant degradation or loss of performance;

◆ **Redundancy**—the extent to which systems, system elements, or other units are substitutable, that is, capable of satisfying functional requirements, if significant degradation or loss of functionality occurs;

◆ **Resourcefulness**—the ability to diagnose and prioritize problems and to initiate solutions by identifying and mobilizing material, monetary, informational, technological, and human resources; and

FIGURE 1 The Resilience Triangle



◆ **Rapidity**—the capacity to restore functionality in a timely way, containing losses and avoiding disruptions.

In transportation systems, robustness reflects the ability of the entire system—including the most critical elements—to withstand disaster-induced damage and disruption. Redundancy can be measured by the extent that alternative routes and modes of transportation can be employed if some elements lose function. After the 1989 Loma Prieta earthquake, for example, expanded use of the Bay Area Rapid Transit system and the trans-Bay ferries overcame to some extent the loss of the San Francisco Bay Bridge.

Resourcefulness reflects the availability of materials, supplies, repair crews, and other resources to restore functionality. Hurricane Katrina was a catastrophe because of the extent and severity of the physical damage and the inability to move critical resources into the disaster-stricken region.

Rapidity is a consequence or outcome of

Ferry *Marissa Mae Nicole* carries local traffic across the Bay of St. Louis, Mississippi, during construction of the new I-90 bridge.



Improving Resilience with Remote Sensing Technologies

RONALD T. EGUCHI AND BEVERLEY J. ADAMS

The performance of highway bridges is a major concern after earthquakes and other extreme events. Serious damage can impede critical emergency response, and the failure to detect collapsed bridge spans—particularly during the first few minutes of an earthquake—can result in serious injuries and fatalities.

During the past five years, a group of researchers from the Multidisciplinary Center for Earthquake Engineering Research in Buffalo, New York, has investigated the use of remote sensing technologies to detect urban damage and to assist in emergency response. The research has focused on damage detection, including the development of algorithms for using optical and synthetic aperture radar data to locate highway and building collapses, as well as a mapping scheme to display and disseminate earthquake-related geospatial data.

Another technology is a tiered reconnaissance system (TRS), which uses satellite images to determine the location, extent, and severity of building damage after an earthquake; the accompanying photographs offer a schematic representation. Output from the TRS can assist in deter-

mining the scale of site visits and of relief efforts and in setting priorities.

A second major effort in postdisaster damage assessment was completed recently under the Joint Program on Remote Sensing and Spatial Information Technologies of the U.S. Department of Transportation and NASA. As part of the Safety, Hazards, and Disasters Consortium led by the University of New Mexico, ImageCat, Inc., developed innovative methods for near real-time damage assessment of highway bridges. The methods employ remote sensing technology. The products from the research were Bridge Hunter, which produces a catalogue of key bridge attributes and images from a range of airborne and satellite sensors, and Bridge Doctor, which assesses the damage state of bridges by evaluating changes between images acquired before and after an earthquake.

Eguchi is CEO, ImageCat, Inc., Long Beach, California; Adams is Managing Director, ImageCat Ltd., London, United Kingdom.



(a)

Schematic Representation of the Postearthquake Tiered Reconnaissance System

Note: Color in original images (a) and (b) indicates severity of damage.

(a) Tier 1: Regional—moderate-resolution imagery detects changes and allows a quick assessment of regional damage.

(b) Tier 2: Neighborhood—high-resolution imagery allows detailed analysis for determining the level of damage within communities.

(c) Tier 3: Per building—supports the prioritization and coordination of field-based response and recovery and of field reconnaissance.



(b)



(c)

improvements in robustness, redundancy, and resourcefulness. The slow pace of restoration and recovery in the Gulf Region after Hurricane Katrina indicates low levels of resilience throughout the area. At the same time, some states, communities, and infrastructure systems have proved more resilient than others.

The literature and the MCEER research consider resilience to comprise both inherent and adaptive properties (2–3). Inherent resilience refers to an entity's ability to function well during noncrisis times. Adaptive resilience refers to an entity's demonstrated flexibility during and after disasters—the ability to adapt behavior and exercise creativity in addressing disaster-induced problems. These two properties of resilience may be correlated; entities with inherent resilience also may be better able to develop and implement adaptive coping strategies.

Resilience Domains

MCEER investigators identified four dimensions or domains of resilience: the technical, organizational, social, and economic (TOSE):

- ◆ The **technical** domain refers primarily to the physical properties of systems, including the ability to resist damage and loss of function and to fail gracefully. The technical domain also includes the physical components that add redundancy.

- ◆ **Organizational** resilience relates to the organizations and institutions that manage the physical components of the systems. This domain encompasses measures of organizational capacity, planning, training, leadership, experience, and information management that improve disaster-related organizational performance and problem solving. The resilience of an emergency management system, therefore, is based on both the physical components of the system—such as emergency operations centers, communications technology, and emergency vehicles—and on the properties of the emergency management organization itself—such as the quality of the disaster plans, the ability to incorporate lessons learned from past disasters, and the training and experience of emergency management personnel.

- ◆ The **social** dimension encompasses population and community characteristics that render social groups either more vulnerable or more adaptable to hazards and disasters. Social vulnerability indicators include poverty, low levels of education, linguistic isolation, and a lack of access to resources for protective action, such as evacuation.

- ◆ Local and regional **economies** and business firms exhibit different levels of resilience. Economic

resilience has been analyzed both in terms of the inherent properties of local economies—such as the ability of firms to make adjustments and adaptations during nondisaster times—and in terms of their capacity for postdisaster improvisation, innovation, and resource substitution (3). In general, social and economic resilience relate to the ability to identify and access a range of options for coping with a disaster—the more limited the options of individuals and social groups, the lower their resiliency.

Resilience Metrics

Understanding the attributes and dimensions of resilience provides guidance for defining and achieving acceptable levels of loss, disruption, and system performance. The R4 approach highlights the multiple paths to resilience. Investments can improve all four resilience components—robustness, redundancy, resourcefulness, and rapidity. The TOSE framework emphasizes a holistic approach to community and societal resilience, looking beyond physical and organizational systems to the impact of the disruptions on social and economic systems.

The MCEER perspective suggests a range of approaches to enhance resilience, including mitigation-based strategies, the development of a robust organizational and community capacity to respond to disasters, and improving the coping capabilities of households and businesses. In conjunction with disaster loss estimation techniques and other types of decision support tools, the MCEER resilience framework can help community officials, transportation and utility lifeline service organizations, and other stakeholders to explore the outcomes and trade-offs associated with different resilience-enhancing strategies. For example, MCEER investigators are now collaborating with officials of the Los Angeles Department of Water and Power to assess the resilience of the electric power and the water systems after earthquake-induced damage and disruption.

References

1. Bruneau, M., S. E. Chang, R. T. Eguchi, G. C. Lee, T. D. O'Rourke, A. M. Reinhorn, M. Shinozuka, K. Tierney, W. A. Wallace, and D. von Winterfeldt. A Framework to Quantitatively Assess and Enhance the Seismic Resilience of Communities. *Earthquake Spectra*, Vol. 19, No. 4, 2003, pp. 733–752.
2. Rose, A. Defining and Measuring Economic Resilience to Earthquakes. In *Research Progress and Accomplishments, 2003–2004*. Multidisciplinary Center for Earthquake Engineering Research, State University of New York at Buffalo, 2004, pp. 41–54.
3. Rose, A., and S.-Y. Liao. Modeling Regional Economic Resilience to Disasters: A Computable General Equilibrium Model of Water Service Disruptions. *Journal of Regional Science*, Vol. 48, No. 1, 2005, pp. 75–112.

The Prague Subway's New Flood Protection System

Lessons from the Disaster of 2002

TOMAS JILEK, ANTONIN FEDORKO, AND JIŘÍ ŠUBRT



Jilek is General Manager, Fedorko is Security Director, and Šubrt is Safety and Security Manager, Prague Public Transit Co., Inc., Czech Republic.

The Vltava River passes through the city of Prague in the Czech Republic. The river has several dams upstream, and two major tributaries run into the Vltava just before it reaches the city.

Because of the proximity of the river, the city's subway system has included protections against flooding, based on the probability of occurrence once

every 100 years. Flood levels have been recorded since 1827, and the highest summer floods occurred in 1890. The 100-year flood level was established at 50 centimeters above the 1890 flood levels.

In August 2002, disastrous floods struck the city. The unexpected surge was likely a once-every-500-years occurrence; some experts have theorized about river floods on a 1,000-year cycle, but historic records are not available to verify the possibility.

The 2002 floods affected parts of the city situated at lower levels, as well as the transportation system and public transit system, which comprises tram, bus, and subway services. Because the subway is deep underground, subway tunnels were flooded to a greater extent than other affected parts of the city.

Since then, Prague has worked to address its flood protections, with particular attention to the underground stations. The solutions are not simple but can apply to other subway systems that face similar dangers.



(Above:) Prague Castle and the Vltava River at ordinary high water level. (Right:) Removable flood walls deployed in the city center, August 2002.

Prague Transit

Prague is the capital of the Czech Republic, with a population of more than 1 million and a metropolitan area of 192 square miles. Tables 1–3 present data about the city’s transit system.

Prague is located on hills that surround the central valley of the Vltava River. All three subway lines—A, B, and C—run through the valley; Lines A and C cross the river via underground tunnels. The entire subway network runs underground.

Located in the valley, the historic city center and its subway stations always have faced the risk of flooding. The subway system had been protected against floods that could reach the probable high levels expected once every 100 years.

The Vltava riverbed has changed position over the centuries, and some subway stations away from the river are actually below the former riverbed. The local subsoil consists of alluvial sand, gravel, and mud, which makes it permeable to water.

Watertight Protections?

Before August 2002, the subway system relied on the following flood protections:

- ◆ Barriers that would be effective against waters higher than the recorded 100-year flood level;
- ◆ Dams that could retain the flood waters before reaching the city;
- ◆ A design that allowed the structure to serve as an air raid shelter, with divisible sections that could be sealed off; and
- ◆ A timely flood warning system operated by the national weather service.

The floods of August 2002, however, overcame each of these safety measures:

- ◆ The waters rose higher than expected, with flood levels reaching the likely 500-year levels;
- ◆ The dams were unable to retain the floods;



TABLE 1 Prague Transit Routes

	Daytime	Nighttime	Total length (miles)
Subway	3	0	33.8
Tram	24	8	350.0
Bus	192	13	1,324.0

TABLE 2 Prague Transit Passengers (thousands)

	Total / year	Average / day
Total	1,160,532	3,180
Subway	496,013	1,359
Tram	342,844	939
Bus	321,675	882

TABLE 3 Prague Transit Rolling Stock

Subway cars	715
Trams	968
Buses	1,250

- ◆ The subway structure was not sufficiently stable and leakproof; and

- ◆ The hydrometeorological warning systems failed.

Flaws and Inspiration

Because of these failures, the August 2002 flood waters overwhelmed 17 subway stations, including escalators, power sources, and control centers; 12 miles of tunnels; two trains; and shops, sanitary facilities, information booths, and related structures. The flood waters flowed into stations and tunnels for the following reasons:

- ◆ Removable walls at the accesses to subway stations were designed for 100-year flood levels, which the waters overflowed by more than 1 meter.

- ◆ Some walls between Lines A and B were not built to standards for structural load resistance and collapsed.

- ◆ Some subway sections, designed to serve as public shelters during a war, had lockable gates to provide leakproof barriers against flooding. Although the gates were locked in a timely way, water flowed through the spaces around rails and under the rail sleepers.



(Left:) Subway train overwhelmed by floodwaters in a station. (Right:) Roof of a subway station entrance rises above the floods.

Removable wall protects a subway entrance during the floods of August 2002.



- ◆ Cable seals in the walls between some of the separated subway sections were unable to withstand the hydrostatic pressure of the flood waters.

- ◆ Water discharge pipes that pumped leakage water from tunnels were not fitted with return flaps, and when the water pumps broke down, the return flow of water could not be stopped.

Part of the historic center of the city, however, was protected successfully from flooding by the prompt installation of removable metal walls. Although the removable walls could not be set up in most other parts of the city for various reasons, the quick installation in the city center successfully resisted the floodwater surge, providing an inspiration for development of new flood protection plans for the city and the subway system.

Addressing Priorities

After the pumping of an estimated 1.2 million cubic meters of water out of the subways, restoration of the premises began. Immediate tasks included cleaning away the mud and totally replacing the power system, including the cables, as well as all water-absorbent materials, gravel on the track beds, and the rail sleepers. At the same time, planners began to examine how to protect the subway system against similar floods.



(Left:) Floodwaters at an interchange station pour over the platform into a subway tunnel after a break in the wall separating two subway lines. (Right:) During the 2002 floods, rail seals failed to withstand the hydrostatic pressure after the tunnel gates were locked; water gushed through into the next section of the tunnel.

Priority problems included the water leakage around the cables and the locking gates and other technical deficiencies that were the result of poor-quality construction at different stages of the system's development or the result of changes in subway maintenance technology. The pump discharge pipes were fitted with spherical caps, improving the protection of the drainage system against return flows of water.

The key issue, however, was to bring stations into compliance with the new flood resistance requirements, which had been changed from protection against 100-year flood levels to hold against the higher levels likely to occur once in 500 years. The 500-year flood level was calculated as 60 centimeters above the August 2002 flood level.

Technical Solutions

Two issues arose over protecting the subway stations. The first was how to prevent flooding through entrances to stations and through ventilation shafts. The solution was to increase the height of the removable barrier walls and of the related anchoring and supports.

The second issue was more complex. High water levels exercise a high hydrostatic pressure on stations, not only from above, but also from below—because of the local subsoil characteristics, water can leak through sand and gravel alongside and under the station. This can cause walls to collapse and—in extreme cases—can push the station upward or cause it to drift toward the surface.

After an analysis of possible solutions, the following measures were adopted:

- ◆ Add a concrete layer up to 1 meter thick to increase the weight of the stations and the trackage.

- ◆ Improve the soundness of the structures with jet grouting and reinforced concrete beams. The beams also would add weight and would be anchored to the bottom layer.





Broken cable seals were evident after the 2002 floodwaters were pumped from the stations.

- ◆ Provide lateral anchorage with slurry trench walls, reinforcing the station walls and adding weight, with foundations that would reach deeper than the station foundations.

- ◆ Anchor a foundation plate into the bottom layer.

Another long-term solution to the problem of station drift would be the construction of more buildings on the surface. This also would be cost-efficient, because private investors would bear the costs of construction.

The flood prevention measures aimed at increasing the structural load resistance of the stations. With some exceptions, the structural load resistance of the walls, however, could not be increased, because of the enormous costs involved.

Case-by-Case Assessments

Each station at risk from floods was assessed case by case in terms of structural load resistance and possible drift-out, and an appropriate combination of measures was proposed to protect each station from subsoil water. Calculations showed that large interchange stations faced the greatest problems.

The station protection measures that were implemented included the following:

- ◆ If a station had adequate structural load resistance and if the calculations showed no risk of the

station drifting outward, the flood protection could consist exclusively of a removable wall capable of restraining waters at the 500-year flood level.

- ◆ In other cases, protection could consist of a removable wall able to withstand 500-year flood levels, and weight could be added to the station structure through one of the methods described.

- ◆ The next level of severity would require the installation of pump wells around the station. Located within the dammed area, the pump wells would reduce the groundwater level and therefore the hydrostatic pressure on the station.

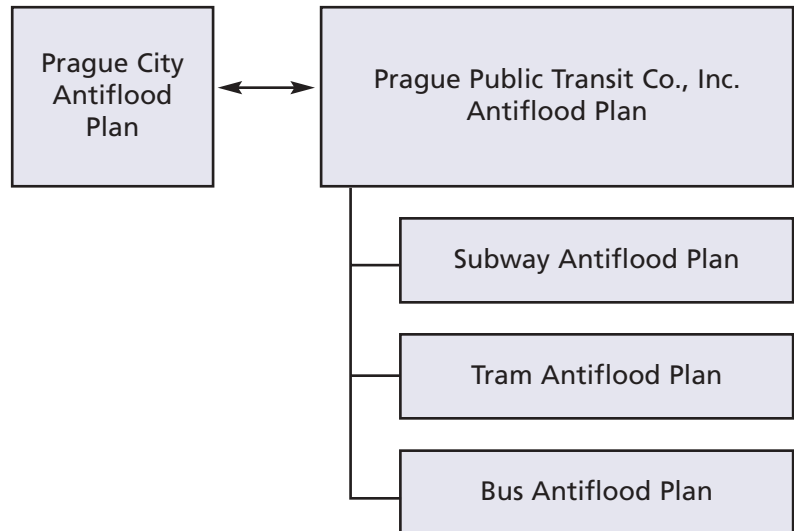
- ◆ One large station did not have a precisely specified structural load resistance, and reinforcement and protection against drifting out would have cost more than the recovery from partial flooding. In this case, the recommendation was to rely on the removable wall, which can withstand 100-year flood levels, as a backup to the city's removable walls along the riverbanks; the riverbank walls are capable of countering waters up to 30 centimeters above the 2002 flood level. If the city protection should fail, the station would be partly flooded with clean water up to the platform level, with the tunnel gates locked; this controlled flooding would add weight to the station and would reduce the hydrostatic pressure on the structure.

These examples demonstrate the complexity of the issues but can serve as best-practice examples for addressing similar risks in other transit systems.

Test Run

The Prague public transportation agency's new anti-flood plans include the coordination of emergency rescue services. The previous antiflood plan applied

FIGURE 1 Antiflood Plans



A removable wall is put in place along the riverbank during installation training.



only to the subway system; the plan now includes the other modes of transit—trams and buses—and addresses depots, garages, and other facilities for each transit mode.

The transit agency plan is closely linked to the City of Prague’s antiflood plan (Figure 1). The key is cooperating with the government’s hydrometeorological service, which reports and forecasts the river water levels upstream from Prague.

An important next step was to verify under simulated conditions the workability of the antiflood plans and the appropriateness of the associated training. The trial run concurrently tested the training for the subway system’s antiflood technology and the training for the installation of removable flood walls along the riverbanks. The removable walls along both riverbanks are designed to protect the parts of the city that are at risk. The test was scheduled for a weekend to minimize disruptions to city life.

The training test simulated conditions that would occur immediately after the city crisis management team was informed of a flood surge approaching within 48 hours. The rescue teams were able to install the removable antiflood walls for the entire city within 10 hours. In real conditions, this could take longer, but the results of the trial run showed that the city and the subway system still would be protected well in advance of the flooding.

Lessons Learned

The lessons learned from the 2002 floods have guided adaptation of Prague’s antiflood measures

to counter surges at the 500-year level and have led to a new approach for protecting the subway system.

Hazard Categorization

The flood protection plan for Prague’s subway system relies on hazard categorization, a well-established method employed in the American Public Transportation Association’s Safety Program Plans and also used by many transportation consulting firms. Instead of classifying the likelihood of a hazard on a traditional general probability scale, a precisely defined scale can be used that considers the probability of occurrence once in 100, 500, and 1,000 years. A traditional hazard severity scale cannot apply to subway flooding, which invariably represents the critical category involving possible casualties, fatalities, or system loss.

After determining the hazard probability and hazard severity, planners developed a matrix to illustrate the changes in hazard resolution for the subway system after August 2002 (see Table 4).

Technological Challenges

Protecting the subway system against 500-year flood levels involved technological challenges. Fixed and removable barrier walls were introduced. Also addressed was the structural load resistance of stations, as well as the possibility of stations drifting outward under enormous hydrostatic pressure. Protection of the subway system had to be integrated into the flood protection for the parts of the city exposed to flood risk.

In addition, a completely new technology was applied when the structural reinforcement of a station was difficult. Pump wells were installed in the protected subway area to reduce the groundwater level and therefore the hydrostatic pressure on the station walls.

Organizational Cooperation

In addition to improved antiflood plans, the transit agency has implemented a closer cooperation with the city crisis management team. The hydrometeorological services authority that regulates the water levels at the dams above Prague also has learned from mistakes and has instituted improvements.

Catastrophic events like Prague’s 2002 floods typically and historically lead to relevant innovations. The flooding of the Prague subway system has led to the development and improvement of flood protection measures—dearly bought lessons to be shared to increase the quality and safety of public transportation in other cities subject to flooding.

TABLE 4 Prague’s Hazard Resolution Matrix for Subway Flooding

		Hazard Severity: Critical	
		Old Plan	New Plan
Hazard Probability	Once in 100 years	Unacceptable	Unacceptable
	Once in 500 years	Undesirable	Unacceptable
	Once in 1000 years	Acceptable with review by management	Undesirable

Sea-Based Emergency Response Planning

A Proven but Overlooked Strategy

JOSEPH SCANLON

The author is Director, Emergency Communications Research Unit, Carleton University, Ottawa, Ontario, Canada.



Photo: FEMA

(Above:) The USS *Iwo Jima* served as a command center for military operations and relief efforts and was one of several ships conducting humanitarian assistance operations along the Gulf Coast during Hurricane Katrina. *(Right:)* A Coast Guard Disaster Area Response Team guides a skiff to a flooded house near Lake Pontchartrain, to search for survivors of Hurricane Katrina.

Eight hours after Hurricane Katrina had passed, the U.S. Coast Guard began its most intensive rescue mission. Coast Guard helicopter teams assisted and evacuated more than 33,544 stranded survivors from Louisiana, Mississippi, and Alabama—six times as many rescues as normally done in a year—yet most of its own per-



Photo: L. F. CHAMBERS, USCG

sonnel in the area also suffered personal losses, and its stations sustained \$190 million in damage. A Washington Post columnist called the Coast Guard's response a "silver lining in a storm" (1).

The Coast Guard adapted as problems arose. After one crew chopped through a roof to rescue someone, all teams were supplied with fire axes. New fan-driven ice boats were brought in from the Great Lakes because the vessels could operate safely along flooded streets.

In addition, the Coast Guard repaired or restored 1,800 navigational aids and cleaned up thousands of oil spills. When personnel were brought in from New England, the Canadian Coast Guard assisted by patrolling the Atlantic Coast, and *William Alexander*, a Canadian ice breaker, sailed as far as the Gulf of Mexico to fix buoys. Two technicians from the National Data Buoy Center in Stennis, Mississippi, joined *William Alexander* for the repair work (2).

The Coast Guard was not the only U.S. marine response to Hurricane Katrina. After the hurricane's



PHOTO: NOAA

In the waters off the coast of North Carolina, the Canadian Coast Guard ship *William Alexander* approaches a buoy damaged during Hurricane Katrina.

impact became apparent, the U.S. Navy activated a task force in Norfolk, Virginia, led by *Iwo Jima*, an amphibious assault ship. After reaching New Orleans, *Iwo Jima* became a secure federal command and control center, handling more than 1,000 flight rescue missions with its own helicopters. A sister ship, *Tortuga*, provided emergency quarters for police and other personnel.

Fitting into a Larger Plan

The Coast Guard had prepared and executed a hurricane response plan. Although major destructive incidents on land often have received maritime response, waterborne response usually is not part of a larger plan. The potential of response by water is considered mostly after the event, although the sea normally repairs itself, while roads and rail lines require restoration (3–4).

In Halifax, Nova Scotia, in 1917, a French ship carrying munitions caught fire in the harbor and exploded minutes later with one-seventh the power of the first atomic bomb. One-fifth of the city's 60,000 inhabitants were killed or injured; the poorer North End was largely destroyed.

Within hours, two U.S. Navy ships, *Tacoma* and *Von Steuben*, which had seen and heard the blast at sea, arrived, reported to the Canadian admiral, and offered assistance. Another U.S. ship, *Old Colony*, served as a hospital. All this occurred while hundreds of fires were yet burning, rescue work was still under way, railway telegraph lines were down, and the roads were barely passable.

On Christmas Eve 1974, Cyclone Tracy devastated Darwin, on Australia's tropical north coast, more than 1,000 miles from a major city. Darwin was left without water or power, its streets were blocked with debris, and 97 percent of the homes were damaged or destroyed. The Royal Australian Navy recalled most of its sailors from Christmas leave, and the ships sailed as soon as supplies were loaded and the crews sufficient. Picking up addi-

tional crew en route, the ships arrived at Darwin within a week (5).

Shipside Advantages

Like the U.S. ships in Halifax, the Australian ships were self-sufficient. The crew members went into the city each day and then returned to the ships to eat, sleep, clean up, and change clothing.

Ships can arrive even when airports must close because of damage or adverse weather, or when roads and rail lines are blocked with debris. Ships can provide a secure operations center. Ships can carry an enormous amount of supplies but unload only what is needed. Ships can assist victims who need medical services.

The government of Norway has recognized these benefits and has retrofitted all coastal vessels to serve as emergency responders. The major ferries that run between Norway and Denmark have equipment to convert the car decks into hospital wards. If the vessels are sent on an emergency, the ship's captain remains the captain, and the crews continue to operate the ship, but medical teams and other responders occupy the passenger cabins. The Norwegian Navy would take charge of the ferry, however, at the captain's request in imminent danger.

The United States could adopt a similar approach. More than half of the nation's largest cities are ports—Boston, New York, Los Angeles, San Francisco, Seattle, Chicago, Detroit, and Milwaukee. Scores of other smaller communities are important maritime centers—such as Norfolk, Miami, New Orleans, Galveston, Texas City, and Long Beach.

Canadian Lessons

In 1964, Canada tested what a warship could do in an emergency. Port Alberni, on an inlet off the west coast of Vancouver Island, was struck by the tsunami from the Alaska earthquake. The Navy sent the

A plume of smoke from the explosion of a munitions ship in Halifax harbor, 1917, is visible in a photo taken approximately 15 seconds after the event and 13 miles from the site.



PHOTO: NATIONAL ARCHIVES



PHOTO: NOAA-NGDC

Extensive damage to railroad facilities at Seward Port in the aftermath of the 1964 Alaska earthquake.

frigate *Calgary* to Port Alberni for a tsunami exercise.

Several problems arose. Part of *Calgary's* water supply derived from desalinating the sea water. The Port Alberni harbor water had been contaminated by effluent from the paper mill. *Calgary* also did not have the equipment to link its power to the town's system. The exercise exposed limitations and taught the Canadian Navy how to make an actual sea-based response effective.

Nonetheless, many benefits were evident from the exercise. *Calgary's* communications nets allowed for contact between Port Alberni and other agencies—the ship replaced the local radio station. Moreover, *Calgary's* medical capacity made the ship a back-up hospital. *Calgary* provided a well-equipped, secure location for a local emergency operations center. The ship's crew also was able to assist on shore without straining local resources.

Historic Examples

Many other similar sea-based responses to emergencies have occurred throughout history, past and recent:

- ◆ A U.S. Revenue cutter responded after a major fire largely destroyed Saint John, New Brunswick, in the late 19th century.
- ◆ A U.S. carrier provided accommodations after the Loma Prieta earthquake in California in 1989.
- ◆ A British warship served as a radio station and provided other relief services for a West Indian island in the wake of Hurricane David in 1979.
- ◆ After Hurricane Andrew, Canadian service personnel rebuilt part of Gouls, Florida, with an ocean-based response.
- ◆ An amphibious assault was effective in delivering large amounts of supplies and equipment by sea to the beaches after the 2004 Indian Ocean tsunami, by helicopter or by landing craft—no ports were required.

One of the most impressive marine responses occurred on September 11, 2001, when ferries and other small craft evacuated an estimated 210,000 persons from Lower Manhattan—without a plan and without a single accident. The Coast Guard observed what was happening and let the unplanned evacuation proceed. Local emergency planners were unaware of what went on (6). What happened illustrates how a water-based response to a disaster can be varied and effective and yet rarely part of a larger plan and also rarely documented.

Part of the Plan?

If ocean-based response works without planning, would it work better with planning? A first and necessary step would be to maintain an inventory of



coastal vessels. The potential of cruise ships on the East and West Coasts should be assessed as part of this inventory, because most of these vessels carry a physician and many have an operating theater.

Potential threats should be considered, as well as the water-based resources available, and what could be moved by sea quickly enough to be of value. Geographic Positioning Systems and communications technologies can locate and link with vessels at sea, facilitating decisions about which vessels could offer the fastest assistance and deliver the most useful cargoes.

Emergency planning should incorporate sea-based response. Experience indicates that when disaster strikes, a water-based response can be extremely effective—with or without a plan.

Acknowledgment

A presentation by Commander Steven Craig and Master Chief J. R. Stafford at the 54th Annual Conference of the International Association of Emergency Managers, Orlando, Florida, November 2006, and several pieces in *Coast Guard Special Edition: Katrina, The Gulf Response*, served as general resources for this article.

References

1. Barr, S. Coast Guard's Response to Katrina a Silver Lining in the Storm. *Washington Post*, Sept. 6, 2005, p. B-2.
2. Evanson, C. Canadian Beacon. In *Coast Guard Special Edition: Katrina: The Gulf Response*, 2005, pp. 86–89.
3. Scanlon, J. Help from the Deep: The Potential of Ocean-Based Response to Disaster. *Disaster Prevention and Management*, Vol. 5, No. 3, 1996, pp. 15–22.
4. Scanlon, J. From Ship to Shore. *Homeland Protection Professional*, March 2005.
5. Scanlon, J. Day One in Darwin: Once Again the Vital Role of Communications. In *Planning for People in Natural Disasters* (Joan Innes Reid, ed.), James Cook University of North Queensland, Townsville, Australia, 1979.
6. Kendra, J., T. Wachtendorf, and E. L. Quarantelli. Who Was in Charge of the Massive Evacuation of Lower Manhattan on 9/11? No One Was. Yet It Was an Extremely Successful Operation. Implications? Disaster Research Center, Newark, N.J., 2002.

Shallow-draft, high-speed vessel *WestPac Express* loading equipment and supplies for tsunami relief at Kin Red Beach Training Area, Okinawa.

Risk Management for Multimodal Transportation Infrastructure

Interactive Tool Nears Completion

MICHAEL C. SMITH, STEPHEN C. LOCKWOOD,
KEVIN DUFFY, AND HASKELL GARON

Smith is Associate Professor, Department of Systems and Information Engineering, University of Virginia, Charlottesville, and consultant to Science Applications International Corporation (SAIC), McLean, Virginia. Lockwood is Principal Consultant, PB Consult, Washington, D.C. Duffy is Program Manager, and Garon is Research Assistant, SAIC.

The Guide to Risk Management of Multimodal Transportation Infrastructure, now in preparation under National Cooperative Highway Research Program Project 20-59(17), will help the owners and administrators of transportation assets determine the budget effects of countermeasures—both capital and operational—and identify those assets that require more detailed risk assessments. The guide presents an iterative and interactive process for transportation owners to assess risks by considering the objective conse-

quences of events and the physical characteristics of infrastructure assets.

The guide takes an integral approach in describing the factors related to program decision making and in addressing the spectrum of natural hazards and intentional threats. The approach is designed to encourage and facilitate the “mainstreaming” of risk management into transportation agency planning, design, and operations.

Transportation infrastructure owners can use the guide to identify cost-effective countermeasures to



PHOTO: KIMBERLY WHITE, REUTERS

Engineers inspect a collapsed highway in Oakland, California, April 29, 2007. A segment of highway vital for San Francisco Bay Area commuters collapsed after a fuel truck crashed and ignited flames more than 200 feet high.

reduce risks to transportation assets, including risks from natural disasters and from sources of intentional harm, such as terrorism. The levels of concern about each of the many hazards and threats vary widely. Many of the countermeasures recommended in the guide have well-established design standards, but countermeasures for many other hazards and threats have yet to be addressed adequately.

Risk Assessment Approach

The risk assessment process follows a variation of the general equation:

$$\text{Risk} = (\text{probability of the event}) \times (\text{consequence of the event})$$

Probability indicates the frequency or likelihood of a specific event, and *consequence* indicates the effects of the event on people and on assets. Consequence therefore reflects the vulnerabilities of an asset or system to hazards and threats. Consequences may be direct, such as deaths, injuries, and damage or loss of property; or indirect—that is, producing secondary economic, social, or psychological effects.

Events can be *unintentional* if the known conditions produce a *safety* risk to people and property. *Intentional* events, in contrast, represent potential *security* risks to people and property; the likelihood and severity of intentional events may be known or



PHOTO: E.V. LEBENDECKER, U.S. GEOLOGICAL SURVEY

unknown. Intentional risks, for example, could result in disruption, damage, destruction, theft, vandalism, wounding, and fatalities inflicted for a political, economic, social, or cultural objective.

Because estimating the likelihood of an event is difficult, the analysis in the guide examines consequences. Through *consequence-based risk assessment*, decision makers can focus on known or predicted outcomes in situations that are characterized by uncertainty, complexity, and multiple hazards. Although the likelihood of an event may

The 7.1-magnitude Loma Prieta, California, earthquake, October 17, 1989, killed 67 people, injured 3,757, and caused an estimated \$7 billion dollars in property damage—including the collapse of 51 spans on I-880 in Oakland.

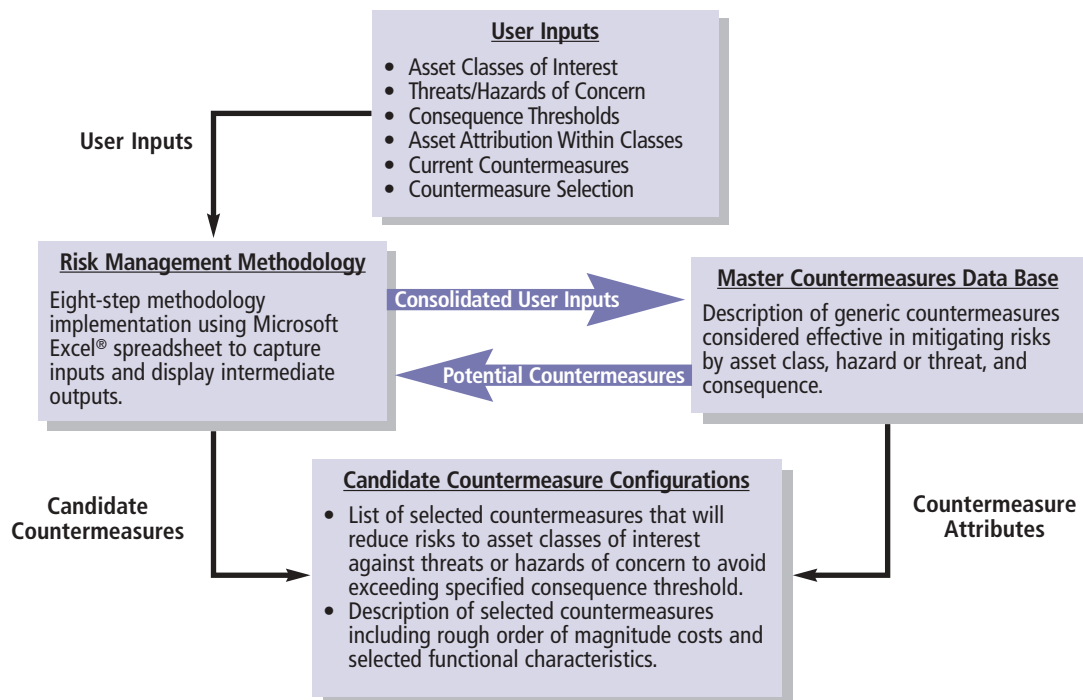


FIGURE 1 Interaction Between the User, the Guide, and the Countermeasure Database

Developing Guidance for Emergency Response Planning at the State Level

DOUGLAS HAM, ANNABELLE BOYD, STEPHEN C. LOCKWOOD, AND KEVIN DUFFY

A Guide to Emergency Response Planning at State Transportation Agencies is in development through the National Cooperative Highway Research Program [Project 20-59(23)]. The guide will expand on the 2002 Guide to Updating Highway Emergency Response Plans for Terrorist Incidents.

The guide will provide state transportation agencies with a framework for establishing emergency response roles and will recommend ways to integrate these roles into other incident and emergency response functions, such as traffic incident management (TIM) and road weather management. The project will take a comprehensive approach to possible hazards and will consider all modes of transportation managed and supported by state transportation agencies.

The primary focus will be to clarify the emergency planning and response requirements currently placed on state transportation agencies—for example, through the National Incident Management System. The project then will assess the state of the

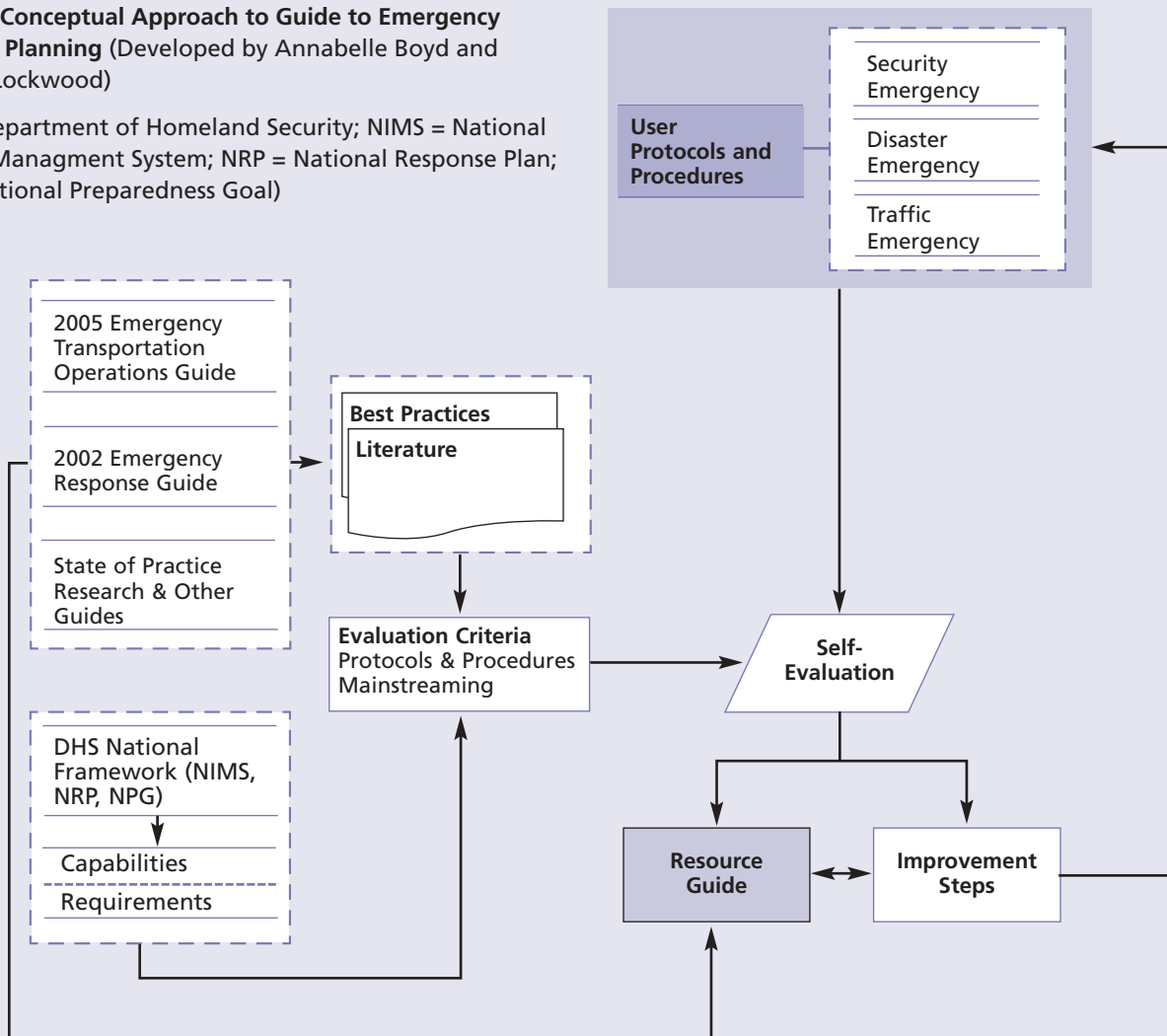
practice at transportation agencies, determining how well requirements are being addressed and identifying opportunities to enhance capabilities, particularly in conjunction with TIM programs. Figure 1 shows the conceptual approach for the project.

The final product will help state transportation agencies (a) assess how well they have made emergency response a mainstream function; (b) identify response strengths and shortcomings; and (c) provide a resource to assist in mitigating and eliminating any shortcomings. The project team is composed of Telvent Farradyne, which developed the 2002 guide, BCG Transportation Group, PB Consult, and SAIC.

Ham is Manager, Telvent Farradyne, Inc., Rockville, Maryland. Boyd is President, BCG Transportation Group, Earlysville, Virginia. Lockwood is Principal Consultant, PB Consult, Washington, D.C. Duffy is Program Manager with Science Applications International Corporation, McLean, Virginia.

FIGURE 1 Conceptual Approach to Guide to Emergency Response Planning (Developed by Annabelle Boyd and Stephen Lockwood)

(DHS = Department of Homeland Security; NIMS = National Incident Management System; NRP = National Response Plan; NPG = National Preparedness Goal)



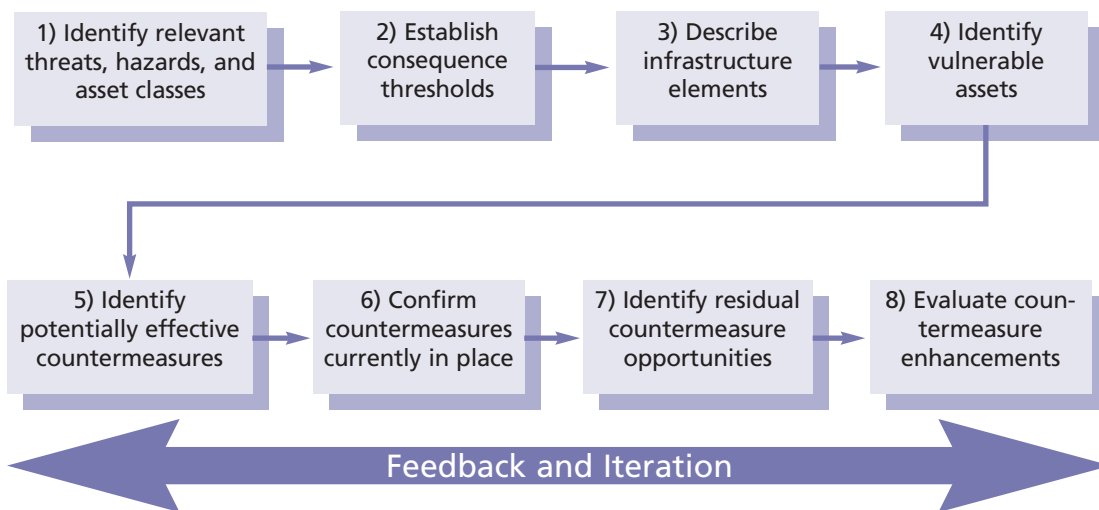


FIGURE 2 Overview of the Risk Management Approach Implemented in the Guide

be unknowable, the outcome can be predicted, so that decision makers can take measures to reduce the likelihood or to mitigate the consequences.

Key Features of the Guide

The guide is designed for ease of use, transparency, and objectivity. The goal is the allocation of program-level resources for risk management. The process starts by determining a *consequence threshold*—the level of potential losses that would require investments beyond those normally available to transportation and public safety agencies.

The process is implemented in Microsoft Excel®, so that all entries and calculations are visible, and the process is transparent; moreover, agency staff can use the software without external support. The guide’s approach is iterative—decision makers set the initial thresholds and then, based on the results from the calculations, make adjustments to the available resources and competing needs. The consequence thresholds are applied to four areas: potentially exposed population, property damage, mission disruption, and social effects.

Except for the social effects, which are determined by the user, the critical nature of assets in the other three areas is determined by physical or operational parameters such as size, capacity, throughput, occupancy, or delays—for example, the detour length for bridges and tunnels. Because the physical and operational parameters indicate when the consequence thresholds would be exceeded, users do not need to make subjective judgments about the criticality of an asset.

The guide provides a database of common countermeasures associated with specific hazards and threats. The database groups the countermeasures into major classes, such as physical security, access control, asset design and engineering, and operations.

Application

As illustrated in Figure 1, application of the guide is interactive, with the user relying on the risk management tool and on the countermeasures database. The process moves from the user’s high-level input on relevant hazards and threats, asset classes, and consequence thresholds to the identification of specific assets that in a natural, unintentional, or intentional event may produce outcomes that exceed one or more of the consequence thresholds (see Figure 2).

After identifying vulnerable assets, the user selects actions from the countermeasures database. Filters screen out the countermeasures that are least likely to be considered and present the configurations in rough order of magnitude, according to cost estimates and budget implications. The user can work through the process iteratively, adjusting consequence thresholds and countermeasure filters until achieving a satisfactory combination of countermeasures to protect critical assets.

The process also highlights higher risk asset categories within a larger system, and recommends the development of supplemental risk assessment guides.

Acknowledgment

The opinions and conclusions expressed or implied in this article are those of the authors and are not necessarily those of the organizations sponsoring the work, including the Transportation Research Board, the National Research Council, the Federal Highway Administration, the American Association of State Highway and Transportation Officials, or the states participating in the National Cooperative Highway Research Program. More information about the scope and status of the project is posted on the Internet at www.TRB.org/TRBNet/ProjectDisplay.asp?ProjectID=637.

Tools for Improving Evacuations

Federal Highway Administration Develops Primers and Training

LAUREL J. RADOW AND KIMBERLY C. VÁSCONEZ

The authors are with the Office of Operations, Federal Highway Administration, U.S. Department of Transportation, Washington, D.C. Radow is Manager, Evacuation and Planned Special Events Program, and Vásconez is Team Leader, Emergency Transportation Operations, and Manager, Highway Evacuations Program.



Evacuations may involve hundreds to hundreds of thousands of people. In every instance, the transportation network plays a key role in evacuating people out of harm's way.

In the past two decades, the ability of the transportation community to manage and operate the transportation network at top efficiency has improved mobility. Because disasters place unique challenges on mobility and on the safe and secure movement of people and goods on the nation's highways, the U.S. Department of Transportation's (DOT) Federal Highway Administration (FHWA) in 2006 renewed efforts to improve evacuation planning and capacity building by local, state, and regional authorities.

In the past decade, U.S. DOT has developed tools and capabilities to aid federal authorities in supporting disaster response. The major burden of evac-

uating populations, however, remains on local and state governments and on regional authorities.

Launching Primers

Effective mass evacuations—to save lives and mitigate suffering—remain an elusive goal. The 2005 hurricane season demonstrated the need for increased cooperative efforts between local, state, and federal agencies to ensure successful evacuations of at-risk populations, including improvements to assist transit-dependent and special-needs populations.

After reviewing the many studies and after-action reports of recent hurricane seasons, FHWA concluded that basic guides, checklist templates, and best practices could contribute to the improvement of evacuation planning and capacity building by local, state, and regional authorities. FHWA recently completed the first in a series of planning primers,

Evacuation via Interstate 37 near Corpus Christi, Texas, in 1999. Texas DOT has published plans for contraflow operations and for use of the inside shoulder—specially striped and signed—during hurricane evacuations.

TRB Annual Meeting Safety and Security Sessions Online

Safety- and security-related e-sessions from the 2006–2007 TRB Annual Meetings provide viewers with Powerpoint slides synchronized with corresponding audio and are available at the TRB website. A 2006 session, *Financial Implications of the U.S. Security System and Opportunities for Improvement*, features the presentations, *Benefits of Greater Coordination Between Border and Security Management*, by Solomon Wong, InterVistas Consulting; *Making Sustainable Security Investment Decisions*, by Gloria Bender, TransSolutions; *Next Generation Technologies for Cost-Effective Security*, by Rick Gordon, Civitas Group; and *Making Timely Eco-*

nomic Impact Assessments for Security Policy Decisions, by Robert M. Peterson.¹

A 2007 session, *Disaster Planning for Low-Income and Disadvantaged Communities*, includes presentations on *General Disaster Planning for Low-Income and Disadvantaged Communities*, by James C. Schwab, American Planning Association; and *How Low-Income and Disadvantaged Residents of New Orleans Were Affected by Hurricane Katrina*, by John L. Renne, University of New Orleans.²

¹ www.TRB.org/conferences/e-session/2006am.htm#DI

² www.TRB.org/conferences/e-session/2007am.htm#SEC

the “Routes to Effective Evacuations.” Because local and state authorities are responsible for conducting evacuation operations, the first primer and the subsequent guides are written to aid local and state planners in developing evacuation plans for their communities, states, and regions.

The recently completed primer, *Routes to Effective Evacuations: Using Highways During Notice Evacuation Operations*, covers the basics of planning for evacuations that are primarily road-based and that follow advance notice of the need to evacuate. The guide includes transportation elements to be considered by local, state, and regional planning groups.

Series in Summary

Other primers in preparation cover various aspects of evacuations:

◆ *Integrating Multiple Modes into Evacuation Transportation Planning for Events with Advanced Notice* introduces effective ways to integrate rail, air, and waterway transportation into road-based evacuation planning before an event.

◆ *Using Highways to Evacuate At-Risk Populations in the No-Notice Event Environment* covers spontaneous or no-notice evacuations, taking into consideration the security environment during a biological, chemical, terrorist, or other hazardous event, as well as natural events such as earthquakes or tornadoes. Also addressed are considerations of evacuation versus shelter-in-place orders.

◆ *Integrating Multiple Modes into Evacuation Transportation Planning for Events with No-Notice* introduces effective ways to integrate rail, air, and waterway transportation into road-based evacuation planning for

response to a no-notice event.

◆ *Overview: Routes to Effective Evacuation Planning* is an executive summary of the four evacuation primers, reviewing the tools and approaches for developing an effective plan. The focus is on involving transportation professionals in planning for evacuations, recognizing the importance of regional and corridor planning, and on integrating transportation into the coordination of mass care, health and medical, security, and other emergency support functions. The overview also highlights best practices, as well as the tools available to local and state authorities in planning for and managing evacuations.

Emergency Evacuation Study Under Way

On April 20, 2006, TRB’s Committee on the Role of Public Transportation in Emergency Evacuation, appointed by the National Research Council of the National Academies, began a 20-month study to evaluate the 38 largest U.S. urban public transportation systems and their abilities to accommodate the evacuation, egress, and ingress of people to and from critical locations in times of emergency.

The project, sponsored by the Federal Transit Administration and the Transit Cooperative Research Program, was created in response to a congressional request that called for examination of transportation’s role in providing emergency assistance and evacuation in recent U.S. disasters including the terrorist attacks of September 11, 2001, and Hurricane Katrina. The analysis will examine existing literature, case studies, and state and regional emergency evacuation plans to determine how public transportation can be used most effectively in emergency evacuations. The committee’s report is scheduled for release in April 2008.



Addressing All Stages

The primers are the result of an effort to conduct research and to provide products that present practical information and guidance to state and local government evacuation planners—including people involved in emergency management, public safety, transportation, and mass care, as well as political officials, people in the private sector, and other stakeholders involved in developing, coordinating, and executing evacuation operations.

The series of primers will serve as tools and aids in developing effective evacuation plans, particularly by emphasizing the involvement of the right players—including transportation officials. Planners will be able to use the products to update plans and processes already in place or to develop new ones, improving the effectiveness of evacuations.

Comprehensive plans need to address several

stages of evacuation, including planning and preparedness, readiness, activation, operations—which embraces such concerns as at-risk populations and the return of evacuees—and, finally, the return to readiness. Plans for accepting evacuees from other areas are among the topics to consider. The primers describe the potential roles of all transportation modes in evacuations, in coordination among neighboring jurisdictions, and in communications before and during evacuations and then during reentry. The primers also present tools that are available to aid state and local agencies in evacuations and reentries.

Related Initiatives

The primers also complement FHWA's recently published report, *Simplified Guide to the Incident Command System (ICS) for Transportation Professionals*,

Professional Capacity Building for Transportation Security

Initiatives, Objectives, and Research Needs

JOHN BOINEY

Transportation security in the United States was not a novel concern in August 2001. But after the events of September 11, 2001, the standards for security increased dramatically. The heightened standards applied as much to highway-related transportation and infrastructure as to any other mode. Although the nation's economy depends on a robust, safe, and secure highway network, the highways have received less attention and fewer resources for improving security, especially in comparison with air transportation and water ports.

Meeting highway-related security needs has become the task of the state departments of transportation (DOTs), which manage and maintain much of the nation's critical transportation infrastructure. A substantial gap has opened between the nation's needs for surface transportation security and the states' professional capacity for meeting those needs.

The Federal Highway Administration (FHWA) is working to close that gap, in part by establishing a Professional Capacity Building (PCB) Program for Security and Emergency Management. Initiated in January 2006, the program has been planned and developed in partnership with the American Association of State Highway and Transportation Officials' Special Committee on Transportation Security and with input from the Transportation Research Board's Critical Transportation Infrastructure Protection Committee.

Capacity Building

PCB is more than training. A complete PCB program fulfills many complementary functions, providing resources to enable users with varying technical needs, learning styles, and time or

resource constraints to gain the help they need, when they need it. Core functions of a PCB program include the following:

- ◆ Building knowledge for long-term application, primarily through classroom-based training;
- ◆ Enhancing skills for more immediate application, through workshops, web-based seminars, and technical assistance;
- ◆ Collecting, synthesizing, and sharing effective practices via case studies and scans or site visits;
- ◆ Providing a central clearinghouse for information, typically with a website;
- ◆ Building and supporting communities of practice—for example, through peer-to-peer exchanges; and
- ◆ Defining professional competencies and recommending curricula.

Effective Practices

The Security and Emergency Management PCB Program supports several initiatives. Cosponsored by the Transportation Security Administration (TSA), the program is conducting a series of regional workshops for state DOTs and others to exchange effective practices. FHWA, TSA, and participating state DOTs are pooling funds to develop a suite of training materials in four subject areas: emergency transportation operations, risk management, evacuation planning, and bridge and tunnel security. The learning objectives focus on results of research under TRB's National Cooperative Highway Research Program (1–4) and on guidance developed by FHWA (see accompanying article by Radow and Vásconez).

which introduces the ICS to stakeholders who may be asked to provide specific expertise, assistance, or material during highway incidents, disasters, or other events. FHWA's Security Pooled-Fund Study includes an initiative on professional capacity building for transportation security and emergency preparedness.

These complementary efforts stem from state DOT requests for assistance in security and emergency preparedness, particularly in related training and other professional capacity building. State DOTs have requested guidance on how to

- ◆ Position themselves to respond a disaster;
- ◆ Build a security and emergency response plan;
- ◆ Use existing operations to enhance security and emergency response;
- ◆ Consider security and emergency response in engineering and construction; and

◆ Include security and emergency response in transportation planning.

The American Association of State Highway and Transportation Officials' Special Committee on Transportation Security has worked closely with FHWA and with the Research and Innovative Technology Administration's Volpe Center to develop a comprehensive plan to address these needs through training, technical assistance, peer exchange, and other forms of professional capacity building.

The pooled-fund study will develop a suite of training materials for state DOTs to enhance capacity in emergency transportation operations, infrastructure risk management, and evacuation planning. With a multifaceted approach, FHWA is responding to the needs of state and local DOTs in preparing and implementing effective and comprehensive evacuation plans.

FHWA also plans to conduct a series of web-based seminars on current topics. The seminars will run less than 2 hours each and will be designed to communicate current guidance and to encourage the sharing of effective practices. Other efforts under consideration include peer-to-peer exchanges, a web portal for information and technical resources, and a database of training and related assistance.

Research Needs

Although the PCB Program for Security and Emergency Management¹ is in the early stages of its evolution, some challenges that present research opportunities should be noted:

1. **The overlap of emergency management and security.** The "all hazards" approach leverages resources and processes to meet the needs of both emergency management and security. A better understanding of how the two overlap will yield more precise recommendations for managing human and other resources.

2. **Measuring the impacts of the program.** Demonstrating the impact of PCB on individual performance is a demanding task, especially for security, because the behavior of interest—namely, the response to a major emergency—is occasional.

3. **The security of information.** The success of this PCB effort, like others, depends on collaboration and on the exchange of information. Professionals need to share information with one another, and the trend is to rely on electronic methods to disseminate effective practices rapidly and widely. For most technical domains, this trend represents progress, but for a security PCB program, it is a major challenge. How can a PCB effort pro-

¹ U.S. DOT also sponsors PCB programs for intelligent transportation systems, transportation planning, roadway safety, freight, and environmental competency.

ceed effectively, when the most useful information is likely to be the most sensitive? This puzzle arguably requires the most attention from the research community.

Promising Initiatives

Professional capacity building in security and emergency management for the nation's roadways is off to a strong start. Key stakeholders—the states, FHWA, and TSA—are partnering on several promising initiatives. This PCB effort will be particularly important with the looming shortfall in the transportation workforce, because the risks created by the loss of experience and expertise are greater for security and emergency management than for many other areas. A robust PCB program will help states and others in managing the impacts of the workforce shortage.

References

1. *NCHRP Report 525: Surface Transportation Security, Volume 6: Guide for Emergency Transportation Operations.* Transportation Research Board of the National Academies, Washington, D.C., 2005.
2. *NCHRP Report 525: Surface Transportation Security, Volume 4: A Self-Study Course on Terrorism-Related Risk Management of Highway Infrastructure.* Transportation Research Board of the National Academies, Washington, D.C., 2005.
3. *NCHRP Project 20-59(17), Guide to Risk Management of Multimodal Transportation Infrastructure.* Transportation Research Board of the National Academies, Washington, D.C. (forthcoming, December 2007).
4. *NCHRP Report 525: Surface Transportation Security, Volume 12; TCRP Report 86: Public Transportation Security, Volume 12: Making Tunnels Safe and Secure.* Transportation Research Board of the National Academies, Washington, D.C., 2005.

The author is Program Manager and Analyst, Volpe National Transportation Systems Center, U.S. Department of Transportation Research and Innovative Technology Administration, Cambridge, Massachusetts.

James M. Crites

Dallas–Fort Worth International Airport

James Crites has made significant contributions to aviation safety, with more than 20 years of experience working on projects that have included improving airport perimeter taxiways, airport emergency response procedures, airfield safety, runway-incursion prevention, pilot situational awareness, and wildlife and environmental management.

A retired U.S. Marine Corps lieutenant colonel, Crites served on active duty from 1976 to 1987. After joining the Marine reserves in 1987, Crites took a position in the Operations Research Department of American Airlines, where he worked to assess opportunities and identify issues related to the development of hub airports, including Dallas–Fort Worth, Texas; Chicago O’Hare, Illinois; Madrid Barajas, Spain; and Sydney, Australia.

Crites also managed a group that provided flight technical support for American Airlines operations worldwide; served as man-

By reducing the number of daily runway crossings, DFW has increased the safety and efficiency of its operations, reducing the potential for runway incursions and for delays in passenger arrivals and departure. The National Transportation Safety Board has endorsed the perimeter taxiways system and is examining the procedure for future implementation in other countries.

Crites’s work on air safety also has included innovations in security in response to the terrorist attacks of September 11, 2001 (9/11). He worked with the Transportation Security Administration to develop and implement an in-line baggage screening system that eliminates the need for separate airport baggage screening locations for passengers. The improved system screens approximately 55,000 pieces of DFW luggage per day for explosives and other potentially hazardous materials and has opened the way for the introduction of similar systems nationwide.

Crites currently is working to update the 1989 DFW Airport Development Plan, focusing on airport infrastructure and the post-9/11 airport security environment.

“One of the major challenges we face is the renovation of airport terminals to accommodate airlines in a self-service environment,” Crites observes. “Renovating terminals to accommodate new technology that enables customer self-service—coupled with a new approach to concessions and retail service offerings and the goal of increasing customer satisfaction—is a challenge in a post-9/11 world of enhanced screening of passengers and their baggage.”

Chair of TRB’s Aviation Group, Crites has contributed his time and expertise to TRB for almost a decade. He has chaired the Airfield and Airspace Capacity and Delay Committee and the Committee for Stakeholder Input in Developing the Airport System Management Services Component of the National Airspace System, and he has served as a member on many other committees and groups.

“I’ve been grateful to be a part of TRB,” Crites shares. “The timing for the introduction of TRB’s Airport Cooperative Research Program (ACRP) could not have been better. The program is serving as a catalyst for developing solutions in aviation, when the industry is in need of solutions.” Crites currently serves on the ACRP Oversight Committee, appointed by former U.S. DOT Secretary Norman Mineta.

A graduate of the University of Illinois and the Naval Postgraduate School, Monterey, California, Crites is a past chair and a current member of the Airports Council International North American Technical and Operations Committee; a member of the U.S. Government Accountability Office Naval Aviation Studies Advisory Panel; a former member of the Federal Aviation Administration’s Research and Engineering Development Advisory Committee; and a member of the NASA Research Advisory Committee and Airspace Systems Program Subcommittee.



“One of the major challenges we face is the renovation of airport terminals to accommodate airlines in a self-service environment.”

aging director of financial planning, overseeing the development of the American Airlines corporate operating budget and the capital development program; and contributed to the early development of airport customer self-service kiosks and other customer service innovations that led to the deployment of airport boarding pass scanners.

In 1995, Crites moved to Dallas–Fort Worth International Airport (DFW), where he currently serves as executive vice president of operations, managing all aspects of airport planning, capital planning, and market research. Of all his accomplishments, a personal and professional highlight for Crites was his work on DFW perimeter taxiways, a 17-year endeavor involving the National Aeronautics and Space Administration (NASA), the Federal Aviation Administration, DFW, and many major airline organizations. By routing planes to perimeter taxiways, the project helped eliminate runway crossings for aircraft arrivals and departures.

“The project implemented a revolutionary concept that required a tremendous amount of review and research,” Crites explains. “NASA conducted tests at the Ames Research Center Future Flight Central facility that demonstrated the impact of perimeter taxiways on operational efficiency—a 30 percent improvement in aircraft throughput was achievable.”

David S. Ekern

Virginia Department of Transportation

Transportation engineer David Ekern has developed a working philosophy that incorporates the disciplines of art and science, and he employs this philosophy in transportation leadership roles at the state and national levels. Engineering, says the commissioner of the Virginia Department of Transportation (DOT), “is no longer just about constructing and maintaining things—it also is about selling and service in a context of human concerns and aspirations.”

When Ekern joined Virginia DOT as commissioner in September 2006, he called for the department to become “multimodal and intermodal in breadth, intelligent in character, and inclusive in service,” and he identified the department’s paramount goals: facilitating safer driving; setting targets for Virginia DOT and system performance; and expediting goods



“It’s not only how you build something, it is the look, fit, and feel that are also important.”

and service delivery by reducing congestion.

“Bottlenecks in the aging highway system must be addressed to decrease congestion and improve safety, especially in traffic-choked urban areas,” Ekern explains. “We must create a public transportation system that gives Virginians travel options, and we must use technology to help wring additional capacity out of the current system. We will not build our way out of congestion. We must use technology and innovation to address today’s complex transportation issues.”

Ekern stresses that research is critical to the survival of the 21st-century transportation industry: “Rapid deployment of research is the challenge we’re facing. We have to put research in the marketplace on a short cycle and help the research community sell its products.”

In his 37-year career, Ekern has made important contributions to many state DOTs. In Minnesota, he created programs that would be adopted by DOTs nationwide; as Idaho DOT Director, he launched the “Connecting Idaho Initiative,” the largest single transportation investment program in the state’s history; and in Virginia, in his months as commissioner, he began the groundwork to make the DOT a model for the 21st century.

Ekern’s leadership at the national level has resulted in many transportation program innovations and system operations changes. From 2001 to 2003, he took an assignment with the American Association of State Highway and Transportation Officials (AASHTO) focusing on critical issues that included intelligent transportation systems and context-sensitive design. In addition, he drafted proposals for the Safe, Accountable, Flexible, and Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU) and led efforts to determine the potential use of National Aeronautics and Space Administration (NASA)–based technology in state and local transportation programs.

The terrorist attacks of September 11, 2001, demonstrated the vulnerabilities of America’s transportation infrastructure, and Ekern is working to respond to those critical needs. He is chair of AASHTO’s Special Committee on Transportation Security and has chaired National Cooperative Highway Research Program (NCHRP) panels on the AASHTO Guide for Asset Management; Surface Transportation Security Research; Traffic Operations and Management Planning; Emergency Traffic Operations Management; and Transportation Response Options: Scenarios of Infectious Disease, Biological Agents, Chemical, Biological, Radiological, or Nuclear Exposure.

Ekern is active on many TRB panels and committees. He chaired the Steering Committee for the Conferences on Remote Sensing and Spatial Information Technologies for Transportation and the Regional Transportation Systems Management and Operations Committee. He is a past member of the Committee on Developing a Regional Concept for Managing Surface Transportation Operations, Transportation Asset Management Committee, and the Operations Section Executive Board.

Ekern sees engineering in a humanistic framework. Intent on involving nonengineers in the engineering process, Ekern cares how innovative research and technologies will be received by those who will use them.

“We must present the end product, not the steps in the process. It’s not only how you build something, it is the look, fit, and feel that are also important,” he explains. “People trust engineers to know how to put the ingredients together. You’re not talking about the width of a road or the thickness of its concrete; people trust we’re going to do that right.”

Educated at the University of Minnesota and the University of St. Thomas, Minnesota, Ekern is a registered professional engineer and a fellow of the American Society of Civil Engineers.

WORKING TOGETHER—Representatives from nine automobile manufacturers, two associations of automobile manufacturers, and a supplier of automotive technology met with TRB staff to explore potential cooperation in the Strategic Highway Research Program 2 Safety Research Program. (Below, left:) Richard K. Deering, General Motors; (photo, right, left to right) Sarah C. Hiple, Nissan North America; Rob Lyons, Bosch; Michael L. Caruso, Bosch; Micheal X. Cammisa, Association of International Automobile Manufacturers; Maurice Arcangeli, Subaru; and Tom Dingus, Virginia Tech Transportation Technology Institute.



TRAFFIC DATA EXCHANGE—Dave Gardner, chair of TRB's North American Travel Monitoring Exposition and Conference Planning Task Force, speaks to a group of data users and producers from across the Mid-Atlantic Region during the Traffic Monitoring Data Workshop at the National Academies' Keck Center, Washington, D.C. The workshop is a forum for the exchange of information and strategies for the collection and analysis of traffic data.

COOPERATIVE RESEARCH PROGRAMS NEWS

Airport Sources of Particulate Emissions

Domestic airports and their aviation industry partners must assure compliance with particulate matter (PM) controls, specified in environmental requirements and state implementation plans.

In a February 2003 report, *Aviation and the Environment: Strategic Framework Needed to Address Challenges Posed by Aircraft Emissions*, the U.S. Government Accountability Office asked the Federal Aviation Administration (FAA), consulting with the Environmental Protection Agency and National Aeronautics and Space Administration, to develop a strategic framework for addressing emissions from aviation-related PM sources. To develop this framework—the PM Roadmap—FAA worked with the airline industry, aircraft and engine manufacturers, and airports, as well as states that had airport areas with substandard air quality.

The success of the evolving framework requires identifying critical gaps in research on airport PM emissions. Although gaps in the understanding of quantitative aggregate and local contributions of PM emissions at airport sites are recognized within the aeronautical and environmental communities, the aviation sector needs to respond to impending and restrictive environmental compliance issues and to assess the current state of the art and information concerning airport-relevant PM emissions.

Environmental Consulting Group, LLC, Annapolis, Maryland, has been awarded a \$99,897, 1-year contract (ACRP 02-04, FY 2005) to develop a prioritized agenda of research needs relating to airport sources of PM emissions. The agenda will be developed by conducting a survey of airports about PM emissions issues and concerns and by identifying, reviewing, and evaluating past and current research on airport sources of PM emissions.

For further information, contact Christine Gerencher, TRB, 202-334-2970, cgerencher@nas.edu.

Testing and Evaluating Warning Surfaces

The 2001 Americans with Disabilities Act Accessibility Guidelines (ADAAG) require curb ramps to have detectable warning surfaces where pedestrian ways meet vehicular ways. For long-term performance and durability, materials such as plastics, ceramics, metal, brick, and concrete have been used in the construction of detectable warning systems.

Recent ADAAG research has found that materials requirements for detectable warning systems have received limited attention, as have test procedures for evaluating long-term performance and durability. Long-term performance and durability requirements are needed to address the influence and effects of material properties and climate conditions on performance, to recommend test methods for evaluation, and to develop guidance for selecting detectable warning systems.

Wiss Janney Elstner Associates, Inc., Northbrook, Illinois has been awarded a \$349,557, 30-month contract (National Cooperative Highway Research Program Project 4-33, FY 2006) to recommend test methods for evaluating the performance and durability of detectable warning systems and to provide guidance on methods for selecting systems that will prove durable under different climate conditions and meet the ADAAG requirements. The recommended test methods will be considered for adoption by the American Association of State Highway and Transportation Officials.

For more information, contact Amir Hanna, TRB, 202-334-1892, ahanna@nas.edu.

Public Transportation Ridership Increases



PHOTO: LONDON HEAVY LIGHT RAIL NOW PROJECT

Public transportation ridership has increased by 30 percent and vehicle miles traveled by passenger car have increased by 24 percent since 1995, according to a report from the American Public Transportation Association (APTA).

The report also noted a 5.6 percent increase in ridership among light rail modes of transportation in 2006, with trolleys—both modern and heritage—reporting the largest gains. Cities that recorded the highest increases in light rail use included Saint Louis, Missouri; Minneapolis, Minnesota; San Jose, California; Philadelphia, Pennsylvania; and Salt Lake City, Utah.

Heavy rail ridership had the second largest annual increase at 4.1 percent, with the greatest ridership gains occurring on systems in Los Angeles, California; New Jersey; Staten Island, New York; Atlanta, Georgia; and Chicago, Illinois. Commuter rail systems also experienced increases, notably systems serving Harrisburg, Pennsylvania; South Bend, Indiana; Chicago; Stockton and San Jose, California; and New Haven, Connecticut.

Gains also were found in other modes of public transportation, including paratransit, 2.9 percent, and bus transit, 2.3 percent—with the greatest growth occurring in Seattle, Washington; San Antonio, Houston, and Dallas, Texas; and Los Angeles, California.

Dollar Benefits of Public Transportation Examined

Two-car households that eliminate one car in favor of public transportation will save approximately \$6,200 per year, with transit fare costs included, according to an ICF International study for the American Public Transportation Association (APTA), *Public Transportation and Petroleum Savings in the U.S.: Reducing Dependence on Oil*.

The study calculated U.S. household level of savings by totaling the depreciation and yearly fees for maintenance, insurance, and loan payments on one automobile, using 2006 American Automobile Association figures. The study also concluded that public transportation use in the United States has reduced gasoline consumption by 1.4 billion gallons per year.

Trip-Time Prediction Debuts in California

California's San Francisco Bay Area Metropolitan Commission (BAMC) has expanded its 511 traveler information system, with a new web-based feature, Predict-a-Trip. Created with historical information on average freeway traffic speeds and driving times in the area, Predict-a-Trip allows users of the 511 website to obtain predictions of trip times by entering origin and destination information.

The system calculates an average travel time between different points along the Bay Area freeway network every 15 minutes, using the most recent traffic speeds, providing users with travel time estimates 24 hours per day. Commuters and travelers have found the system particularly useful estimating rush-hour commutes and for assessing holiday traffic conditions.

For more information and to view the Predict-a-Trip calculator, visit http://traffic.511.org/his_traffic_text.asp.



Interstate 80, near Berkeley, California

INTERNATIONAL NEWS

Improving Taxi Accessibility in Europe

The European Conference of Ministers of Transport (ECMT) and the International Road Transportation Union (IRU) have issued recommendations to improve taxi accessibility for disabled and elderly persons. The report, *Improving Access to Taxis*, focuses on user needs and examines medium- and long-term options available to vehicle manufacturers and converters coping with the mobility needs of more than 45 million disabled persons throughout Europe.

Following up on research that led to a 1994 resolution to address accessibility and a 2001 report, *Economic Aspects of Taxi Accessibil-*

ity, the current study identifies how taxi operators can ensure accessibility through improvements in training and interaction with disabled clients. The recommendations for vehicle accessibility incorporate two design levels and include the perspectives of clients and stakeholders from the public and private sectors.

The study has received the backing of major European auto manufacturers, single-purpose taxi manufacturers, specialty companies that convert mass-produced vehicles for the taxi market, and national representative organizations for taxi operators.

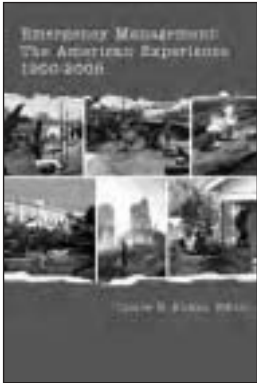
For more information, visit www.ecmt.org.



The Edge of Disaster
S. Flynn. Random House, 2007; 240 pp.; \$25.95; 978-14-000-6551-6.

America's vulnerabilities to terrorist attacks and natural disasters are examined, with special focus on the attacks of September 11, 2001, and the federal government's attempts to strengthen homeland security. The author, a member of the Council on Foreign Relations, maintains that U.S. policymakers need to build resiliency into the systems that make modern American life possible. He presents hypothetical scenarios—a truck-bomb attack on a Philadelphia oil refinery and collapsing levees along California's Sacramento River—to show that U.S. infrastructure has been neglected and is unprepared to respond to bioterrorism, epidemics, floods, earthquakes, and other disasters.

Also examined are the status of U.S. antiterror policy, the importance of confronting terror threats both abroad and on U.S. soil, and the difficulties of ensuring port security. Flynn suggests ways for improving the quality of American life while adapting to modern security requirements.



Emergency Management: The American Experience 1900–2005

Edited by Claire B. Rubin. Public Entity Risk Institute, 2007; 274 pp.; \$35; 978-0-9793722-0-9.

This book brings into perspective the U.S. government's ongoing post-Hurricane Katrina investigation and restructuring of public emergency management systems. Major disasters within the past 100 years of U.S. history—including earthquakes, hurricanes, droughts, floods, a pandemic, and an explosion—are reviewed, with a special focus on government response and crisis management.

As the U.S. government's role in emergency management has expanded, the organizational forms and functions of emergency management have evolved. This 8-chapter book examines why the federal government became involved in emergency management and explains why and how the federal government's role in emergency management has changed.

Introduction to Homeland Security

J. Bullock. Elsevier, 2007; 672 pp.; \$69.95; 0-7506-7992-3.

Developed to give practitioners, educators, and students a comprehensive account of the dynamics of homeland security in the United States, this second edition presents homeland security-related information from an emergency management facilitator's point of view.

This book offers a historical overview of the ter-

rorist threat to the United States; an examination of national security issues, including statutory authority and the PATRIOT Act; commentary on Department of Homeland Security (DHS) directorates and organizational and funding issues, phases of disaster and crisis events, crisis response and recovery, disaster mitigation and preparedness, and communications technology; and an outlook for the future of homeland security.

An in-depth discussion describes DHS before Hurricane Katrina, with applicable questions about the capabilities and functionality of the department. Homeland security hazards are explained, with emphasis on the safety and security of U.S. infrastructure. This text will be useful to students of state, federal, and private security training programs; emergency management personnel; policymakers; and risk assessment professionals.

ECMT Round Table 132: Transport Infrastructure Investment and Economic Productivity

D. Canning, C. Hulten, and A. Kopp. ECMT–OECD, 2007; 109 pp.; \$52; 978-92-821-0124-7.

This book presents information on the macroeconomic effects of transportation infrastructure policies, as well as analytical and empirical tools for determining the amount of public expenditure necessary for transportation infrastructure investment. The volume chronicles one of a series of research events for improving transportation planning sponsored by the Organization for Economic Cooperation and Development (OECD)–European Conference of Ministers of Transport (ECMT).

Topics include infrastructure channels in the structure of production; empirical results from India; cross-national comparisons; an estimation of infrastructure–productivity links in India, the United States, and Spain; the effect of infrastructure on aggregate output; the costs and rates of return for infrastructure; and more. Background papers are provided by David Canning, Harvard University; Charles Hulten, University of Maryland; and Andreas Kopp, OECD–ECMT Transport Research Center.



The books in this section are not TRB publications. To order, contact the publisher listed.

TRB PUBLICATIONS

Making Transportation Tunnels Safe and Secure NCHRP Report 525, Volume 12, and TCRP Report 86, Volume 12

This joint report provides transportation tunnel owners and operators with guidelines for minimizing damage to tunnels from extreme events and for restoring functionality to damaged tunnels. Additional safety and security guidelines aid in identifying principal tunnel hazards and threat vulnerabilities. Deployable, integrated systems for emergency-related command, control, and communication are examined.

2006; 168 pp.; TRB affiliates, \$31.50; nonaffiliates, \$42. Subscriber categories: bridges, other structures, and hydraulics and hydrology (IIC); operations and safety (IV); public transit (VI); rail (VII); freight transportation (VIII); security (X).

Guidebook for Freight Policy, Planning, and Programming in Small and Medium-Sized Metropolitan Areas NCHRP Report 570

Presented are ways to design, initiate, and manage freight policy, planning, and programming processes in metropolitan areas. Included are lessons learned from experience in small- and medium-sized metropolitan areas that have incorporated the consideration of freight issues in policy, planning, and programming decision making.

2007; 192 pp.; TRB affiliates, \$48; nonaffiliates, \$64. Subscriber categories: planning and administration (IA); design (II); operations and safety (IV); rail (VII); freight transportation (VIII).

Roundabouts in the United States NCHRP Report 572

Based on a comprehensive evaluation of roundabouts in the United States, this report presents updates to the design criteria, as well as methods for estimating the safety and operational impacts of roundabouts.

2007; 115 pp.; TRB affiliates, \$39.75; nonaffiliates, \$53. Subscriber category: highway and facility design (IIA).

Guidance for Cost Estimation and Management for Highway Projects During Planning, Programming, and Preconstruction NCHRP Report 574

Estimating the costs of highway projects and implementing management approaches to overcome the root causes of cost escalation are examined in this report. Techniques are presented to support the development of consistent and accurate project estimates through all phases, including long-range planning, priority programming, and project design.

2007; 270 pp.; TRB affiliates, \$53.25; nonaffiliates,

\$71. Subscriber categories: planning, administration, and environment (I); design (II); public transit (VI); rail (VII).

Visualization for Project Development NCHRP Synthesis 361

This synthesis provides an overview of visualization and addresses the challenges of the technology, with detailed case studies from transportation agencies incorporating visualization into the project development process. Results are compared with results of a similar, 1996 study.

2006; 82 pp.; TRB affiliates, \$25.50; TRB nonaffiliates, \$34. Subscriber categories: planning and administration (IA); highway and facility design (IIA).

Training Programs, Processes, Policies, and Practices NCHRP Synthesis 362

The program components required for planning, developing, implementing, funding, and evaluating state department of transportation (DOT) training, development, and education programs are the focus of this synthesis.

2006; 89 pp.; TRB affiliates, \$26.25; TRB nonaffiliates, \$35. Subscriber category: planning and administration (IA).

Control of Invasive Species NCHRP Synthesis 363

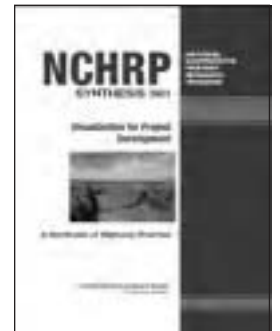
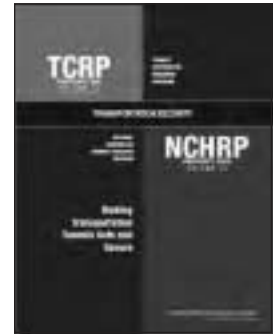
The synthesis explores how state DOTs are identifying actions that halt the spread of, prevent the introduction of, and track the status and location of invasive species in a timely and ongoing manner. Also presented are methods for controlling populations of invasive species, restoring affected habitats, and conducting research.

2006; 115 pp.; TRB affiliates, \$27; nonaffiliates, \$36. Subscriber categories: energy and environment (IB); bridges, other structures, and hydraulics and hydrology (IIC).

Traveler Response to Transportation System Changes: HOV Facilities TCRP Report 95, Chapter 2

Presented are usage characteristics, travel data, and user response information for high-occupancy vehicle (HOV) facilities in eight categories. Topics examined include the parameters that make successful HOV facilities attractive, the mode choice mechanisms and the decisions involved, and the conditions associated with substantial HOV facility traffic volumes.

2006; 127 pp.; TRB affiliates, \$15; nonaffiliates, \$20. Subscriber categories: planning and administration (IA); highway operations, capacity, and traffic control (IVA); public transit (VI).



TRB Meetings 2007

July

- 6 Transforming Transportation Organizations: Tools and Techniques for Organizational Development
Chicago, Illinois
- 6-7 Environmental Analysis in Transportation Committee Workshop
Chicago, Illinois
Christine Gerencher
- 7-9 2007 Summer Conference
Chicago, Illinois
- 7-9 32nd Annual Summer Ports, Waterways, Freight and International Trade Conference
Chicago, Illinois
- 8-11 46th Annual Workshop on Transportation Law
Philadelphia, Pennsylvania
- 8-11 Waste Management and Resource Efficiency in Transportation Committee Meeting and Workshop
Ft. Worth, Texas
- 9-10 Meeting Freight Data Challenges Workshop
Chicago, Illinois
- 9-11 2007 Transportation Planning and Air Quality Conference*
Orlando, Florida

- 9-12 4th International Driving Symposium on Human Factors in Driver Assessment, Training, and Vehicle Design*
Stevenson, Washington
Richard Pain
- 16-18 Water Resources and the Highway Environment: Impacts and Solutions
Sanibel Island, Florida
- 22-24 2007 International Conference of Transportation Engineering*
Chengdu, China
Thomas Palmerlee
- 22-25 2007 TRB Noise and Vibration Summer Meeting
San Luis Obispo, California
- 22-25 Historic and Archeological Preservation in Transportation Committee Summer Conference and Meeting
Flagstaff, Arizona
- 22-26 Workshop on Vehicle Infrastructure Integration and Cooperative Intersection Collision Avoidance Systems
San Jose, California
Richard Cunard
- 23-25 Regional Transportation Systems Management and Operations Committee Summer Meeting
Woods Hole, Massachusetts
Richard Cunard

- 26-27 2nd Strategic Highway Research Program 2 Safety Symposium
Washington, D.C.
- 29-
Aug. 1 Highway Capacity and Quality of Service Committee Summer Meeting
Charlotte, North Carolina
Richard Cunard

August

- 8-10 5th International Conference on Maintenance and Rehabilitation of Pavements and Technological Control*
Park City, Utah
- 24-26 Policy Agenda for Reducing Greenhouse Gases from Transportation*
Asilomar Conference Center, California
Martine Micozzi
- 26-28 Coordination of Transit and Regional Transportation Planning and Land Use Conference
Denver, Colorado

September

- TBA Technical Session on Draped Rockfall Protection Systems
Los Angeles, California
G. Jayaprakash
- 9-12 3rd National and 1st International Conference on Performance Measurement
Irvine, California

Additional information on TRB meetings, including calls for abstracts, meeting registration, and hotel reservations, is available at www.TRB.org/calendar. To reach the TRB staff contacts, telephone 202-334-2934, fax 202-334-2003, or e-mail lkarson@nas.edu. Meetings listed without a TRB staff contact have direct links from the TRB calendar web page.

*TRB is cosponsor of the meeting.

INFORMATION FOR CONTRIBUTORS TO

TR NEWS

TR News welcomes the submission of manuscripts for possible publication in the categories listed below. All manuscripts submitted are subject to review by the Editorial Board and other reviewers to determine suitability for *TR News*; authors will be advised of acceptance of articles with or without revision. All manuscripts accepted for publication are subject to editing for conciseness and appropriate language and style. Authors receive a copy of the edited manuscript for review. Original artwork is returned only on request.

FEATURES are timely articles of interest to transportation professionals, including administrators, planners, researchers, and practitioners in government, academia, and industry. Articles are encouraged on innovations and state-of-the-art practices pertaining to transportation research and development in all modes (highways and bridges, public transit, aviation, rail, and others, such as pipelines, bicycles, pedestrians, etc.) and in all subject areas (planning and administration, design, materials and construction, facility maintenance, traffic control, safety, geology, law, environmental concerns, energy, etc.). Manuscripts should be no longer than 3,000 to 4,000 words (12 to 16 double-spaced, typed pages). Authors also should provide appropriate and professionally drawn line drawings, charts, or tables, and glossy, black-and-white, high-quality photographs with corresponding captions. Prospective authors are encouraged to submit a summary or outline of a proposed article for preliminary review.

RESEARCH PAYS OFF highlights research projects, studies, demonstrations, and improved methods or processes that provide innovative, cost-effective solutions to important transportation-related problems in all modes, whether they pertain to improved transport of people and goods or provision of better facilities and equipment that permits such transport. Articles should describe cases in which the application of project findings has resulted in benefits to transportation agencies or to the public, or in which substantial benefits are expected. Articles (approximately 750 to 1,000 words) should delineate the problem, research, and benefits, and be accompanied by one or two illustrations that may improve a reader's understanding of the article.

NEWS BRIEFS are short (100- to 750-word) items of interest and usually are not attributed to an author. They may be either text or photographs or a combination of both. Line drawings, charts, or tables may be used where appropriate. Articles may be related to construction, administration, planning, design, operations, maintenance, research, legal matters, or applications of special interest. Articles involving brand names or names of manufacturers may be determined to be inappropriate; however, no endorsement by TRB is implied when such information appears. Foreign news articles should describe projects or methods that have universal instead of local application.

POINT OF VIEW is an occasional series of authored opinions on current transportation issues. Articles (1,000 to 2,000 words) may be submitted with appropriate, high-quality illustrations, and are subject to review and editing. Readers are also invited to submit comments on published points of view.

CALENDAR covers (a) TRB-sponsored conferences, workshops, and symposia, and (b) functions sponsored by other agencies of interest to readers. Notices of meetings should be submitted at least 4 to 6 months before the event.

BOOKSHELF announces publications in the transportation field. Abstracts (100 to 200 words) should include title, author, publisher, address at which publication may be obtained, number of pages, price, and ISBN. Publishers are invited to submit copies of new publications for announcement.

LETTERS provide readers with the opportunity to comment on the information and views expressed in published articles, TRB activities, or transportation matters in general. All letters must be signed and contain constructive comments. Letters may be edited for style and space considerations.

SUBMISSION REQUIREMENTS: Manuscripts submitted for possible publication in *TR News* and any correspondence on editorial matters should be sent to the Director, Publications Office, Transportation Research Board, 500 Fifth Street, NW, Washington, DC 20001, telephone 202-334-2972, or e-mail jawan@nas.edu.

- ◆ All manuscripts should be supplied in 12-point type, double-spaced, in Microsoft Word 6.0 or WordPerfect 6.1 or higher versions, on a diskette or as an e-mail attachment.

- ◆ Submit original artwork if possible. Glossy, high-quality black-and-white photographs, color photographs, and slides are acceptable. Digital continuous-tone images must be submitted as TIFF or JPEG files and must be at least 3 in. by 5 in. with a resolution of 300 dpi or greater. A caption should be supplied for each graphic element.

- ◆ Use the units of measurement from the research described and provide conversions in parentheses, as appropriate. The International System of Units (SI), the updated version of the metric system, is preferred. In the text, the SI units should be followed, when appropriate, by the U.S. customary equivalent units in parentheses. In figures and tables, the base unit conversions should be provided in a footnote.

NOTE: Authors are responsible for the authenticity of their articles and for obtaining written permissions from publishers or persons who own the copyright to any previously published or copyrighted material used in the articles.

Emergency Preparedness, Response, and Recovery *Resources at the Ready*

The destruction caused by Hurricane Katrina in August 2005 demonstrated the vital importance of transportation in the response to natural disasters and in recovery, as well as in connecting regional economies to the nation's. The loss of terminals, pipeline, railroad lines, and bridges along the Gulf Coast, for example, had an immediate impact on the energy supply nationwide. The Transportation Research Board and other parts of the National Academies have produced an array of information to help transportation professionals and decision makers prepare for and recover from natural—as well as man-made—disasters. Recent publications of interest include the following:

**Improving Disaster Management:
The Role of IT in Mitigation,
Preparedness, Response, and
Recovery**

National Research Council, ISBN 0-309-10396-7, 192 pages, 6 x 9, paperback, \$40.25 (2007)

**Making Transportation Tunnels
Safe and Secure**

National Cooperative Highway Research Program (NCHRP) Report 525 and Transit Cooperative Research Program Report 86, Vol. 12, ISBN 0-309-09871-8, 168 pages, 8.5 x 11, paperback, \$42 (2006)

**A Guide to Transportation's Role
in Public Health Disasters**

NCHRP Report 525, Vol. 10, ISBN 0-309-09852-1, 123 pages, 8.5 x 11, paperback, \$39 (2006)

**Disruption Impact Estimating
Tool—Transportation (DIETT):
A Tool for Prioritizing High-Value
Transportation Choke Points**

NCHRP Report 525, Vol. 11, ISBN 0-309-09854-8, 25 pages, 8.5 x 11, paperback, \$29 (2006)

**Guidelines for Transportation
Emergency Training Exercises**

NCHRP Report 525, Vol. 9, ISBN 0-309-09850-5, 168 pages, 8.5 x 11, paperback, \$42 (2006)

**Defending the U.S. Air
Transportation System Against
Chemical and Biological Threats**

National Research Council, ISBN 0-309-10074-7, 46 pages, 8.5 x 11, paperback, \$12 (2006)

**Facing Hazards and Disasters:
Understanding Human Dimensions**

National Research Council, ISBN 978-0-309-10178-3, 408 pages, 6 x 9, paperback, \$67 (2006)

**Marine Salvage Capabilities:
Responding to Terrorist Attacks
in U.S. Ports—Actions to Improve
Readiness**

TRB Conference Proceedings 30, ISBN 0-309-09459-3, 38 pages, 8.5 x 11, paperback, \$29 (2004)

**Deterrence, Protection,
and Preparation: The New
Transportation Security Imperative**

TRB Special Report 270, ISBN 0-309-07710-9, 84 pages, 6 x 9, paperback, \$20 (2002)



THE NATIONAL ACADEMIES™

Advisers to the Nation on Science, Engineering, and Medicine

The nation turns to the National Academies—National Academy of Sciences, National Academy of Engineering, Institute of Medicine, and National Research Council—for independent, objective advice on issues that affect people's lives worldwide.

www.national-academies.org