**Cooperative Research for Hazardous Materials Transportation**

*Defining the Need, Converging on Solutions*

The transportation safety record for the nearly 1 million shipments of hazardous materials per day is admirable—incidents with severe consequences are rare, because of the collective efforts of public and private entities. Yet the challenge continually changes, with new materials, new methods of shipping, and new concerns about security, public health, and the environment.

The need for cooperation on research into the transportation of hazardous materials is mounting. This report describes the shared responsibilities of shippers, carriers, regulators, and emergency responders in building a safe and secure system of hazardous materials transportation and identifies several problems that cooperative research can address.

The authoring committee recommends a trial national cooperative research program for hazardous materials transportation that will marshal the expertise of all who have a stake in managing risks and responding to incidents. Recommendations also cover the research program's structure, financing, governance, and management.

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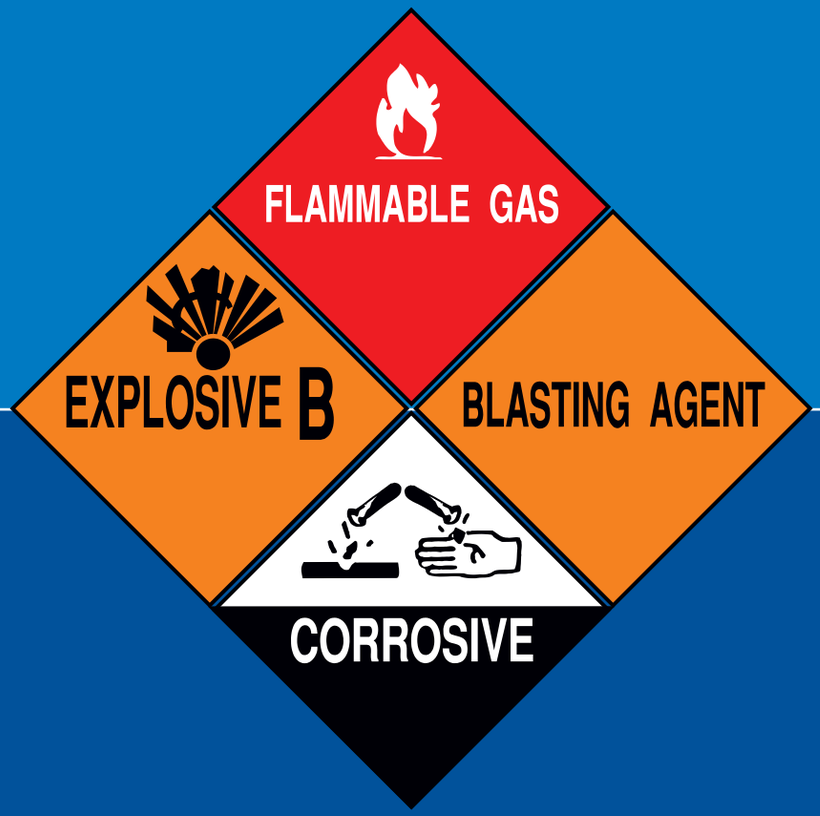
COOPERATIVE RESEARCH FOR HAZARDOUS MATERIALS TRANSPORTATION




# COOPERATIVE RESEARCH FOR HAZARDOUS MATERIALS TRANSPORTATION

*DEFINING THE NEED, CONVERGING ON SOLUTIONS*

TRANSPORTATION RESEARCH BOARD
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SPECIAL REPORT 283

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# Cooperative Research for Hazardous Materials Transportation

## Defining the Need, Converging on Solutions

Committee for a Study of the Feasibility of a
Hazardous Materials Transportation
Cooperative Research Program

TRANSPORTATION RESEARCH BOARD
*OF THE NATIONAL ACADEMIES*

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NOTICE: The project that is the subject of this report was approved by the Governing Board of the National Research Council, whose members are drawn from the councils of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine. The members of the committee responsible for the report were chosen for their special competencies and with regard for appropriate balance.

This report has been reviewed by a group other than the authors according to the procedures approved by a Report Review Committee consisting of members of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine.

This study was sponsored by the Research and Special Programs Administration, the Federal Motor Carrier Safety Administration, and the Federal Railroad Administration of the U.S. Department of Transportation and by the U.S. Coast Guard of the U.S. Department of Homeland Security.

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Thomas R. Menzies, Jr.

# Preface

Hazardous materials are moved throughout the country by all modes of freight transportation, including pipelines, ships, trucks, trains, and airlines. The shipments themselves vary widely in size and type. Small parcels may contain a few ounces of infectious or radioactive substances. River barges and railroad tank cars may carry bulk quantities of flammable, toxic, and corrosive gases, solids, and liquids. Shippers of these materials range from multinational manufacturing companies to small businesses, and the frequency of their shipments may range from thousands daily to one or two per year. Depending on the size and frequency of their hazardous materials shipments, shippers may maintain expertise in hazardous materials safety or rely on third-party logistics companies for such expertise.

The shipments present risks to public safety and security, human health, and the environment. A diverse mix of government agencies is responsible for controlling these risks. Some focus on specific materials (e.g., radioactives, armaments, high-energy fuels), others on specific risk areas (e.g., safety, security, environment), and others on specific modes of transportation (e.g., rail, marine, air, and highways). Moreover, some public agencies are responsible for operating the transportation infrastructure, others for regulating its use, and others for responding to hazardous materials incidents when they occur.

This is a synopsis of the hazardous materials transportation "sector." It is less an organized enterprise than a loosely connected assortment of public and private entities sharing a goal of ensuring that hazardous cargoes are moved without incident. This goal has spurred the creation of a number of venues for various entities with related interests to work together. The trade associations from the transportation and shipping

industries work with one another, as do government regulatory and enforcement agencies at the federal, state, and local levels. They share information, resources, and expertise. Meanwhile, the federal government has created the Office of Hazardous Materials Safety within the U.S. Department of Transportation's (DOT's) Research and Special Programs Administration (RSPA)[1] to develop uniform requirements for hazardous materials transportation and to coordinate with international bodies. The result of all of these efforts could even be described as a system—one that is continually challenged but that has produced a good safety record.

Perhaps the most notable gap in this system for ensuring hazardous materials safety and security is in the conduct of research. To a large extent, government agencies have their own research programs that support their own mission needs, and industry has the same. Collaborative research takes place, but mostly in an ad hoc way, on a project-by-project basis. Formed more than three decades ago, the Transportation Research Board's (TRB's) Transportation of Hazardous Materials Committee has been the only ongoing venue for the many elements of the hazardous materials transportation community—both public and private—to come together to identify research needs, promote the conduct of research, and share research results on a regular basis. From time to time, this standing committee has pointed to the absence of a continuing means of coordinating research to address shared problems in hazardous materials transportation, and it has sought out ways to fill this gap.

In June 1997, the committee convened a special workshop with funding support from RSPA and several other DOT agencies to explore the idea of creating a national cooperative research program for hazardous materials transportation.[2] More than 30 representatives from shippers; carriers; container makers; and government regulatory, enforcement, and emergency response agencies participated. Workshop participants

[1] On November 30, 2004, the president signed into law the Norman Y. Mineta Research and Special Programs Improvements Act, which reorganizes DOT's pipeline safety, hazardous materials safety, and research activities. The law will move hazardous materials and pipeline regulatory functions into one administration and departmentwide research activities into another. This report refers to RSPA as it existed at the time of the committee's deliberations. The recommendations in this report, however, are not materially affected by the imminent reorganization.

[2] The facilitator's report of this workshop can be found at the following website (as of November 1, 2004): projects.battelle.org/trbhazmat/.

explored the idea of establishing a cooperative research program for hazardous materials transportation whose aim would be to find solutions to problems and concerns shared by the many parties who would cooperate in defining, coordinating, and overseeing the research. Cooperative research programs in the highway and public transit fields—the National Highway Cooperative Research Program and the Transit Cooperative Research Program—were used as models. These two programs, which are managed by TRB, focus on finding solutions to problems shared by operators of highway and transit systems, respectively.

Participants in this initial workshop identified a number of possible advantages and disadvantages of establishing a cooperative research program for hazardous materials transportation. They saw as potential advantages the prospects of such a cooperative program earning the widespread trust of stakeholders by emphasizing objective research, leveraging limited research resources, and solving practical problems by tapping an array of related expertise and perspectives. They saw as potential disadvantages the possibility that resources used to fund the program would be diverted from other research activities and that the coordination and consensus-building involved in the cooperative process could slow the research process. In general the workshop participants were receptive to the idea. They recognized that more definitive conclusions could not be drawn without a more thorough examination of options for financing, governing, and managing such a program.

Drawing on the results of this initial workshop, the Transportation of Hazardous Materials Committee outlined how a cooperative research program might function and be structured.[3] The committee developed a fairly detailed set of candidate projects for the program. The standing committee did not, however, examine options for financing the overall program, nor did it recommend steps for bringing about the program. It was recognized that such advice would require a more thorough examination of the merits and feasibility of the program, including options for program finance, governance, and management.

[3] The Transportation of Hazardous Materials Committee has drafted a prospectus for a national hazardous materials transportation research program, which can be found at the following website (as of November 1, 2004): projects.battelle.org/trbhazmat/. The prospectus contains detailed problem statements developed as candidates for research.

## STUDY CHARGE AND APPROACH

Interested in the basic concept, RSPA, the Federal Motor Carrier Safety Administration, the Federal Railroad Administration, and the U.S. Coast Guard pooled their resources to sponsor this study of the feasibility of a cooperative research program for hazardous materials transportation. The sponsors asked TRB to convene a committee of experts, formed under the auspices of the National Research Council (NRC) of the National Academies, to offer advice on the need for such a research program and on ways to bring it about if desirable. Specifically, the study sponsors set forth the following charge:

> This project will determine the feasibility of a hazardous materials transportation cooperative research program. In consideration of other cooperative programs in government and industry, this feasibility determination will include governance, research topics, program structure, and potential funding mechanisms. In determining the need for such a program, the project will review current funding of hazardous materials transportation research in existing programs of industry and the U.S. Departments of Transportation, Energy, Defense, Homeland Security, and other relevant agencies. Assuming that a cooperative program is determined to be needed and feasible, gaps in current research programs that could be filled with a collaborative program of research will be identified. In addition, organizational governance, program structure, and funding mechanisms will be recommended.

In accordance with usual NRC procedures, TRB assembled a committee with a range of expertise and a balance of perspectives on issues related to the study charge. Robert E. Gallamore, Director of the Transportation Center, Northwestern University, was appointed chair of the committee, which included 13 other members with expertise in hazardous materials shipping, transportation, research management, risk analysis, enforcement, and emergency planning and response. Committee members served in the public interest without compensation.

The study committee met three times from April 2004 to September 2004. During its deliberations, the committee reviewed the previous work of the TRB Transportation of Hazardous Materials Committee, including the results of its 1997 workshop and outline of how a cooperative research program could be structured and possible topics for

research. In conjunction with its second meeting, the study committee sponsored a 1-day workshop in which more than 60 individuals from various parts of the hazardous materials and transportation sectors were invited to provide information and advice on the need for and possible ways of organizing a cooperative research program. The agenda for this workshop can be found in the Appendix. Many of the research needs identified in this report (see Chapter 4) were gleaned from the workshop discussions.

In recent years TRB study committees have been convened to examine proposals for cooperative research programs in a number of fields, including environmental protection, naval engineering, public transportation, and airport operations. The study committee made a point of reviewing this earlier work, which contains helpful descriptions and evaluations of many ongoing cooperative research programs. In particular, the committee benefited a great deal from *Special Report 272: Airport Research Needs: Cooperative Solutions* (TRB 2003). Much of the discussion in Chapter 5 on cooperative research programs in other fields was drawn from that report.

More details on the approach taken by the committee in conducting the study and the organization of the report are provided in Chapter 1. In conducting the study, the committee focused on the key funding, governance, and management characteristics that have been important to the success of cooperative research programs in other fields. The committee did not examine such details as financial reporting methods, contract administration procedures, and governance decision-making protocols. These are important matters, but they are largely issues of implementation rather than policy.

## ACKNOWLEDGMENTS

During its information-gathering meetings, which were open to the public, the committee was briefed by representatives of the four federal agencies that sponsored the study. Douglas Reeves of RSPA's Office of Hazardous Materials Safety attended all open meetings. In serving as the federal sponsors' main liaison with the committee and TRB staff, he clarified questions about the study charge and sponsor expectations. The

committee thanks him for his close participation and support throughout the course of the study. In addition, thanks go to liaisons Manny Pfersich of the U.S. Coast Guard, William Schoonover of the Federal Railroad Administration, William Quade of the Federal Motor Carrier Safety Administration, and Kin Wong of RSPA.

The committee also thanks all who participated in its July 1 workshop. Special thanks go to Emil H. Frankel, Assistant Secretary for Transportation Policy, for opening the workshop. Thanks are also due to those workshop participants who joined in special panel discussions: Dennis Ashworth, U.S. Department of Energy; Edwin B. Bave, U.S. Army Corps of Engineers; Paul Bomgardner, Commercial Vehicle Safety Alliance; Andrew J. Bruzewicz, U.S. Army Corps of Engineers; Montressa Elder, Oklahoma Department of Environmental Quality; John Eversole, International Association of Fire Chiefs; Robert Fronczak, Association of American Railroads; Cliff Harvison, National Tank Truck Carriers; Thomas Schick, American Chemistry Council; Robert Trainor, National Transportation Safety Board; and Todd Treichel, Railway Supply Institute and Association of American Railroads. During the workshop, Robert Reilly, Director of the TRB Division of Cooperative Research, explained the organization and operation of TRB's cooperative research programs. Jonathan L. Gifford, George Mason University, provided a cogent and concise summary of the workshop discussions. The committee thanks both of them for their contributions.

Thomas R. Menzies, Jr., managed the study and drafted the report under the guidance of the committee and the supervision of Stephen R. Godwin, Director of Studies and Information Services.

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

NRC thanks the following individuals for their review of this report: Mark D. Abkowitz, Vanderbilt University, Nashville, Tennessee; Richard

Barlow, Lyondell Chemical Company, Houston, Texas; Lawrence W. Bierlein, McCarthy, Sweeney & Harkaway, Washington, D.C.; Marc D. Boyle, Boyle Transportation, Billerica, Massachusetts; Alexander MacLachlan, E. I. DuPont de Nemours & Company (retired), Wilmington, Delaware; Charles Swinburn, Rail America, Inc., Boca Raton, Florida; and Wesley A. Thomas, Downers Grove Fire Department, Mokena, Illinois. Although the reviewers provided many constructive comments and suggestions, they were not asked to endorse the committee's findings, conclusions, or recommendations, nor did they see the final draft before its release. The review of this report was overseen by David G. Hoel, Medical University of South Carolina, Charleston, and C. Michael Walton, University of Texas at Austin. Appointed by NRC, they were responsible for making certain that an independent examination of this report was carried out in accordance with institutional procedures and that all review comments were carefully considered. Responsibility for the final content of the report rests solely with the authoring committee and the institution.

Suzanne Schneider, Associate Executive Director, TRB, managed the report review process. The report was edited and prepared for publication by Senior Editor Norman Solomon and Senior Editorial Assistant Jennifer J. Weeks under the supervision of Javy Awan, Director of Publications, TRB. Special thanks go to Frances Holland and Amelia Mathis for providing the significant amount of administrative support required in holding the workshop and committee meetings.

## REFERENCE

***Abbreviation***

| | |
|---|---|
| TRB | Transportation Research Board |

TRB. 2003. *Special Report 272: Airport Research Needs: Cooperative Solutions.* National Research Council, Washington, D.C.

# Contents

# Executive Summary

The need for cooperation in research to ensure the safe and secure transportation of hazardous materials is mounting. Responsibility for building a safe and secure system of hazardous materials transportation is shared by shippers, carriers, regulators, and emergency responders throughout the country, industry, and all levels of government. This report, the product of a year-long study by a committee of experts in hazardous materials transportation, research management, risk analysis, enforcement, and emergency planning and response, describes these shared responsibilities and identifies numerous problems that cooperative research can help address. The committee recommends the trial of a national cooperative research program for hazardous materials transportation that will make use of the expertise and perspectives of all those having an interest in overcoming problems and improving capabilities for managing risks, preparing for incidents, and responding to emergencies.

The safety record of hazardous materials in transportation is admirable for the nearly 1 million shipments moved daily. Incidents with severe public safety consequences are rare due to the collective efforts of the thousands of public and private entities responsible for ensuring the safety of these shipments. The challenge before these entities, however, is continually changing as new materials are developed, means and methods of transporting them evolve, and new concerns emerge, including concerns about security, public health, and environmental harm. Traditional measures of safety are no longer fully adequate in assessing overall system performance in controlling risks. An expanding array of entities responsible for aspects of performance presents many practical challenges in creating a responsive and effective system for controlling the varied risks associated with transporting hazardous materials. The

committee believes that cooperative research will become an important part of the strategy for meeting these challenges.

The committee believes that a national program for cooperative research can be developed and can succeed. Hazardous materials shippers and carriers, regulators, and emergency responders have long worked together to develop standards, share resources and information, and respond to emergencies. Cooperative research programs have proved successful in several related fields. They demonstrate that such a program can yield widely accepted and useful results.

This study examines the idea of a cooperative research program for hazardous materials transportation, that is, a program aimed at finding solutions to problems and concerns shared by the many parties who would cooperate in defining, coordinating, and overseeing the research. The focus of the study is on determining whether a national cooperative research program would be a useful supplement to existing research in the hazardous materials transportation field. Four federal agencies with central roles in ensuring the safety and security of hazardous shipments sponsored the study: the U.S. Department of Transportation's Research and Special Programs, Federal Motor Carrier Safety, and Federal Railroad Administrations and the U.S. Coast Guard of the U.S. Department of Homeland Security.

The study committee believes strongly that cooperative research will prove useful, and may be essential, in ensuring a safe and secure hazardous materials transportation system. Nevertheless, bringing it about may require a pilot test to reveal its potential and build interest in a larger-scale program. The fragmentation and diversity of the hazardous materials transportation sector make cooperative research important, while they present challenges to its implementation. A pilot program will do much to determine the value of a cooperative research program. It will demonstrate how well the hazardous materials community can work together, the extent to which shared problems exist and are suited to cooperative research, and how useful a cooperative research program can be in seeking practical solutions to these problems.

A program structure is recommended, and ways of financing, governing, and managing the program are outlined. The four sponsors of this study are urged to pilot test the program concept by pooling a modest

amount of their research funds to finance research projects. The projects would be selected by a special committee of stakeholders drawn from a cross section of the hazardous materials transportation sector, to include shippers, carriers, and emergency responders. The program should be managed and the research conducted in a manner similar to that of cooperative research programs that have proved successful in other fields such as public transit and highways. On the basis of experience with the trial program, the stakeholder panel and the hazardous materials sector as a whole will be in a position to judge the desirability of creating a larger and more lasting national cooperative research program.

## MOUNTING NEED FOR COOPERATIVE RESEARCH

Hazardous materials are substances that are flammable, explosive, or toxic or have other properties that would threaten human safety, health, the environment, or property if released. The threat stems not only from accidental releases but from a concern that terrorists will target these materials to cause harm to public health and safety and to the economy.

More than 15 percent of the freight tonnage moved in the United States is regulated as hazardous by the U.S. Department of Transportation. The challenge of ensuring the safety and security of hazardous materials is complicated by the large volume and ubiquity of these shipments, which are found in all modes of freight transportation, all regions of the country, and all segments of the economy. Ensuring safety and security is necessary because many of these materials are vital to commerce and the daily lives of Americans.

Ensuring the safe and secure transportation of hazardous materials requires the efforts of carriers in nearly all modes of transportation, shippers of a wide range of products, and government agencies at all jurisdictional levels. The main responsibility is that of shippers and carriers, who follow their own good practices and long-standing rules and standards put in place by industry, the federal government, and international bodies. Because releases in transportation occur on occasion, this responsibility extends to state and local police and fire officials, who are often first to arrive on the scene of a release and who must act quickly to minimize harm. Moreover, state and local authorities must work with

industry and federal agencies to ensure the security of shipments passing through critical infrastructure and population centers. Even within the federal government, more than a dozen agencies have regulatory, enforcement, operational, and other responsibilities pertaining to hazardous materials transportation. All of these entities have much at stake in providing a safe and secure system for transporting hazardous materials.

All parties responsible for the transportation of hazardous materials require information to support their decisions. Which routes and modes of transportation are safest, most secure, and pose the least risk to the environment? Which materials are suited for which type of packaging? Which emergency preparations are most prudent given the nature of the materials passing through the transportation system? Which shipments merit extra security attention? These are examples of the kinds of decisions that industry and government must make on a regular basis.

Such decisions are often made independently by thousands of public and private entities, but their ramifications can be far-reaching. Decisions to move hazardous materials by one mode versus another, for example, can affect the emergency preparations needed in various parts of the transportation system and in the communities in which the transportation facilities are located. Changes in material packaging requirements can lead to the diversion of hazardous cargoes to different transportation vehicles, modes, and routes, which may have safety and security implications.

Good decisions demand good information. They require data and analytic tools for weighing options and understanding causal relationships and systemwide effects. The promise of a cooperative research program is that it will allow such problems to be addressed from a wider range of perspectives. It will allow the consolidation of resources to seek solutions more efficiently, as opposed to piecemeal and duplicative efforts. It will lead to greater acceptance of research results from the many entities involved because each will participate in the process. And it will lead to more widespread dissemination of the results and their use in the field. By cooperating in the setting of the research agenda and in guiding individual research projects, the diverse parties responsible for hazardous materials safety and security would have a dependable way to work together in finding solutions to their shared problems.

A cooperative research program could provide objective information and analyses for use in making regulatory and investment decisions, planning for hazardous materials emergencies, and improving the capabilities of emergency responders. The committee identified a number of research areas that are candidates for cooperative research; they include a review of how hazardous materials safety regulations relate to security concerns, a national assessment of hazardous materials emergency response coverage, and technical support for updating and improving the Department of Transportation's *Emergency Response Guidebook* as needed.

## ENVISIONING A FULL-SCALE PROGRAM

The committee finds that there is a demonstrable need for a cooperative research program for hazardous materials transportation. While there are numerous ways to structure such a program and bring it about, the experience of cooperative research programs in other fields suggests the importance of the following guidelines for building a successful program:

- It should be financed, at least in part, by a cross section of end users of the research. Federal assistance in financing may encourage and sustain broad-based participation by these stakeholders, including those who do not have the financial means to support the program.
- It should be governed and guided by the end users of research, including all who have key roles in ensuring the safety and security of hazardous materials transportation.
- It should be managed in ways that lead to trusted and high-quality research results, engage stakeholders in all stages of the research process, and ensure widespread dissemination of the research results.

The following represents the committee's vision of how a hazardous materials transportation cooperative research program could be financed, governed, and managed.

### Federal and Stakeholder Financing

The diverse array of stakeholders in hazardous materials transportation means that no single industry segment is likely to have the incentive to

fund cooperative research, and some will not have the financial means to do so. The federal government regulates hazardous materials transportation because of the broad public interest in ensuring its safety and security. A federal appropriation of funds to help pay for a hazardous materials transportation cooperative research program can be rationalized on the same public interest grounds.

**Federally appropriated funds would provide core financing of the overall program of research, perhaps coupled with supplemental funds contributed on a discretionary basis by stakeholders for individual projects.** In the committee's view, the problems and research needs associated with hazardous materials transportation are at least as complex and numerous as those associated with public transit, which receives federal appropriations for cooperative research on the order of $8 million per year. **The committee believes that a cooperative research program comparable in magnitude with that of the cooperative research program for public transit, on the order of $5 million to $10 million per year, can be justified to ensure the safety and security of hazardous materials in transportation.**

If the program proves successful over a period of 3 to 5 years, an increasing portion of program funding may be derived in a more direct manner from stakeholders and users of the research. Stakeholders must be convinced of the program's value and must commit their time and finances to support it. The funding approach must be agreeable to the stakeholder communities, not forced on them. If its use for this purpose is permitted by Congress, the Hazardous Materials Registration Fee is one possible funding source. The fee is already being collected from carriers, shippers, and others in the hazardous materials transportation industry. It varies from $300 per year for small businesses to $2,000 per year for larger businesses. It generates about $13 million per year in federal revenues, most of which is appropriated to states and localities to strengthen their preparedness for hazardous materials emergencies. Raising the fee by about 8 percent, or $25 for small businesses and $150 for others, would generate about $1 million in annual revenues for cooperative research. **Increasing stakeholder financing of the program over time, even if it is discretionary, is key to fostering a sense of ownership of the program by stakeholders and ultimately ensuring that the research products remain useful.**

## Governance by a Broad Base of Stakeholders

**The program should be guided by a governing board that is largely independent and composed primarily of the end users of research, who will be responsible for soliciting research needs, prioritizing them, and setting the program's research agenda.** The governing board should ensure that the products of research are useful and well disseminated within the broad array of stakeholder communities. **A majority of the board members should be shippers, carriers, suppliers, and state and local emergency managers and responders,** because they are the significant end users of research. **The board should also have representation from the federal agencies that have programmatic, operational, and regulatory responsibilities for hazardous materials transportation safety, security, and environmental protection.** These agencies will likewise gain from cooperating in research with one another as well as with other segments of the industry.

## Management Modeled on Existing Cooperative Programs

Without knowing how a hazardous materials transportation program would be financed and governed, it is premature to lay out precisely how and by whom the program should be managed. However, experience with existing cooperative research programs indicates that certain key features of a research process will be integral to the success of the program. First, **individual research projects should be conducted by contractors selected on a competitive basis.** Contract research, as opposed to investment in specialized research facilities and the hiring of in-house staff, will allow for greater flexibility in the research program. A competitive process for selecting contractors on the basis of both qualifications and cost will encourage quality and efficiency, build program credibility, and enable more research projects to be undertaken with a limited research budget. Second, **technical panels should be responsible for defining the scope of individual research projects, developing requests for proposals from researchers, selecting the researchers to perform the work, overseeing and reviewing the work, and assisting with dissemination of the final product.** The technical panels should include end users of the research as well as technical experts from academia, the private sector, and government. Third, **the organization man-**

**aging this process should be perceived as independent and focused on research as a main organizational mission—characteristics that are essential in building trust.** As a corollary to this point, the host organization should be known for research products that meet scientific and professional standards of quality and should have the capability to disseminate these products widely.

## NEXT STEPS: PILOTING THE CONCEPT

The program outlined above would require a dedicated effort not only from research advocates but also from the stakeholder communities. However, the benefits of research are not always apparent to those focused on day-to-day operations and concerns. The committee recognizes this practicality and the challenge of securing support for a cooperative research program absent tangible evidence of its utility. **The building of support may require a smaller-scale effort that demonstrates the functioning of the program and yields some early and useful research results.**

A pilot test of the hazardous materials transportation cooperative research program is needed. **The committee therefore urges each of the four agencies that sponsored this study to contribute $250,000 in research funds to create a pooled fund of $1 million for cooperative research.** The four agencies may seek additional contributions to enlarge the pool from other federal agencies, including the Department of Homeland Security, the Federal Aviation Administration, and the Department of Energy. A $1 million fund should be sufficient to pay for three or four research projects that are carefully selected to yield results that are timely and useful. A number of candidate research projects are identified in this report to illustrate research topics that may be suited to a full-scale cooperative research program. A pilot program would need to focus on projects costing between $100,000 and $300,000 and capable of being completed in 12 to 18 months. Some of the projects may be precursors to larger research projects identified in this report, such as literature analyses and syntheses of practice in the field.

**The sponsoring agencies should ensure that a broad-based committee of stakeholders is formed to identify needed research and advise on how the pooled research funds should be programmed to**

**meet these priority needs.** The stakeholder committee, acting in a manner similar to a program governing body, should represent a cross section of the hazardous materials shipping and carrier communities as well as experts in emergency response, risk management, and hazardous materials transportation safety and security. This committee should identify and define a series of individual research projects and recommend funding for those with the greatest potential for yielding practical solutions to important problems in the field. The projects selected for the pilot program should be of interest to a large number of stakeholders and promise usable products to practitioners in a short period of time. **Each research project should be guided by an oversight panel that includes both technical experts and practitioners from the stakeholder communities.** The panels for the pilot program need not be large or elaborate. They may consist of four or five members of the larger stakeholder committee, supplemented by one or two outside experts as needed. The panels will select contractors to perform the work on the basis of merit.

In the end, the value of the research should speak for itself. If the research results from the pilot program are useful, the cooperative research concept can be expected to generate stakeholder interest in pursuing a larger-scale program. **A formal critique of the pilot program should be undertaken by the sponsoring agencies along with the stakeholder committee.**

The successful programs in other fields suggest that stakeholder involvement and interest in cooperative research must be present at inception. A pilot program can help establish stakeholder ownership from the start.

# 1

# Introduction

Shipments of hazardous materials come in many sizes and forms, pose many kinds and degrees of hazard, and are moved by nearly all modes of transportation through all parts of the country. Ensuring the safe, secure, and efficient movement of these cargoes requires the concerted efforts of both industry and government. The actions of private companies that produce and ship hazardous materials, which range from household paints and motor fuel to explosives and radioactive wastes, are especially important. They must be sure that shipments are properly packaged, labeled, and accompanied by accurate information on contents, quantities, and emergency contacts. In turn, the carriers of these shipments must provide a safe and secure operating environment, both in terminal areas and en route. Shippers and carriers must be sure that all hazard information is properly displayed, accurate, and available for emergency personnel.

The public sector's role is equally important. With the exception of railroads, state and local governments own and operate much of the fixed transportation infrastructure on which these shipments pass, such as airports, seaports, rural farm roads, and Interstate highways. They are responsible for enforcing traffic safety laws and regulations, and their police and fire officials are often the first to arrive on the scene of a hazardous materials incident. These officials must know how to react in the event of an incident, when circumstances can be chaotic, confusing, and dangerous to the public. The federal government's role is largely to ensure that safe and secure practices are uniformly applied and followed by shippers and carriers. Having a national perspective, the federal government is in the best position to ensure safety and security on a systemwide basis. The U.S. Department of Transportation's (DOT's) Office

of Hazardous Materials Safety promulgates safety regulations that cover all modes of transportation. International bodies, such as the United Nations Committee of Experts on the Transport of Dangerous Goods,[1] assist in the development of standards for uniformity in packaging, labeling, and hazard communication for shipments in world trade.

The many entities responsible for the safety and security of hazardous materials shipments are by no means homogeneous. The tens of thousands of individual shippers, carriers, and receivers span nearly all industries. Thousands of state and local agencies have relevant responsibilities ranging from public safety and security to public health and environmental protection. Even at the federal level, more than a dozen agencies have important roles in the transportation of hazardous materials.

In light of the many entities responsible for hazardous materials transportation, the consistently good safety record of this enterprise is impressive. Major incidents involving fatalities, injuries, and public evacuations are rare, and they have become rarer over time, even as the volume of shipments has grown. Nevertheless, maintaining this safety record is becoming increasingly challenging as hazardous materials traffic grows and becomes more intermodal and international in nature. Movements of hazardous commodities, like those of many other kinds of freight in highly competitive markets, are dictated by world prices and just-in-time inventorying and manufacturing practices. The volumes, routes, and modes of shipment are not fixed, and liberalization and growth in international trade mean that more and more shipments arrive from and head to markets abroad. This dynamic environment is sure to present many new challenges and concerns.

## SOLUTIONS THROUGH COOPERATIVE RESEARCH

Ensuring safety in a changing transportation environment requires vigilance in detecting emerging problems and finding and implementing solutions. The fragmentation of the hazardous materials transportation sector, however, can mean that problems shared by many entities are

[1] The full committee name is the Committee of Experts on the Transport of Dangerous Goods and on the Globally Harmonized System of Classification and Labeling.

not readily understood to have significance collectively. Individual organizations, public and private, may not have the incentive or resources to search for solutions to a problem, especially when it is viewed in isolation rather than from multiple perspectives.

The concept of a formal and ongoing means of cooperation in the search for solutions to shared problems is not new. There are many examples of organizations cooperating in the funding, programming, and conduct of research. Many industry associations support cooperative research projects on a periodic basis, and some, such as the Electric Power Research Institute started by the nation's electric utilities more than 30 years ago, have created large and lasting cooperative research organizations. A long-standing research program in the transportation field is the National Cooperative Highway Research Program, which was initiated more than 40 years ago by state highway and transportation departments seeking solutions to shared problems encountered in building, operating, and maintaining the nation's network of highways. There are also research programs jointly funded and administered by industry and government, such as the Health Effects Institute, which has been cosponsored for more than two decades by the automotive industry and the U.S. Environmental Protection Agency to understand better the effects of automobile emissions on air quality and human health.

All of these programs seek solutions to problems and concerns shared by multiple parties, who cooperate in defining, coordinating, and overseeing the research. The main indication of the success of such programs is that they have been able to sustain funding for such a long period on a voluntary basis. Apparently, the organizations cooperating in the sponsorship of these research programs have found the research products to be useful and cost-effective; otherwise, they would not continue to volunteer the program funding.

## GENESIS OF THE STUDY

In many ways, interest in a cooperative research program for hazardous materials transportation stems from the same basic concern that led Congress to create a single DOT agency to oversee hazardous materials transportation safety during the 1970s. The concern was that industry

and institutional fragmentation was impeding the systemwide management of the risks of hazardous materials transportation. By the 1990s, when the idea of a cooperative research program was first being raised, the environmental and human health effects of hazardous materials releases had become more prominent concerns, along with the traditional concern about public safety. Long before, it had become apparent that a mode-by-mode approach to regulating hazardous materials in transportation was obsolete and potentially counterproductive. "Intermodalism" became the popular term to describe the interconnectivity of the transportation modes and the traffic moving through them. The fostering of intermodalism had become a national policy goal with passage of the Intermodal Surface Transportation Efficiency Act of 1991.

Intermodal movements are common in freight transportation today. However, the main regulatory and enforcement agencies in DOT remain mode based. Meanwhile, concern over the safety and environmental risks of hazardous materials has been joined by intensified concern over security. Public safety, security, and environmental protection are now all important goals of hazardous materials regulation. Several new federal agencies have been created and others have been reorganized to deal with security risks. In particular, the Department of Homeland Security (DHS) has a strong interest in hazardous materials transportation because of concerns that hazardous cargoes will be targeted by terrorists. The Transportation Security Administration and the U.S. Coast Guard (USCG), both previously housed within DOT, are now part of DHS, which creates an additional set of regulatory and institutional challenges.

In this changing landscape, four of the federal agencies responsible for managing the risks associated with hazardous materials transportation—the Research and Special Programs Administration, the Federal Motor Carrier Safety Administration, the Federal Railroad Administration, and USCG—decided to sponsor this study to examine the idea of a cooperative research program for hazardous materials transportation. In doing so, they asked the National Academies, under the auspices of the Transportation Research Board, to convene a study committee with members drawn from industry, government, and academia who would consider the value of such a program and have an understanding of how similar programs have worked elsewhere.

## STUDY APPROACH AND REPORT ORGANIZATION

The committee approached the study with an intention to

- Determine whether there is a need for a national cooperative research program for hazardous materials transportation—that is, whether research needs are shared by many entities and have limited prospects of being met by existing research programs;
- Examine possible ways of structuring a cooperative research program, in part by drawing on the experience of other programs in financing, governing, and managing cooperative research;
- Identify options for program finance, governance, and management that are commensurate with furthering the kinds of research needed and compatible with the structure and characteristics of the hazardous materials transportation sector; and
- Offer practical advice on whether and how best to pursue a cooperative research program for hazardous materials transportation.

To inform the study, the committee examined previous proposals for hazardous materials cooperative research programs, including examples of candidate research projects developed as part of these earlier efforts. It drew on its members' expertise and experience in the hazardous materials field to assess research needs and consider models for organizing a cooperative research program. It convened a workshop with participants from industry and government to discuss research needs, options for financing and structuring a cooperative program to meet these needs, and the prospects for generating sufficient interest and support for such a program. The information and insights obtained from the workshop are reflected in the committee's proposal for proceeding.

The following five chapters mirror the study approach. Chapter 2 provides an overview of the industry, describes the safety and other risks associated with hazardous materials transportation, and outlines the many roles and responsibilities of industry and government in managing these risks. Chapter 3 describes the array of federal research programs related to hazardous materials transportation. Chapter 4 reviews the kinds of problems that are candidates for cooperative research and offers example projects for illustration purposes. Chapter 5 examines several

existing cooperative research programs, both within and outside the transportation sector, the kinds of research they emphasize, and how they are financed, governed, and managed. Chapter 6 examines options for structuring a hazardous materials transportation cooperative research program on the basis of insights gained from examining other cooperative research programs.

Finally, Chapter 7 presents the committee's conclusions about the need for cooperative research on hazardous materials transportation, its vision for how a national cooperative research program might be organized to help address this need, and recommended next steps in bringing about such a program.

# 2

# Overview of Hazardous Materials Transportation

Background information on the transportation of hazardous materials shipments, the challenges involved in ensuring their safety and security, and the interrelated roles of government and industry in meeting these challenges is provided in this chapter.

## TRANSPORTATION OF HAZARDOUS MATERIALS

The federal Hazardous Materials Transportation Act of 1975 (HMTA) and its reauthorizing legislation define a hazardous material as a substance or material that, if not regulated, may pose an "unreasonable risk to health, safety, or property when transported in commerce." In implementing the act, the Department of Transportation (DOT) has identified by name more than 3,000 materials subject to regulation. Thousands of unnamed materials are also covered by regulation because they are explosive, flammable, corrosive, infectious, or hazardous in other ways. The federal hazard classifications, along with example materials, are given in Table 2-1.

Excluding shipments by pipeline and oceangoing international tankers,[1] DOT has estimated from 1997 Census Bureau data that about 817,000 shipments consisting of 5.4 million tons of hazardous materials are made daily in the United States, which would total nearly 300 million

[1] Pipelines are a major mode for transporting petroleum products, accounting for about 45 percent of tonnage. Pipelines have characteristics that differ from those of other modes and are regulated separately. They have some commonality with fixed facilities. Likewise, tanker vessels are regulated separately by the U.S. Coast Guard. Statistics for pipelines and tankers are not reviewed here, although it is recognized that these modes may participate in cooperative research on hazardous materials transportation.

**TABLE 2-1 Hazard Classes and Divisions with Example Materials**

| Hazard Class and Division | Name of Class and Division | Example Materials | Brief Description of Hazard |
|---|---|---|---|
| 1.1 to 1.6 | Explosives | Black powder, fireworks, rocket motors | Mass explosion, projection hazard |
| 2.1 | Flammable Gas | Propane | |
| 2.2 | Nonflammable, Nontoxic Gas | Compressed oxygen | Contents under pressure |
| 2.3 | Poison Gas | Chlorine | |
| 3 | Flammable Liquid Combustible Liquid | Paint, gasoline, diesel fuel | |
| 4.1 | Flammable Solid | Safety matches, Sterno | Readily combustible, self-reactive |
| 4.2 | Spontaneously Combustible | Calcium dithionite | Self-heating materials, ignite or heat when exposed to air |
| 4.3 | Dangerous When Wet | Calcium carbide | Reacts with water to yield flammable or toxic gas or becomes combustible |
| 5.1 | Oxidizer | Potassium bromate | Yields oxygen or fire potential |
| 5.2 | Organic Peroxide | Methyl ethyl ketone peroxide | Thermally unstable, burns rapidly, sensitive to impact |
| 6.1 | Poisonous Material | Pesticides | Toxic to humans |
| 6.2 | Infectious | Virus culture | |
| 7 | Radioactive | Cobalt-60 | |
| 8 | Corrosive | Caustic soda | Damages skin on contact or corrodes metal |
| 9 | Miscellaneous | Heated liquid asphalt | |

shipments and 2 billion tons of hazardous cargo per year (Table 2-2). On a tonnage basis, this was equivalent to about 18 percent of total freight shipped at that time. Since then, the amount of freight shipped in the United States has increased by roughly 5 percent, which suggests that annual hazardous materials shipments today are on the order of 2.1 billion tons.[2]

[2] According to the Census Bureau's 2002 Commodity Flow Survey preliminary report, 11.6 billion tons of freight was shipped in 2002, an increase of 4.4 percent from 1997 estimates (Census Bureau 2003, 14, 15; Census Bureau 1999). Although figures for 2003 and 2004 are not available, the committee conservatively assumes a total of 5 percent growth since 1998.

**TABLE 2-2 Hazardous Materials Shipped in the United States by Mode, 1997–1998**

| Mode | Daily Shipments | Tons Shipped Daily | Ton-Miles Shipped Daily (millions) | Average Shipment Size (tons) | Percentage of Total Daily Shipments | Percentage of Tons Shipped Daily | Percentage of Ton-Miles Shipped |
|---|---|---|---|---|---|---|---|
| Truck | 768,907 | 3,709,180 | 205 | 4.82 | 94 | 69 | 34 |
| Rail | 4,315 | 378,916 | 205 | 87.81 | 1 | 7 | 34 |
| Water | 335 | 1,272,925 | 187 | 3,799 | 0 | 24 | 31 |
| Air | 43,750 | 4,049 | 0.26 | 0.09 | 5 | 0 | <0.01 |
| Total | 817,307 | 5,365,070 | 597 | 6.56 | 100 | 100 | 100 |

NOTE: The most recent years available for estimates are 1997 and 1998. Pipelines are excluded from calculations. The types of commodities shipped differ by mode. About 41 percent of truck shipments of hazardous materials are petroleum products, and most of the remaining 59 percent are chemical and allied products. Only about 10 percent of rail shipments are petroleum products, while 90 percent are chemical and allied products. Petroleum products account for more than 75 percent of waterborne shipments.
SOURCES: RSPA 1998; Census Bureau 1999, Table 1.

Hazardous materials make up such a large percentage of the nation's freight because they include many widely used commodities and products. Gasoline and other petroleum products are estimated to account for about 40 percent of all hazardous materials shipments and about three-quarters of the tonnage shipped (RSPA 1998, 1). Excluding pipeline and tanker traffic, more than two-thirds of petroleum tonnage is shipped by truck, mostly over short distances on distribution routes.

Other hazardous cargoes include basic industrial and agricultural chemicals such as pesticides, fertilizers, compressed gases, and acids. Many common household and consumer products are regulated as hazardous in transportation, such as paints, adhesives, batteries, cleaning solutions, and swimming pool chemicals. Shipments of hazardous wastes and radioactive materials used by the nuclear energy and medical industries are likewise subject to regulation. In short, hazardous materials are ubiquitous in the national economy. They are used not only by industry but also by consumers and businesses on a daily basis.

## Carriers

Hazardous materials are transported by nearly all kinds of carriers and in many shipment sizes and forms of packaging. While some carriers

specialize in the movement of hazardous materials shipments, many others that carry them do not.

The movement of hazardous cargoes is a normal part of the business of large railroads, barge operators, and shipping lines. The same is true of specialized carriers such as tank truck operators and other trucking companies that regularly move products such as paints, batteries, and cleaning chemicals. DOT estimates that about 45,000 carriers in all modes have equipment and operations dedicated to the transportation of hazardous materials (RSPA 2003). About 400,000 large trucks are dedicated to hazardous materials service, including most tank trucks (RSPA 2003). About 115,000 railroad tank cars and more than 3,000 tank barges operating on the inland and coastal waterways are in hazardous materials service (TRB 1994, 47; RSPA 2003, 1; USACE 2002).

DOT further estimates that at least 500,000 carriers transport hazardous materials on an occasional or periodic basis (RSPA 2003). As a practical matter, most carriers move hazardous materials to one degree or another. Even trucking companies that specialize in small-package and less-than-truckload shipments regularly move hazardous cargoes. DOT estimates that while only 43 percent of hazardous materials tonnage is transported by truck, about 94 percent of individual shipments are transported by this mode because of the many small shipments (RSPA 1998, 1).

Table 2-2 shows a breakdown of hazardous materials tonnage moved by mode of transportation, excluding pipeline. Because shipments by rail and water tend to be heavier than shipments by truck, they account for major shares of hazardous materials traffic measured in this way. They also account for a much larger share of ton-miles of hazardous materials shipped, since water and rail shipments average much longer distances than shipments by truck. On average, the highways have the largest number of shipments, the waterways have the heaviest shipments, and the railroads move shipments over the longest distances. As a result of these modal differences, these three major modes of hazardous materials transportation each account for about one-third of ton-miles shipped, while the share by air transport (as would be expected) is negligible by this measure (Table 2-2).

## Shipment Types and Sizes

Carriers specializing in the transportation of hazardous materials often move what are defined by DOT as "bulk packaged" shipments, which are single packagings exceeding 119 gallons for liquids, 882 pounds for solids, and 1,000 pounds for gases. Tank trucks, railroad tank cars, barge tankers, and intermodal tanks are forms of bulk packaging. Tank trucks typically hold between 2,000 and 10,000 gallons, railroad tank cars typically hold between 10,000 and 34,500 gallons, and barge tankers can hold several hundred thousand gallons. Intermodal tank containers, which are transported on flatbed trucks and flat rail cars, can hold as much as 6,500 gallons. Bulk packaged shipments may also be shipped by truck in van-type trailers, on railroad flatcars, on flat barges, and in other nontank vehicles and containers. Many portable tanks, bins, and drums for transporting hazardous liquids and solids exceed 119 gallons or 1,000 pounds and are thus defined in the regulations as bulk shipments. Multiple bulk shipments are often transported in the same truck, rail car, or vessel.

A fairly small number of commodities constitute the vast majority of hazardous materials moved in bulk in terms of weight. Gasoline, diesel, and home heating fuel are the most common hazardous cargoes moved in tank trucks. About 125 commodities account for 90 percent of shipments moved by railroad tank car, but 6 of these—liquefied petroleum gas, caustic soda, sulfuric acid, anhydrous ammonia, chlorine, and fuel oil—account for more than half of tank car shipments (AAR 2002). Tank and dry barges are mainly used to carry many of these commodities.

"Nonbulk" shipments are packaged in boxes, drums, cylinders, and other smaller containers. They may range in weight from a few ounces to hundreds of pounds. Indeed, most products that are regulated as hazardous are shipped in nonbulk packagings. Compared with bulk shipments, nonbulk cargoes include a much wider range of materials. As noted earlier, trucks are the main means of transporting nonbulk shipments. Nearly all shipments moved by air are in nonbulk packaging. The fact that a vehicle contains nonbulk shipments does not mean that the total amount of material is small or insignificant. A single truck, for example, may carry several dozen shipments in nonbulk packages that together weigh tens of thousands of pounds.

The largest carriers of hazardous materials are oceangoing tanker vessels, which carry crude oil, petroleum products, chemicals, and liquefied petroleum and natural gas. The vast quantities of materials carried at one time in these vessels are of an entirely different scale than the amounts carried in a single rail car, truck, or barge. Oceangoing tankers vary widely in size and capacity. Even smaller vessels are capable of holding several million gallons, while the world's supertankers can carry tens of millions of gallons. These shipments and the vessels that carry them are regulated by the U.S. Coast Guard (USCG) and are subject to statutory requirements different from those applying to shipments in bulk and nonbulk packagings discussed above. Containerships are also regulated by USCG; however, the intermodal containers that they carry—which can number in the thousands—are subject to DOT regulation since they are also carried by rail, barge, and truck.

## Origins and Destinations

According to the U.S. Department of Commerce's Commodity Flow Survey, more than 14,000 establishments in the country are engaged in the manufacture of hazardous materials (Census Bureau 2003; RSPA 2003). DOT estimates that about 45,000 firms regularly ship significant quantities of hazardous materials and that another 30,000 are occasional shippers (RSPA 2003). These estimates do not take into account the multiple business locations of many shippers, which can result in many more shipping points.

Shippers of large quantities of hazardous materials include oil refiners, chemical manufacturers, and gasoline distributors. Among gasoline suppliers alone there are about 2,000 large bulk distributors, which ship to large manufacturers and utilities, and more than 10,000 local distributors, which supply individual gasoline retailers, farms, and filling stations. Shippers of smaller quantities of hazardous materials include hospitals, small manufacturers, and residential suppliers of home heating fuel.

Between the time a hazardous materials shipment leaves its place of origin and arrives at its final destination, it may pass through several modes of transportation and transfer points. The nation's ports serve as hubs for traffic moving by vessel, truck, and rail and are major transfer points for hazardous materials of all kinds. Rail yards and truck termi-

nals are also major transfer points. Typically, tank cars pass through numerous yards and are switched among trains several times during their trips, which may take 1 to 2 weeks. The terminals of carriers that specialize in small-package and less-than-truckload shipments (including UPS and FedEx) are also major transfer points for nonbulk shipments. Bulk shipments by truck, especially in tank trucks, are less likely to involve a transfer, because they are used to deliver partial loads to receivers and because trip distances tend to be shorter.

Receivers of hazardous materials shipments are even more dispersed and diverse than originators. Some are located where large quantities of hazardous materials are used in production, such as refineries, utilities, chemical plants, and factories. Hazardous materials shipments may be sent directly to their site of final use (e.g., blasting agents to a construction site) or to retail outlets (e.g., paint stores), hospitals, gasoline stations, and waste disposal sites. In the United States, more than 150,000 service stations and convenience stores receive regular shipments of motor fuel by tank truck (RSPA 1998).

## ENSURING SAFETY AND SECURITY

### Safety Challenge

Hazardous materials have been transported in large quantities since the rapid industrialization of the late 1800s. Ships, barges, and rail cars had long been used by the military to transport explosives, armaments, and other hazardous cargoes. However, the transportation of hazardous materials for commercial purposes did not grow markedly until after the Civil War. Demand for oil following its discovery in western Pennsylvania in the late 1860s led to increasing quantities of crude being transported long distances, first by horse and river barge and soon after by pipeline, tank car, and tanker ship (TRB 1993; Heller 1970; Newton 2002). By the start of World War I, significant amounts of hazardous materials were being transported on the nation's highways, waterways, and railroads. Tank trucks delivered gasoline and home heating fuel, steel tank cars were outfitted to carry dozens of petroleum products and chemicals, and steam-powered tankers and barges were carrying such cargoes on the inland and coastal waterways.

Concern over the safety of these shipments soon followed. Several spectacular railroad accidents prompted the railroads to create the Bureau of Explosives (BOE) in 1907 to serve as a "self-policing," standard-setting body for the shipment of hazardous materials by rail. Railroads began demanding that shippers label hazardous shipments. A year later, Congress authorized the Interstate Commerce Commission (ICC) to regulate the transport of explosives and other hazardous cargoes. As one of its first actions in this area, ICC began formally approving design safety standards for railroad tank cars and other containers used for hazardous commodities. By the 1930s, Congress had extended ICC's authority to cover interstate motor carriers, and USCG and the Civil Aeronautics Board were given similar authority over the maritime and air transportation sectors, respectively.

The hazardous materials authority of ICC was transferred to DOT when it was created as a cabinet-level agency in 1966. DOT inherited a body of policies and regulations rooted in a number of statutes and implemented by a number of agencies. The regulations consisted of a piecemeal mix of voluntary and mandatory safety measures developed through decades of expert judgments and consensus building among shippers, carriers, and container makers (NTSB 1971). There was little consistency among modes in the rationale for the standards, most of which were adopted on a mode-by-mode and commodity-by-commodity basis over the course of many decades. Before 1968, no research funds were budgeted to support regulatory development. Data on the safety performance of hazardous materials transportation were seldom collected to assess risks and develop countermeasures. Instead, regulatory changes were often made in response to individual high-profile accidents.

A series of fatal tank car accidents beginning in the late 1960s was one factor prompting Congress to reform the federal hazardous materials safety program. The accidents generated public attention and calls for more concerted federal involvement in the safety process. In 1970, Congress passed the Hazardous Materials Transportation Control Act, which required DOT to collect information about hazardous materials incidents across all of the modes and to report annually on the activities and accomplishments of the various regulatory agencies responsible for safety in each mode. The act also withdrew or curtailed many of the reg-

ulatory functions delegated to the railroad industry's BOE and other industry groups. Initiatives for regulatory changes began shifting from the shippers and carriers to the regulators themselves. These developments culminated in the passage of landmark legislation, the HMTA, which for the first time offered a consistent and coherent rationale for the federal regulatory program—"to protect the Nation adequately against risks to life and property which are inherent in the transportation of hazardous materials in commerce." In passing HMTA, Congress made it clear that the transportation of hazardous materials was to be regulated in a more consistent and systematic manner that conceptualized risks across modes and commodity types and with respect to hazards before, during, and after an incident. DOT placed this responsibility within the Office of Hazardous Materials Safety of the Research and Special Programs Administration (RSPA).

As discussed in more detail below, the federal hazardous materials safety program continues to emphasize reducing risks to public safety. Judged in this way, the industry's performance is viewed as good by RSPA, which has observed that 99.995 percent of hazardous materials shipments are transported without incident (RSPA 2003). To be sure, the occurrence of fatalities and other significant consequences from hazardous materials incidents has fallen off markedly since the statutory changes and institutional reforms of the 1970s. In recent years, however, the elevation of other risk concerns, such as security and environmental harm, has expanded and complicated the role of the federal government in controlling the risks associated with hazardous materials transportation.

## Safety Performance

Since passage of HMTA in 1974, federal law has defined a hazardous materials transportation incident as an unintentional release of a hazardous material from its package during transportation, which includes periods of loading and unloading and storage incidental to transportation. RSPA's Hazardous Materials Information System (HMIS) is DOT's main source of safety data related to hazardous materials transportation. The agency requires the reporting of an incident within 30 days, although the incident must be reported immediately if it involves a

death, evacuation lasting 1 hour or more, or the need to alter the flight of an aircraft. Other federal agencies collect data pertinent to hazardous materials safety. The Federal Railroad Administration (FRA) maintains the Railroad Accident/Incident Reporting System, the Federal Motor Carrier Safety Administration (FMCSA) maintains the Motor Carrier Management Information System, and USCG maintains the Marine Casualty and Pollution Database. However, RSPA's HMIS is the most widely used source of data on hazardous materials incidents.

In 2003, RSPA received 14,660 reports of incidents from carriers and shippers (Table 2-3). During the past decade, the number of incidents reported each year has fluctuated, with no discernible trend, between about 14,000 and 18,000. About 87 percent of the incidents reported during this period involved trucks, 7 percent air, 6 percent rail, and less than 0.1 percent water (Table 2-3). The vast majority (about 97 percent) of reported incidents can be characterized as having minor consequences—that is, they did not have any of the serious outcomes that require immediate reporting (Table 2-4). Incidents involving bulk shipments, which account for about one-fifth of reports, had nearly twice as many injuries and four times as much property damage as did reported incidents involving nonbulk shipments (Table 2-4). Gasoline was by far the most common material involved, as might be expected given the prevalence

**TABLE 2-3 Hazardous Materials Incidents Reported to DOT, 1994–2003**

| | Mode | | | | |
|---|---|---|---|---|---|
| **Year** | **Air** | **Truck** | **Rail** | **Water** | **Total** |
| 1994 | 931 | 14,011 | 1,157 | 6 | 16,105 |
| 1995 | 817 | 12,869 | 1,155 | 12 | 14,853 |
| 1996 | 925 | 12,034 | 1,112 | 6 | 14,077 |
| 1997 | 1,031 | 11,932 | 1,102 | 5 | 14,070 |
| 1998 | 1,386 | 13,111 | 989 | 11 | 15,497 |
| 1999 | 1,582 | 14,953 | 1,073 | 8 | 17,616 |
| 2000 | 1,420 | 15,131 | 1,059 | 17 | 17,627 |
| 2001 | 1,081 | 15,909 | 899 | 5 | 17,894 |
| 2002 | 734 | 13,818 | 872 | 9 | 15,433 |
| 2003 | 748 | 13,154 | 751 | 7 | 14,660 |
| Total | 10,655 | 136,922 | 10,169 | 86 | 157,832 |
| Percentage | 6.8 | 86.8 | 6.4 | <0.05 | 100.0 |

SOURCE: See hazmat.dot.gov/ for latest hazardous materials incident data from HMIS.

**TABLE 2-4 Hazardous Materials Incidents and Consequences by Mode, Bulk and Nonbulk, 1994–2003**

| Mode | No. of Incidents | No. of Fatalities | No. of Injuries | Damages ($) |
|---|---|---|---|---|
| Air, total | 10,655 | 110 | 202 | 2,042,118 |
| Bulk | 1 | 0 | 0 | 0 |
| Nonbulk | 10,654 | 110 | 202 | 2,042,118 |
| Truck, total | 136,951 | 97 | 1,941 | 338,136,186 |
| Bulk | 21,632 | 94 | 907 | 258,255,178 |
| Nonbulk | 115,319 | 3 | 1,034 | 79,881,008 |
| Rail, total | 10,169 | 3 | 1,332 | 166,791,761 |
| Bulk | 9,142 | 3 | 1,307 | 157,739,539 |
| Nonbulk | 1,027 | 0 | 25 | 9,052,222 |
| Water, total | 86 | 0 | 2 | 2,211,559 |
| Bulk | 45 | 0 | 1 | 576,378 |
| Nonbulk | 41 | 0 | 1 | 1,635,181 |
| Total | 157,861 | 210 | 3,477 | 509,181,624 |
| Bulk | 30,820 | 97 | 2,215 | 416,571,095 |
| Nonbulk | 127,041 | 113 | 1,262 | 92,610,529 |

SOURCE: See hazmat.dot.gov/ for latest hazardous materials incident data from HMIS.

of tank trucks on the highways. Together, gasoline, other flammable liquids, and corrosives accounted for 57 percent of serious incidents (RSPA 2003).

Ever since DOT has required the reporting of hazardous materials incidents, questions have arisen concerning the accuracy, completeness, and relevance of the data. The large number of reported incidents involving trucks stems in part from the many small, nonbulk shipments moved by this mode. Most of the reported incidents involve small leaks from drums and other nonbulk containers discovered during loading and unloading, with few, if any, consequences except for cleanup expenses at the site. Even though most reported incidents do not involve serious consequences, the annual statistics reveal some highly costly and consequential ones. For instance, the 1996 figures include 110 airline passenger and crew fatalities from the crash of ValuJet Flight 592, which was caused by oxygen generators that caught fire. During the same year, chlorine gas escaping from a tank car damaged in a train derailment in Alberton, Montana, resulted in the evacuation of more than 1,000 people, more than 700 injuries, and 1 fatality. The 1998 statistics include the deaths of five people from gasoline that spilled and ignited during the

unloading of a tank truck in Biloxi, Mississippi. The incident also resulted in the evacuation of 80 people and the closing of an Interstate highway. Because such major incidents are rare, they stand out and tend to dominate the safety data when they do occur.

Major hazardous materials incidents are usually investigated by the National Transportation Safety Board (NTSB). NTSB reports typically detail the circumstances of the incident and its aftermath, including the performance of emergency response. The reports attempt to identify factors causing and contributing to the severity of the incident. These investigations are helpful to DOT as it seeks remedies to problems and weighs needed changes in regulations and safety programs. NTSB, however, does not have the resources to investigate more than a handful of hazardous materials incidents each year.

## Other Risks and the New Security Imperative

Hazardous materials regulation has long been focused on acute hazards, such as flammability, which pose a risk to the public when hazardous materials are accidentally released. This focus, however, has diminished over time as concern over other nonacute risks to human health and the environment has grown. During the 1970s, Congress called on the U.S. Environmental Protection Agency (EPA) to require the reporting of releases of certain environmental contaminants in specific quantities. DOT was subsequently required to regulate the transportation of these hazardous substances when they are shipped in quantities equal to or exceeding their reportable quantities.

More recently, concern over the risk of accidental releases has been joined by concern over intentional releases, especially the use of hazardous materials shipments by terrorists to injure people or disrupt the economy. A particular concern is that shipments of certain hazardous materials—such as poison gases, flammables, and explosives—will be targeted or seized. Railroad tank cars passing through populated areas, tank trucks delivering gasoline to service stations, chemical and gas tankers at ports, and trucks carrying radioactive wastes are now viewed as candidates for terrorist activity. Whereas procedures to prevent the accidental release of hazardous materials may be beneficial in protecting against intentional releases, they may not be sufficient. It has become clear that

security concerns will require new risk calculations and possibly changes in how risks are managed.

Already, concerns about security have led to questions about the adequacy of packaging to withstand terrorist attacks and the advisability of allowing tank cars carrying toxic gases to be routed through urban areas. Some long-standing measures to communicate hazard information to emergency responders, such as the labeling of containers and the placarding of vehicles, have come under scrutiny as possibly aiding terrorists in identifying hazardous materials shipments (RSPA 2003).

Understanding and managing the full array of public safety, environmental, and security risks associated with the transportation of hazardous materials have become more explicit goals of both government and industry. During the past 3 years, DOT and industry have taken a number of steps to enhance the security of hazardous materials transportation. These steps include the development of guidelines to improve security awareness in the hiring of personnel, the conduct of on-site security reviews targeting shippers and carriers of very hazardous materials, and the evaluation of common hazardous materials routes from a security perspective. In passing the Marine Transportation Security Act of 2002, Congress required all ports and their users to develop comprehensive security plans and incident response capabilities.

Risk management involves not only preventing accidental and intentional releases of hazardous materials but also being ready to contain and mitigate the effects of incidents when they occur. The first responders to hazardous materials incidents are often local (county and municipal) law enforcement and emergency personnel. Consequently, the role of firefighters, police, and other emergency personnel in responding to hazardous materials incidents is especially important. Much of the DOT regulatory and safety program is geared toward providing needed emergency response information—from requirements for placarding to the development and distribution of the *Emergency Response Guidebook.*

Emergency response is one example of how the private and public sectors at all jurisdictional levels must cooperate to ensure the safe and secure transportation of hazardous materials. In the following section, the roles and responsibilities of the sectors are described in more detail.

## ROLES OF GOVERNMENT AND INDUSTRY

Because hazardous materials are so pervasive in commerce, it is not practical to describe all the roles of public and private entities in their efficient, safe, and secure movement. The focus here is on those roles pertaining directly to safety and security. Some vitally important roles, such as the provision of an integrated network of waterways by the U.S. Army Corps of Engineers and the building and operation of the nation's highway system by state departments of transportation, are not reviewed, although they are essential to the efficient movement of hazardous cargoes in commerce. The goal of the discussion that follows is not to provide a comprehensive review of government and industry roles in safety and security but to provide a general sense of how dispersed and interdependent these roles are.

### Federal Agency Roles

#### *Transportation Agencies*

As described above, laws passed by Congress give the Secretary of Transportation primary responsibility for regulating the safe and secure transportation of hazardous materials affecting interstate commerce. This regulatory authority not only covers transportation activity directly but also extends to the handling, labeling, and packaging of hazardous materials by shippers and to the fabrication, reconditioning, repair, and testing of shipping containers. The secretary has delegated the lead responsibility for developing the regulations to RSPA and its Office of Hazardous Materials Safety.

RSPA rulemaking covers two broad requirement areas: hazard containment and hazard communication. The first set of rules classifies materials according to their hazard characteristics and establishes material packaging and handling requirements. The second spells out how shippers and carriers must communicate these hazards through the use of placards, shipping papers, and package markings and labels. These communication requirements are intended to provide essential information about hazardous cargo to the public and emergency response personnel when incidents occur.

In developing these rules, RSPA consults with the modal agencies within DOT, which are most familiar with the operations and environ-

ments of their respective modes. These agencies—most notably, the Federal Aviation Administration (FAA), FRA, and FMCSA—have primary responsibility for enforcing carrier compliance with the regulations through inspections and penalties. Each modal agency has inspectors versed in hazardous materials regulation. FRA's Office of Safety Enforcement employs several hundred inspectors, about 20 percent of whom are trained hazardous materials specialists. FRA inspectors cover shipper and receiver facilities, rail yards and lines, and tank car manufacturing and repair facilities. In contrast, FMCSA has only a handful of inspectors, because it has arranged for states to assist with motor carrier inspection and enforcement activities. The agency has helped in the training of state inspectors to familiarize them with federal hazardous materials regulation. In the case of marine transportation, the March 2003 transfer of USCG from DOT to the newly created Department of Homeland Security (DHS) complicated the delegation of enforcement authorities for hazardous materials shipments. Nevertheless, USCG has retained responsibility for enforcing DOT hazardous materials regulations in the maritime sector.

Many shippers use more than one mode of transportation to move their hazardous cargoes. Hence, RSPA is responsible for enforcing compliance by shippers. It also has primary responsibility for enforcing compliance by manufacturers, repairers, and reconditioners of most kinds of containers, including intermodal containers. The agency is responsible for working with international standard-setting bodies to ensure that federal rules are compatible and consistent with international standards. RSPA usually carries out this responsibility with assistance from the relevant modal entities. For example, it works with USCG and the International Maritime Organization on marine transportation and with FAA and the International Civil Aviation Organization on air transportation.

Both RSPA and the individual modal agencies have various outreach programs to inform the regulated industries and state and local authorities about the federal requirements and what to do in the event of a hazardous materials incident. RSPA develops and publishes the *Emergency Response Guidebook,* which is provided to state emergency management agencies for distribution to local responders. It contains basic hazard identification and response information for those who are first to arrive

at the scene of a hazardous materials incident. RSPA also assists state and local authorities with enforcement and compliance training through the Transportation Safety Institute. DOT's modal agencies have similar outreach programs to the public and private sectors. As an example of the latter, FRA works with railroads, as part of its Safety Assurance and Compliance Program, to identify systemic safety issues, including issues pertaining to hazardous materials transportation, and to develop and implement plans to address them.

As noted earlier, NTSB conducts independent investigations of hazardous materials transportation accidents to determine probable causes and recommends corrective measures to DOT, other government agencies, and industry. Although NTSB does not have enforcement or regulatory authority, it monitors the actions taken in response to its recommendations, submits comments to DOT and other federal agencies on rulemakings, and testifies before Congress on matters related to hazardous materials transportation safety. It also conducts periodic special studies of multiple accidents to determine recurring safety problems.

***Other Federal Agencies***

Besides USCG, other federal agencies outside DOT have regulatory, enforcement, and related responsibilities pertaining to the transportation of hazardous materials. EPA designates certain materials as hazardous substances that are potentially harmful to human health and the environment if they are released in specific quantities. These designated substances are regulated by DOT in transportation. EPA also requires generators of hazardous wastes to keep track of shipments of these wastes by maintaining detailed manifests of their movements from origin to disposal.

The U.S. Department of Energy is responsible for carrying out the federal government's spent nuclear fuel and high-level radioactive waste disposal program. It has been transporting spent nuclear fuel for several decades as part of its research, defense, and cleanup missions. Most notably, its Office of National Transportation is responsible for planning and carrying out the multidecade program to transport spent fuel and high-level radioactive waste to a geologic repository. Federal standards for the design and performance of packages used for certain shipments

of radioactive materials, including spent nuclear fuel, are set by the independent Nuclear Regulatory Commission.

Several other cabinet-level departments have notable responsibilities. The Department of Defense is responsible for establishing requirements governing the movement of most hazardous cargoes for military purposes. Within the Department of Labor, the Occupational Safety and Health Administration (OSHA) is responsible for regulating hazardous materials used and stored in the workplace, which has implications for transportation. The safety of transportation workers handling hazardous materials is within OSHA's purview, although some of these responsibilities are handled by DOT through memoranda of understanding between the two departments. OSHA has set package marking and labeling requirements for materials it has designated as hazardous in the workplace. It requires employers who use or store these materials in the workplace to maintain Materials Safety Data Sheets (MSDS), which contain emergency response information. MSDS are familiar to many emergency responders, who use them at both fixed-site and transportation incidents.

One way in which these varied roles and functions of the federal agencies are coordinated is through the National Response Team (NRT). NRT consists of 16 federal agencies with interests and expertise in various aspects of emergency response to hazardous materials incidents. EPA and USCG lead NRT, which acts as a national planning, policy, and coordinating body. In that capacity, NRT coordinates federal emergency response capabilities. Among other NRT member agencies are the Federal Emergency Management Agency, the Department of Agriculture, the Department of Health and Human Services, and the National Oceanic and Atmospheric Administration.

Finally, the security of the nation's hazardous materials freight has become a major concern since the terrorist attacks of September 11, 2001. DHS, along with its Transportation Security Administration (TSA) and Bureau of Customs and Border Protection, is taking a more prominent role in ensuring hazardous materials security. TSA was created by the Aviation and Transportation Security Act of 2001, which gave the agency comprehensive powers to identify security threats in all modes of transportation and to take actions to address them. The Homeland Security Act of 2002 gave DOT authority to prescribe regulations for "the safe

transportation, including security of hazardous materials in intrastate, interstate, and foreign commerce."[3] DHS and DOT therefore work together on many security issues pertaining to hazardous materials transportation. In particular, the two departments are examining enhanced security requirements for the rail transportation of hazardous materials that pose a toxic inhalation hazard.[4]

## Roles of State and Local Governments

In the regulation of hazardous materials in transportation, federal rules preempt most state and local requirements. State and local governments cannot make requirements that unreasonably burden interstate commerce, reduce the overall safety of the transportation system, or interfere with the uniformity of federal regulatory standards (for instance, by developing different placard symbols). States and localities can limit movements of hazardous materials on public highways for clear safety reasons (e.g., to restrict movements on certain bridges or in tunnels). However, they have limited authority to impose permits and fees for hazardous materials transportation or to adopt hazardous materials regulations that differ from those of the federal government.

Traditionally, states had more freedom to regulate the intrastate transportation of hazardous materials. However, DOT has long encouraged states to adopt regulations compatible with federal regulation, first under the State Hazardous Materials Enforcement Development Program and later under the Motor Carrier Safety Assistance Program (MCSAP) and the Cooperative Hazardous Materials Development Program. In 1997, Congress made the federal hazardous materials regulations fully applicable to intrastate transportation, and conflicting state rules were thus preempted.

State and local governments are responsible for enforcing federal hazardous materials regulations, especially those pertaining to truck transport. The federally funded MCSAP, which is administered by FMCSA, has strengthened state enforcement efforts by providing funding for

[3] See discussion of agency roles in the *Federal Register,* Volume 60, No. 157, Aug. 16, 2004, pp. 50988–50994.

[4] *Federal Register,* Volume 60, No. 157, Aug. 16, 2004, pp. 50988–50994.

this activity. MCSAP encourages states to conduct more frequent roadside and terminal safety inspections to ensure that federal (and state) requirements, including federal hazardous materials regulations, are being complied with. Historically, states have had less authority to enforce hazardous materials regulation pertaining to railroads, but changes in FRA provisions have given states more latitude to enforce the federal regulations. FRA has agreements with a number of states to conduct railroad inspections under federal authority.

State and local governments respond to hazardous materials incidents. The first responders are often local police and fire units, who may be warned of a hazardous material only by the presence of placards. Most local emergency responders are trained to recognize placards and take initial protective measures, but only a fraction are trained at the highest level of competence for dealing with threatened or actual hazardous materials releases. Metropolitan communities are more likely to have specialized teams trained and equipped to handle hazardous materials accidents than are rural areas. Some states have therefore established hazardous materials response teams to assist in major emergencies, with planning and coordination handled through state emergency management agencies.

To aid state and local governments in preparing for hazardous materials emergencies, Congress established the Hazardous Materials Emergency Preparedness (HMEP) grant program in 1990. The grants are used by state and local authorities to develop and implement emergency plans, train public employees to respond to incidents involving hazardous materials, and determine flows and patterns of hazardous materials transported in their jurisdictions. Since 1993, state and local governments, as well as territories and Native American tribes, have been awarded about $100 million in grants. The grants are funded through registration fees collected from carriers and shippers of hazardous materials. The HMEP grant program and registration fee are discussed in more detail later in this report.

## Industry Roles

The safety of hazardous materials transportation hinges on shippers and carriers fulfilling their respective roles. The role of shippers is especially important. Most shippers have compelling economic reasons to ensure

the safe movement of their cargoes. Large shippers may tender and receive hundreds of bulk shipments and thousands of nonbulk shipments each day in their plants and distribution facilities. A single chemical plant, for instance, may have multiple loading and unloading areas for trucks and rail cars; these vehicles must be efficiently and safely loaded and unloaded to keep the plant in operation. Even minor incidents can be disruptive and costly. Consequently, most shippers of large quantities of hazardous materials have active safety programs to monitor the condition of the vehicles and containers that carry their products and to ensure that they are securely loaded and readied for transport.

Most DOT rules pertaining to hazardous materials transportation are directed toward shippers, which are responsible for ensuring that shipments are properly classified, named, packaged, marked, and labeled. In addition, shippers must ensure that their shipments are accompanied by shipping papers with instructions on emergency response. With few exceptions, shippers are required to provide a 24-hour telephone number that can be used by emergency responders to obtain information about the hazardous shipment.

Trucking companies, railroads, and other carriers must abide by the rules governing the safe handling of hazardous cargoes, the routing of certain shipments, maintenance and inspection of vehicles, and temporary storage of hazardous materials en route. For instance, federal rules govern the positioning in the train of rail cars carrying hazardous materials. As noted earlier, carriers must report incidents and releases involving hazardous materials to DOT.

Many large shippers and carriers have specially trained emergency response teams that can assist in the response to a hazardous materials incident. The chemical industry maintains a mutual-aid network of emergency response teams (known as CHEMNET) that can be deployed in a few hours to assist carriers and local emergency personnel in responding to chemical emergencies around the country. The American Chemistry Council, the trade association for chemical manufacturers, maintains a 24-hour hot line known as CHEMTREC. Emergency responders can obtain hazard information and technical guidance from this hot line by giving the name of the product and nature of the emergency. CHEMTREC can also establish a communications link between the responders on the scene and the shippers, if the shippers are known.

Industry also has a role in promoting hazardous materials transportation safety through research, education, and training. As an example, the Association of American Railroads' (AAR's) BOE monitors and responds to incidents and works with shippers to ensure proper packaging of hazardous materials shipments. AAR oversees the setting of design standards for railroad tank cars. It also operates the Transportation Technology Center, Inc., in Pueblo, Colorado. The center, which receives some of its research funding from FRA and other DOT agencies, can conduct full-scale equipment tests and is often used by industry and government to test tank car designs, components, and construction materials. It also coordinates classroom and field training on hazardous materials emergency response.

Several joint activities merit mention because they illustrate the industry's cooperation in promoting the safe transportation of hazardous materials. Since 1970, AAR and the Railway Supply Institute have cosponsored the Tank Car Safety Research and Test Project to identify and understand accident-caused releases from tank cars. The information derived from this research program has led to a number of changes in tank car design and operations to dramatically improve safety performance. Another example of a cooperative effort is the Transportation Community Awareness Emergency Response (TRANSCAER) program. Supported by shippers, carriers, and their trade associations, TRANSCAER promotes transportation safety by assisting communities in preparing for and responding to hazardous materials transportation incidents.[5] These efforts include assisting local communities with emergency response training and planning, participating in exercises to test the plans, and maintaining a dialogue with state and local authorities to keep emergency contacts and plans current.

Another means by which industry cooperates in the promotion of hazardous materials safety is through the Dangerous Goods Advisory Council (DGAC). DGAC, which has more than 100 shipper and carrier members, provides hazardous materials training and information to facilitate compliance with federal rules and the following of good safety

[5] TRANSCAER sponsors are the American Chemistry Council, the AAR Chemical Educational Foundation, National Tank Truck Carriers, Inc., and the Chlorine Institute.

practices in general. Another example of a public–private cooperative effort is the Commercial Vehicle Safety Alliance (CVSA), which seeks uniformity in commercial vehicle inspections and enforcement activities. CVSA operates several safety-related committees, including a hazardous materials committee comprising state enforcement personnel, motor carriers, and federal officials. The committee provides technical expertise related to hazardous materials transportation in an effort to reduce incidents and encourage uniformity and consistency in the application of the regulations.

Box 2-1 provides a summary listing of many of the entities having important roles in ensuring the safe and secure transportation of hazardous materials.

BOX 2-1

## Entities Involved in Ensuring the Safe and Secure Transportation of Hazardous Materials

### FEDERAL: REGULATION, ENFORCEMENT, AND RESEARCH

**Department of Transportation**
Research and Special Programs Administration[a]
Federal Railroad Administration
Federal Motor Carrier Safety Administration
Federal Aviation Administration
Federal Highway Administration
Bureau of Transportation Statistics
National Highway Traffic Safety Administration

**Department of Homeland Security**
United States Coast Guard
Transportation Security Administration
Bureau of Customs and Border Protection
Federal Emergency Management Agency

**Department of Energy**
National laboratories

**Nuclear Regulatory Commission**

**Department of Defense**
U.S. Army Corps of Engineers

**Occupational Safety and Health Administration**

**Environmental Protection Agency**

**National Transportation Safety Board**

**STATE AND LOCAL: INFRASTRUCTURE, EMERGENCY RESPONSE, AND ENFORCEMENT**
State emergency planning management offices
Local emergency management offices and committees
State and local police
Local firefighters
State, regional, and local hazardous materials response units
State highway, railroad, and transportation agencies
State and regional airport and marine port authorities
State environmental protection agencies

**PRIVATE COMPANIES: OPERATIONS, INFRASTRUCTURE, PRODUCTION, AND USE**
Carriers: truck, railroad, pipeline, barge, maritime (about 45,000 dedicated; about 500,000 occasional)
Shippers (about 45,000 regular; about 30,000 occasional)
Receivers: farms, disposal sites, refineries, factories, retailers, hospitals

**INDUSTRY ASSOCIATIONS: STANDARDS, TRAINING, AND EMERGENCY RESPONSE**

**Dangerous Goods Advisory Council**

*(continued on next page)*

BOX 2-1 (*continued*)
**Entities Involved in Ensuring the Safe and Secure Transportation of Hazardous Materials**

**Commercial Vehicle Safety Alliance**

**Association of American Railroads**
Bureau of Explosives
Tank Car Committee

**Railway Supply Institute**
RSI–AAR Tank Car Safety Research and Test Project

**American Chemistry Council: CHEMTREC, CHEMNET (with shippers)**

**American Trucking Associations**

**National Tank Truck Carriers, Inc.**

NOTE: This list is intended not to be comprehensive but to summarize the organizations and entities identified in Chapters 2 and 3. Several international organizations not listed here, such as the United Nations, also serve in various standard-setting and educational capacities.

[a] As noted in the Preface, Congress has passed legislation dividing RSPA into separate administrations for research activities and hazardous materials and pipeline regulatory functions.

## REFERENCES

***Abbreviations***

| | |
|---|---|
| AAR | Association of American Railroads |
| NTSB | National Transportation Safety Board |
| RSPA | Research and Special Programs Administration |
| TRB | Transportation Research Board |
| USACE | U.S. Army Corps of Engineers |

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# 3

# Federal Research and Hazardous Materials Transportation

Research pertaining to hazardous materials transportation is conducted by industry as well as by government at the federal, state, and local levels. The focus of this chapter is on characterizing the research sponsored and performed by federal agencies. As described in the preceding chapter, responsibility for ensuring the safe, secure, and efficient transportation of hazardous materials resides in a number of federal agencies. While the Research and Special Programs Administration (RSPA) of the U.S. Department of Transportation (DOT) has the chief responsibility for implementing federal laws governing hazardous materials transportation, many other federal agencies have related responsibilities. All perform research, to varying degrees, in support of their responsibilities.

Any research that leads to improvements in the safety, security, and efficiency of the nation's transportation system or in the overall performance of related areas such as emergency response is likely to confer benefits on hazardous materials transportation. Research that leads to highway designs and operations that are more compatible with large trucks, for example, can be expected to reduce the incidence and severity of accidents involving trucks moving hazardous materials. Likewise, research that leads to fewer derailments can be expected to reduce the number of accidents involving tank cars and other rail cars containing hazardous materials. While the focus of this chapter is on describing federal research specific to hazardous materials transportation, research in many areas outside the traditional bounds of hazardous materials can affect hazardous materials safety, security, and efficiency.

The hazardous materials research programs of four federal agencies—RSPA, the Federal Railroad Administration (FRA), the Federal Motor Carrier Safety Administration (FMCSA), and the U.S. Coast Guard

(USCG)—are described in the most detail in this chapter. These four agencies have the most immediate and direct responsibility for federal regulation and oversight of hazardous materials transportation. Research by nearly a dozen other federal agencies is reviewed briefly. Though much of it is peripheral to hazardous materials, some of the research undertaken by these agencies bears on specific kinds of hazardous shipments, such as the Department of Energy's (DOE's) research in support of the safe and secure transportation of high-level radioactive waste and spent nuclear fuel. In some cases, an agency's current R&D on hazardous materials may not be indicative of longer-term activity. For example, the Department of Homeland Security (DHS) may become a major sponsor of research on hazardous materials security.

Much of the information presented in this chapter was gained from budget, program, and project descriptions available on federal agency websites. One particularly important source of information was DOT's most recent *Research, Development, and Technology Plan* (DOT 2004).

The review reveals a modest amount of federal research pertaining to hazardous materials transportation, with no major sponsor. The emphasis of the research is on meeting the regulatory and programmatic needs of individual agencies in performing their respective missions. There is little ongoing research to address problems and needs that cut across agency missions.

## RESEARCH AND SPECIAL PROGRAMS ADMINISTRATION

RSPA is DOT's multimodal research, safety, and transportation systems agency. It addresses intermodal and multimodal issues. Responsibility for regulating the safe transportation of hazardous materials by all modes (Office of Hazardous Materials Safety) and for ensuring the safety of pipelines (Office of Pipeline Safety) is under RSPA's purview. The agency also plans and coordinates federal involvement in the provision of transportation services during emergencies (Office of Emergency Transportation) and oversees the Volpe National Transportation Systems Center.

RSPA's research budget totaled approximately $14 million in FY 2004. The research program supports the agency's core responsibilities in promoting transportation innovation, research, and education; regulating

pipeline safety; coordinating emergency transportation services; and regulating hazardous materials transportation safety. Spending on pipeline safety R&D accounts for about half of this research budget, and about 10 percent of the total goes to hazardous materials research.

## Pipeline Safety

The Office of Pipeline Safety is the lead federal agency responsible for promoting and regulating pipeline safety. It conducts and supports research to further regulatory and enforcement activities and to provide the technical and analytical foundation necessary for planning, evaluating, and implementing the federal pipeline safety program. Ongoing and planned research activities include projects in the following areas:

- Damage prevention and leak detection, to evaluate new technologies and processes aimed at preventing third-party damage to pipelines, detecting pipeline defects and leaks, and controlling loss of product;
- Improved materials and construction processes that better withstand third-party damage, corrosion, and cracking and that facilitate pipeline operations at higher design pressures; and
- Mapping and information systems to track the location of pipelines in relation to human populations, environmentally sensitive areas, water, and other vital resources and to distribute this information to pipeline operators and public officials in a secure manner.

## Emergency Transportation

DOT has delegated to RSPA's Office of Emergency Transportation the responsibility for directing and managing the transportation of federal, state, and local resources to disaster sites in coordination with the Federal Emergency Management Agency. Ongoing and planned projects in support of this mission include research to improve software and hardware devices that can be deployed in an emergency to track and coordinate transportation resources. The Office of Emergency Transportation also works with DOT's Office of Intelligence and Security and the individual modal agencies in identifying threats to the transportation system's physical and information infrastructure and possible countermeasures.

## Hazardous Materials Safety

The Office of Hazardous Materials Safety has two main research-related programs: (*a*) the Research and Analysis Program, which provides data and analytical support for the office's regulatory and enforcement functions, and (*b*) the Research and Development Program, which is intended to build a stronger technical foundation for these functions and to support the development of emergency response guidance. Together, these two programs spend about $1 million per year in the following areas:

- Hazard classification and risk assessment: In support of specific rulemaking initiatives, RSPA typically sponsors research to analyze the risks associated with individual hazardous materials transported in particular types of packaging. These are typically small projects (less than $100,000) with a narrow focus. Occasionally, however, the agency sponsors broader-based research on risk assessment from a multimodal perspective. Recent examples include a national risk assessment of poison gases and the development of a risk management self-evaluation framework that includes safety and security considerations. In addition, each year RSPA contributes about $100,000 to support research by the U.S. Environmental Protection Agency (EPA) to develop acute exposure guidance levels for hazardous substances.
- Incident analyses: RSPA is required by Congress to collect and report information on the safety of hazardous materials in transportation. The safety data are used to assess the need for new and revised federal regulations. RSPA therefore sponsors research to maintain and improve its incident data and analysis capabilities. During the past few years, it has conducted research to improve the layout of the DOT Incident Report Form, determine the accuracy of incident cost estimates in its safety database, and incorporate more information on carrier and shipper characteristics in the database.
- Packaging requirements and exemptions: In support of its role in setting hazardous materials packaging requirements, RSPA conducts research on kinds of packaging and their components, including their design, manufacture, and reconditioning. One example is a project evaluating the use of random frequencies in the vibration test for containers made of composite material. Another is an investigation of the risks and benefits of the use of pressure relief devices on compressed

gas cylinders. RSPA is regularly petitioned by shippers and container manufacturers to exempt packaging from requirements. The agency undertakes technical analyses in support of the exemption decisions.

- Emergency response: In supporting the *Emergency Response Guidebook* and the development of other emergency response guidance, RSPA conducts research and provides funding in support of the work of other organizations. For example, it provided Argonne National Laboratory with $75,000 to update the isolation distances recommended in the *Guidebook.* In 2003, a major part of the agency's research budget was earmarked by Congress to support the work of the Operation Respond Institute, a public–private program aimed at providing software tools and training to the emergency response community for dealing with hazardous materials incidents.

***Security***

RSPA has increased its funding of research to assess the security of hazardous materials transportation. It has funded projects by the Volpe National Transportation Systems Center to assess the vulnerabilities of hazardous materials transportation to terrorist attacks. The agency has participated with other DOT agencies, including FMCSA, the Federal Highway Administration (FHWA), and the Office of the Secretary of Transportation (OST), in overseeing (though not funding) operational tests of various technologies and procedures for protecting hazardous cargoes from terrorism. The tests, which are being conducted in cooperation with industry, involve about 100 trucks equipped with a variety of technologies such as driver verification systems, vehicle tracking, off-route vehicle alerts, cargo tampering alerts and electronic seals, and remote vehicle disabling.

***Special Studies***

In addition to contributing funds to this study of the concept of a hazardous materials transportation cooperative research program, RSPA is sponsoring another National Academies study of issues associated with the transportation of spent nuclear fuel to a national repository. Other examples of special studies by RSPA include the Volpe Center's examination of the safety and security issues associated with the transportation of hydrogen for fuel.

## FEDERAL RAILROAD ADMINISTRATION

FRA promulgates and enforces railroad safety regulations. It also administers financial assistance to railroads, including Amtrak, and promotes certain policy goals such as the advancement of high-speed rail for passenger travel. In support of these responsibilities, FRA conducts R&D aimed at improving the safety and, to some extent, financial performance of the nation's freight, intercity passenger, and commuter railroads.

The safe movement of hazardous cargo by rail is one of the agency's main safety priorities, since railroads are major carriers of this cargo. Of course, most research that leads to improvements in the safety of the railroad environment and operations will make the movement of hazardous materials by rail safer.

In FY 2004, FRA spent about $34 million on R&D in total. The program consists of several elements: human factors, rolling stock and components, track and structures, track–train interaction, train control, highway–railroad grade crossings, hazardous materials transportation, safety of train occupants, and railroad system safety and security. FRA also manages the Next Generation High-Speed Rail and Maglev Programs, which demonstrate technologies aimed at fostering the deployment of high-speed passenger service.

The Transportation Technology Center, located in Pueblo, Colorado, is owned by FRA and operated by the Association of American Railroads. A portion of FRA's R&D program is carried out at the center, including the periodic testing of railroad tank cars. Another significant portion of FRA's research program is carried out by DOT's Volpe National Transportation Systems Center. The remainder is conducted through grants, cooperative agreements, and competitively awarded contracts to universities, railroads, railroad suppliers, and consultants.

The following is a brief synopsis of the kinds of research performed by FRA relating to hazardous materials transportation. Much of the work focuses on railroad tank cars, which account for the largest amount of hazardous materials moved by rail. Other research projects address topics ranging from the railroad routing of spent nuclear fuel to the integrity of intermodal tank containers. Together, this research accounts for 5 to 10 percent of FRA's research budget, or about $2 million to $3 million per year.

## Research on Tank Cars

Major improvements in the safety performance of railroad tank cars have occurred during the past three decades. They have stemmed in part from the understanding gained by research conducted by industry and FRA. Further gains in tank car safety remain a priority for FRA since they represent nearly one-fifth of the rail car freight fleet and account for most of the hazardous materials moved by rail.

FRA's tank car research program focuses on ways to ensure the structural integrity of tank cars during normal service life and under accident scenarios. It also seeks improvements in tank car inspection and testing procedures. Examples of FRA-sponsored research on tank car safety include the following projects:

- Tank car operating environment: An understanding of the tank car operating environment is important in anticipating the in-service loads to which tank cars are subjected. Severe loads can lead to tank car structural failures or to the accumulation of structural damage over time from many smaller cyclic forces. FRA is working on the use of microprocessor and telecommunications technologies as part of an instrumented tank car that can be placed in service to measure and record stresses and load forces. The data from the car will provide a better understanding of the actual load spectrum experienced by tank cars in operation.
- Safety of larger tank cars: Current regulations prohibit the transportation of hazardous materials in tank cars with a gross rail load (GRL) greater than 263,000 pounds. However, the railroad industry is moving rapidly in the construction and operation of other rail cars with a GRL of 286,000 pounds, which may prompt tank car builders and owners to seek similar size allowances. To evaluate the possible effects of such a size change on tank car safety performance, FRA is undertaking research with train operation simulation models. The results will be used in evaluating anticipated requests for tank cars with higher GRLs.
- Tank car engineering reliability and integrity: To assess tank car engineering reliability, various failure modes must be defined and categorized. Although complete and catastrophic failure is easily recognized, tank car integrity can deteriorate gradually. Problems that can con-

tribute to deterioration, such as corrosion, cracks, and pitting, need to be documented. FRA is developing a methodology for defining the boundaries of reliable use for each tank car type. The results of this work are expected to help tank car owners develop and implement guidelines for the maintenance and use of tank cars. Several FRA research projects are also under way or planned to model fatigue damage in tank car structures, determine the effects of welding and stress relief practice on the location and magnitude of stresses in tank car structures, and examine and adapt failure models for steels to gain a better understanding of failure mechanisms that can occur during accidents.

- Tank car safety devices: Significant safety gains have been achieved during the past three decades through improvements in pressure relief valves on tank cars, thermal insulation, and the use of double-shelf couplers. FRA continues to seek improvements in these devices. One FRA study, for instance, is developing rules to apply in the formulation of relief properties for commodities carried in tank cars, including nonpressurized commodities subjected to high temperatures. Another project is examining the load paths through the coupler, which should prove helpful in assessing future design and material changes to double-shelf couplers.
- Condition assessment and inspection capabilities: An accurate assessment of the condition of a tank car is essential to the safe transport of hazardous materials. Several FRA projects are under way or planned to compare alternatives for assessing the condition of tank cars. They include studies of acoustic emission technologies and nondestructive methods to replace hydrostatic testing.

## Other FRA Research on Hazardous Materials Transportation

Railroads transport hazardous materials in flatcars, hopper cars, and intermodal containers and piggyback truck trailers, in addition to tank cars. Ensuring that the railroad physical environment and operations are suitable to moving these shipments safely is a goal of FRA. The agency supports that goal through research covering the following kinds of topics:

- Hazardous materials shipment routing decisions: FRA recognizes that there are risks associated with restricting hazardous materials shipments to certain classes of track, levels of train control, or areas

of low population density. It is studying the implications of such restrictions to better inform government and private decisions about the railroad routing of hazardous materials shipments. This research is intended to gain a better understanding of the trade-offs associated with various operational and technological approaches to reducing risk exposures from commodity movements by rail.

- Railroad transportation of spent nuclear fuel: Efforts to build a repository for long-term storage of radioactive materials and spent nuclear fuel have raised questions about the safety of moving these materials by rail. FRA research is assessing the risk of transporting spent nuclear fuel in regular freight service versus dedicated train service. As part of this effort, accident environment analyses are being used to determine forces that may be encountered by the casks containing the spent fuel.
- Integrity of intermodal tanks: The use of intermodal tanks for hazardous materials shipments is increasing in concert with international trade and an overall increase in the use of intermodal containers for international freight. FRA is undertaking research to assess the containment integrity of such tanks in railroad service.

## FEDERAL MOTOR CARRIER SAFETY ADMINISTRATION

FMCSA is the main federal agency responsible for implementing federal legislation and regulatory programs pertaining to large trucks and motor coaches. Its research and technology activities are intended to support an understanding of motor carrier safety factors and to better target federal safety initiatives, regulations, and technology promotions.

FMCSA's research and technology program focuses on the major safety factors under the agency's purview, including driver and vehicle performance, carrier compliance, and safety systems and technologies. Most of the agency's research projects do not deal directly with hazardous materials transportation. In FY 2004, only 10 to 15 percent of FRA's total research budget of approximately $7 million, or somewhat less than $1 million, was spent on research related directly to this area. Nevertheless, research that leads to improved motor carrier safety generally is likely to have beneficial effects on hazardous materials safety, since hazardous cargoes account for a significant amount of truck traffic.

The following is a synopsis of the kinds of research carried out by FMCSA that have at least some relevance to hazardous materials transportation.

- Incident analysis: FMCSA is sponsoring the Hazardous Materials Serious Crash Analysis Project, which is intended to enhance the methodology for identifying and characterizing serious hazardous materials truck crashes in the United States. The goal is to support the development and implementation of risk reduction strategies for containers, vehicles, and drivers. The project involves a first phase pilot test to evaluate ways to improve the current approach for identification of serious truck crashes on the basis of incident data collected by DOT. A second phase is intended to involve a more comprehensive examination of the data to determine the causes and effects of truck crashes. To understand better the causes of and factors contributing to truck crashes, FMCSA works with the National Highway Traffic Safety Administration (NHTSA) in developing and analyzing safety databases, including the Large Truck Crash Causation Study and the Commercial Vehicle Analysis Reporting System (CVARS).
- Driver safety performance: The Driver Safety Performance Program seeks to improve the performance of drivers of both commercial motor vehicles and other vehicles in the vicinity of large trucks and buses. Researchers are examining the behavior of motorists operating near large trucks and buses, and they are using driving simulators to identify safe driving parameters for commercial drivers. The goal is to gain a better understanding of commercial driving performance and use that understanding to develop education and training programs for drivers of commercial and noncommercial vehicles.
- Vehicle safety performance: The Vehicle Safety Performance Program focuses on improving truck and bus performance through vehicle-based safety technologies. Projects include the development of deployment plans for forward collision avoidance, rollover avoidance, and lane-departure warning systems. Technologies that can further hazardous materials security are also being assessed in collaboration with other DOT agencies.

- Carrier compliance and safety: FMCSA is interested in improving the regulatory compliance of motor carriers, especially high-risk carriers. Agency-sponsored research to address this area of interest includes studies of unsafe conditions and crash precursors to better target preventive and enforcement activities.
- Safety systems and technologies: FMCSA's Safety Systems and Technologies Program seeks to identify and evaluate new technologies and operational concepts that promise to improve commercial motor vehicle safety and help in targeting enforcement to high-risk carriers. The agency has two main projects in this area. The first is accelerated research and testing of new safety technologies and operational concepts. As part of this project, a roadside demonstration site serves as a testing platform for safety technologies and decision-support tools for state agencies. The second project is exploring ways for federal, state, and local agencies to exchange information electronically to improve the targeting of high-risk truck and motor coach operators.

## UNITED STATES COAST GUARD

USCG is the main federal agency responsible for ensuring maritime safety, security, and environmental protection on both inland and ocean waters. The agency also has law enforcement and national defense responsibilities, and its safety functions encompass commercial operations and recreational boating. USCG's research and development program must meet a wide range of needs with an annual budget of slightly more than $20 million.

About 5 percent of USCG's research budget, or about $1 million per year, is focused specifically on hazardous materials transportation. USCG's varied roles make this figure difficult to estimate. It is one of the few federal agencies with both regulatory and operational responsibilities, and therefore its research often serves multiple objectives. The research it conducts in support of marine security and safety bears directly on the transportation of hazardous materials by water. Likewise, USCG research in support of marine environmental protection is relevant to hazardous materials transportation.

Two major USCG research initiatives to strengthen marine safety and security that relate to hazardous materials transportation are the devel-

opment of (*a*) risk management analytical tools for marine inspection and regulatory decision making and (*b*) countermeasures that minimize human error and reduce crew fatigue in the commercial maritime sector. Another relevant area is USCG's support of vessel fire research, which includes studies of improved fire safety measures for tank vessels.

In the area of marine environmental protection, USCG research focuses on pollution prevention and spill response. Research is being conducted to improve the federal government's ability to mobilize resources in response to major spills of oil and other hazardous substances, mitigate the effects of these pollutants on the marine environment, and improve cleanup capabilities. An example of work in this area is the Fast-Water Containment Project, in which researchers are examining methods to contain and remove floating oil from fast-moving rivers and coastal areas. Among other technologies, researchers are investigating air-deployed systems, skimmers, and absorbent materials.

Also related to hazardous materials transportation is USCG's Tanker Damage Assessment and Countermeasures Project. The aim of this research is to develop a suite of integrated technologies to rapidly assess tanker damage, contain the product in the vessel, and transfer the product quickly and safely to lightering ships.

## OTHER FEDERAL AGENCIES

A number of other federal agencies within and outside DOT have responsibilities for implementing and enforcing federal hazardous materials laws and regulations. In addition, some have more general responsibilities for promoting transportation safety and security. All conduct research bearing on the safe, secure, and efficient transportation of hazardous materials.

### Federal Aviation Administration

The Federal Aviation Administration (FAA) is responsible for regulating civil aviation and ensuring the safe and efficient use of the nation's airports and airspace. It is charged with running the nation's air traffic control system as well as developing and enforcing safety rules. In support of this extensive mission, FAA sponsors R&D covering a wide range of

topics, such as developing improved air traffic control technologies and understanding the environmental impacts of airports and aircraft. FAA R&D accounts for nearly one-quarter of DOT's total R&D budget, with annual spending exceeding $200 million.

FAA periodically sponsors research focused on hazardous materials issues. Major aviation accidents have involved hazardous cargoes, including the 1996 crash in Florida of ValuJet Flight 592. Of particular concern to FAA is the potential for prohibited or improperly packaged shipments of hazardous materials to be loaded onto passenger aircraft. The agency is also interested in ensuring that airlines and airports have the trained personnel and equipment needed to respond effectively to hazardous materials incidents.

FAA has therefore sponsored research to develop protocols for assessing the diligence of air carriers, freight forwarders, and shippers in complying with hazardous materials regulations. It has devoted research funds to developing more suitable packaging for hazardous materials transported by air. Another goal is a searchable database that correlates hazardous materials records from various sources (enforcement, incidents, and inspections) to gain a better understanding of vulnerabilities and risk factors. Other relevant research projects are planned or under way, including a study of the mechanisms involved in battery fires, failures of pressure differential packages, and aerosol can explosions.

## Federal Highway Administration

FHWA works in partnership with NHTSA, FMCSA, and states to improve the safety of the nation's highway system. Research is an important part of its mission. Nearly all of the agency's research leading to improvements in highway safety can be viewed as bearing on hazardous materials safety.

FHWA also administers DOT's Joint Program Office for Intelligent Transportation Systems (ITS). Development and deployment of technologies that can be used to track freight flows through the U.S. transportation system are being pursued as part of ITS. Such information systems may be helpful in prioritizing investments to facilitate commerce and improve safety and security in the freight sector, including the hazardous materials component of this sector.

## National Highway Traffic Safety Administration

NHTSA was established in 1970 to improve the safety of motor vehicles through regulation and other means, including promotion of technology. NHTSA conducts research on reducing traffic fatalities and injuries in crashes, preventing crashes, and understanding driver behavior to develop the most efficient means of bringing about these safety improvements.

NHTSA spends about $80 million each year on research and technology development. Much of its research on heavy vehicles is performed in conjunction with FMCSA. Its research and analysis programs address several areas relevant to hazardous materials transportation:

- The development and maintenance of safety databases and data collection systems such as the Fatality Analysis Reporting System, National Automotive Sampling System, Special Crash Investigations, State Data Program, and Data Analysis Program. As mentioned earlier, NHTSA works with FMCSA in undertaking the Large Truck Crash Causation Study and in administering CVARS. In particular, it is working with FMCSA to include more information on crash causation in CVARS.
- Crash avoidance work to help drivers avoid crashes or decrease crash severity through improvements in driver and vehicle performance.
- Heavy vehicle research that aims to eliminate or mitigate the effects of crashes involving large vehicles. For the most part, this research is technology oriented and focused on furthering technologies such as advanced braking and stability enhancement systems.

## Office of the Secretary of Transportation

OST formulates national transportation policy and has a leadership role in national transportation planning, negotiating and implementing international aviation agreements, and coordinating intermodal issues. The Intermodal Hazardous Materials Program Office is housed in OST. It reviews and guides departmental policies and budget resources pertaining to hazardous materials programs and serves as the principal adviser to the Secretary of Transportation on all intermodal and cross-modal hazardous materials matters. OST's activities are usually undertaken in coordination with other agencies. Its research and development budget totals about $10 million per year. Hazardous materials research, therefore,

tends to be a small part of its overall effort, and such research is focused mainly on policy issues.

## Bureau of Transportation Statistics

The Bureau of Transportation Statistics was created in 1992 by Congress for data collection, analysis, and reporting. In this role it coordinates and establishes quality standards for transportation data. Perhaps its most important role in hazardous materials transportation is in working with the U.S. Census Bureau to conduct periodic Commodity Flow Surveys. The hazardous materials segment of the survey is a major source of data on the location and amount of hazardous materials moving through the nation's freight system. It provides information on commodities shipped, their value and weight, mode of transportation, and origin and destination of shipments. The survey data are used by policy analysts and in transportation planning and decision making to assess the demand for transportation facilities and services and to perform safety, security, and environmental risk assessments.

## Transportation Security Administration and DHS

The Transportation Security Administration (TSA), housed in DHS, was established in November 2001. TSA is charged with examining threats across the transportation system and preventing them. As a result of the Aviation and Transportation Security Act of 2001, TSA has the lead responsibility for federal R&D related to civil aviation security. That responsibility had previously been FAA's.

TSA's R&D program investigates technologies and methods for explosives and weapons detection, airport perimeter security, aircraft hardening, and passenger screening. Although TSA's R&D is focused on aviation security, future R&D activities will be expanded to encompass the security needs of all modes of transportation (GAO 2004; TSA 2003, 24–25). The agency is working with the Bureau of Customs and Border Protection, DOT, and other federal agencies in evaluating technologies for container security, including the deployment of "smart" sensors and tagging and tracking systems. TSA's Rail Cargo Security Branch is working with RSPA and the rail and chlorine industries to perform a systemwide review of the shipment of chlorine as part of its "chlorine initiative."

The review will track the transportation of chlorine through the supply chain to identify best security practices and support the development of standards and performance-based regulations (TSA 2003, 27). Concerned about the security risk presented by the identification of hazardous cargoes through the use of placards, TSA is also sponsoring research to examine technologies that may be used as alternatives to placards for some shipments.

## U.S. Environmental Protection Agency

The National Oil and Hazardous Substances Pollution Contingency Plan, the Superfund and Clean Water Acts, and other federal laws give EPA important roles in preventing and responding to releases of oil, hazardous substances, pollutants, and contaminants into the environment. This has resulted in coordination by DOT and EPA in the placarding, manifesting, and reporting of shipments containing EPA-designated hazardous substances in reportable quantities (RQs). EPA researches and evaluates the intrinsic properties of these substances to assess the possibility of harm from their release into the environment and to determine appropriate RQs. RSPA contributes funds to EPA for conducting this research. EPA's research and analysis are main sources of technical support for the federal regulation of hazardous materials with respect to their longer-term environmental and human health effects.

## U.S. Department of Energy and Nuclear Regulatory Commission

DOE and the Nuclear Regulatory Commission (NRC) have significant roles in regulating and ensuring the safety and security of high-level radioactive materials in transportation. These agencies work with the national laboratories in conducting analyses in support of the packaging, routing, and tracking of radioactive materials. With DOE support, for example, Argonne National Laboratory develops risk assessment models for transporting hazardous chemicals and radioactive materials. Oak Ridge National Laboratory, with the support of DOE, NRC, and DOT, operates the National Transportation Research Center. The center's Packaging Research Facility is charged with developing and testing packaging for radioactive and hazardous materials.

### U.S. Army Corps of Engineers

The U.S. Army Corps of Engineers (USACE) is responsible for improving, maintaining, and operating the nation's inland waterways and the channels that support commerce in ports and harbors. Large quantities of hazardous materials are transported through this system, especially on the waterways of the lower Mississippi River and Gulf Coast, where large portions of the nation's petrochemical and fertilizer industries reside. In operating the locks and dams along these waterways, USACE maintains an extensive database on commerce flowing through the marine system, including movements of petroleum and chemicals. USACE waterborne statistics, which are maintained by the Navigation Data Center of the Institute for Water Resources, are an important resource for researchers and analysts assessing hazardous commodity flows. USACE also collects and analyzes data on U.S.-flag vessels, including the number and characteristics of the tanker and tank barge fleets.

## SUMMARY

The federal agencies with the most significant roles in R&D for hazardous materials transportation are RSPA, FRA, and FMCSA, all of which reside in DOT. These agencies have regulatory responsibility for hazardous materials transportation packaging and operations. Much of the hazardous cargo moved within the United States is carried on the modes regulated by FRA and FMCSA (rail and truck, respectively). USCG also has significant roles in hazardous materials regulation and response in the maritime sector, and it conducts research in support of these roles. However, its research budget is small and dedicated to supporting its many other responsibilities. Collectively, these four agencies spend $5 million to $6 million per year on research related directly to hazardous materials transportation.

The R&D conducted by other federal agencies that pertains to hazardous materials transportation tends to be focused on specific topics (for example, research by DOE and NRC focuses on the transportation of nuclear materials) or more general and overarching issues (for example, research by FHWA and NHTSA focuses on improving the highway safety environment). How much is spent by these other federal

agencies on research relevant to hazardous materials transportation is difficult to estimate because the research is rarely budgeted or programmed as "hazardous materials" research. While it may not be possible to offer a meaningful estimate of this spending, an approximation that includes all federal research related to hazardous materials transportation is likely to be several times larger than the $5 million to $6 million programmed directly.

## REFERENCES

***Abbreviations***

| | |
|---|---|
| DOT | U.S. Department of Transportation |
| GAO | General Accounting Office |
| TSA | Transportation Security Administration |

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TSA. 2003. *Report to Congress on Transportation Security.* U.S. Department of Homeland Security, Washington, D.C., March 31.

# 4

# Cooperative Research Needs

As described in the preceding chapter, many federal agencies sponsor research related to the transportation of hazardous materials. Most of this research is focused on meeting the needs of each agency's own regulatory, inspection, and enforcement programs. Inasmuch as most agencies' mandates are limited to specific undertakings, such as promoting safety in a particular transport mode, protecting the environment, or ensuring transport security, their research tends to be programmed accordingly.

The mission-oriented research of federal agencies is essential but may not be sufficient. Gaps can occur where agency responsibilities do not overlap or where problems cut across agency missions. In such instances, no one agency may have the incentive or authority to address the problem. Hazardous materials are moved by multiple modes of transportation and they pose multiple risks. Actions taken to improve the safety of transporting hazardous materials can affect other kinds of risks. For example, traffic may be diverted to routes in environmentally sensitive areas. Thus, problems should be viewed from multiple perspectives and with regard to multiple goals. For example, from the standpoint of emergency personnel responding to a tank car derailment, the placard affixed to the car offers crucial notice of a potential hazard; but to those concerned about homeland security, the placarding system may be viewed as aiding terrorists in identifying hazardous cargo targets. In such instances collaboration is essential in finding and implementing solutions.

In addition to federal agencies, thousands of state and local governments, carriers, shippers, and makers of containers and vehicles conduct research to meet their own particular needs. This research is also essential. Much of it is aimed at providing solutions to the specific needs of those conducting the research. At the same time, many of these entities

may experience similar problems and have many of the same research needs. Some of the research undertaken is likely to be duplicative, and some shared research needs that are obvious when viewed collectively may not be addressed at all because no one entity has the incentive or resources to do so. Research to develop models for estimating hazardous materials traffic types and flows in local areas, for example, is of great interest to most states and localities because it is helpful in emergency response plans and preparations. While development of such means may be impractical for any one state or locality, it may be feasible and cost-effective for many jurisdictions working together.

The preceding examples reveal opportunities for cooperative research, not only among federal agencies with related missions but also among carriers, shippers, packaging suppliers, and state and local agencies that have important roles in the transportation of hazardous materials. The opportunities for cooperation cut across government jurisdictional levels and the public and private sectors.

This does not imply that all, or even most, research needs are best addressed through cooperation. Federal agencies must retain an ability to undertake research that meets their own program and policy needs, and private entities must engage in research and development to further their own proprietary products. The involvement of multiple parties may not be conducive to longer-range research, which is inherently risky. Each party may have a different level of risk acceptance and a different planning horizon. An urgent problem may require an organization to proceed too quickly with research to collaborate with others.

The remainder of this chapter provides examples of the kinds of problems and needs that are well suited to cooperative research. The examples were derived from the stakeholder workshop held in conjunction with this study, a review of previous efforts to examine the concept of a hazardous materials cooperative research program, and the expertise and insights of committee members. The examples concern subject matter that is likely to be of interest to many parties and that can be investigated with a reasonable expenditure of time and effort. They cover a spectrum of needs. Some are technical in nature while others are oriented toward policy and management needs; some address longer-term planning needs while others are concerned with near-term decision making.

There are many ways to sort the examples to facilitate discussion, since they encompass a wide range of subjects. The groupings used here focus on data and analysis for policy making and regulation, planning and preparing for emergencies, and supporting first response. These three groupings are subsets of broader categories of research that could be undertaken as part of a national cooperative research program. A cooperative research program could be envisioned that is built around such important categories as (*a*) improving tools and data for risk analysis; (*b*) analyzing causal relationships for planning and standard-setting; and (*c*) developing field manuals, guidebooks, and other practitioner guidance. Each of these broad categories would be of interest to a cross section of public agencies at all jurisdictional levels and to hazardous materials carriers, shippers, makers of packaging, and others in industry.

Project ideas offered by stakeholders at the workshop are listed in Box 4-1. The annex to this chapter goes a step further and turns nine ideas into more defined problem statements and project descriptions. They are provided to better illustrate the kinds of projects that a cooperative research program might undertake, the array of organizations and expertise that must be part of the effort, and the kinds of products that cooperative research projects would yield.

## DATA AND ANALYSIS FOR POLICY MAKING AND REGULATION

In March 2000, the U.S. Department of Transportation (DOT) conducted an evaluation of its hazardous materials transportation programs. The evaluation team found that programs "lack the departmentwide strategic planning and direction to ensure effective deployment of resources, and there are not reliable and sufficient data upon which to make informed program decisions" (DOT 2000, ii). The team's report went on to document gaps and inconsistencies in program objectives and priorities. It recommended that institutional capacity be developed within DOT to administer a coordinated hazardous materials program.

Coordinating hazardous materials programs and regulations at the federal level has grown even more challenging since the U.S. Department of Homeland Security (DHS) was created in 2002. DHS now shares responsibility for ensuring the secure transportation of hazardous

BOX 4-1

## Research Projects Identified by Workshop Participants

**Data and Analysis for Policy Making and Regulation**

Comprehensive review of all federal and international regulatory programs and activities affecting the transportation of hazardous materials.

International scan of efforts to harmonize hazardous materials safety and security regulations and to share information in support of effective regulation.

Review of the extent to which current requirements governing hazardous materials packaging take into account security risks.

Comparison of analytic methods used for assessing safety and security risks and the prospects of using them to develop analytic models that account for both types of risk.

Review of projections of the kinds and quantities of hazardous materials transported to assess the challenges that will emerge in ensuring safety and security (e.g., how are chemical and energy markets and means of transportation expected to change over the next decade and how will these changes affect safety and security?).

**Planning and Preparing for Emergencies**

Synthesis of best practices in the sharing of information on hazardous materials shipments among carriers, shippers, and government agencies.

Examination of how state and local emergency planning agencies (including SERCs and LEPCs) use available hazardous materials traffic data for planning, and an assessment of opportunities for improving data availability and use.

Evaluation of the potential benefits of using electronic shipping papers as an aid in estimating flows of hazardous materials, real-time monitoring of certain hazardous shipments, and informing emergency responders about the contents of shipments in the event of an incident.

*(continued on next page)*

BOX 4-1 (*continued*)
**Research Projects Identified by Workshop Participants**

Review of nonproprietary and user-friendly risk assessment methods and models that can be made more widely available to public and private entities for planning purposes.

Development of models to be used by states and localities to predict possible targets of hijacked tank trucks and other vehicles containing hazardous materials.

Review of technologies capable of tracking the location of tank trucks and tank cars containing certain hazardous materials, including possible uses of GPS and other geographic information systems for this purpose.

Case studies of how security measures are being implemented in various parts of the hazardous materials sector focusing on implementations that are proving cost-effective.

**Supporting First Response**

Examination of both technological and nontechnological means of improving the accuracy, accessibility, and timeliness of hazardous materials shipment information available to emergency responders.

Evaluation of the prospects of using GIS and other options to develop and maintain a nationwide database of "public safety answering points" along the nation's rail and highway systems, for use in facilitating emergency contacts between carriers, shippers, and public safety agencies.

SOURCE: Workshop held in conjunction with study on July 1, 2004.

materials with DOT. Within each department, numerous agencies have specific authorities pertaining to hazardous materials security. Hazardous materials security is a direct concern of DOT's Research and Special Programs Administration (RSPA), which has issued rules requiring that shippers and carriers of certain highly hazardous materials develop and implement security plans and that all shippers and carriers

of hazardous materials ensure that employee training programs include a security component. The Federal Motor Carrier Safety Administration (FMCSA) has met with more than 40,000 motor carriers to encourage voluntary steps to improve security. The Federal Railroad Administration is working with the Association of American Railroads (AAR) to assess security risks and implement measures to reduce them.

Within DHS, the U.S. Coast Guard (USCG) has established requirements for operators of ports, terminals, and vessels to develop comprehensive security plans and response capabilities. Other DHS agencies, especially the Transportation Security Administration (TSA) and the Bureau of Customs and Border Protection, have security programs and requirements related to hazardous cargoes. As mentioned previously, TSA has focused its attention on securing specific elements of the transportation system. While its aviation activities remain prominent, the securing of hazardous materials has emerged as one of the agency's highest priorities.

With so many agencies having so many related roles and responsibilities, the need for coordinating policies, programs, and regulations is easy to see. Coordination is crucial to ensure that individual decisions by agencies do not work at cross purposes, that resources are complementary across programs and departments, and that risks are managed in a harmonious way.

Cooperative research could provide policy makers with information and analyses to make regulatory and investment decisions that cut across program areas. In particular, the threat of terrorism requires explicit consideration of how safety performance translates into security performance. For example, should standards and practices governing the safe containment, handling, and routing of certain materials be subject to additional criteria associated with reducing vulnerability to sabotage, hijacking, or attack? Should programs designed to educate and train all transportation personnel (in addition to hazardous materials employees) in safety awareness also contain training to raise security awareness? Should evacuation planning for hazardous materials incidents cover public gathering places as well as more typical hazardous materials transportation routes and production and storage facilities?

Research projects identified by workshop participants that could be helpful in this regard are as follows:

- A comprehensive review of federal and international regulatory programs and activities that affect safety, security, and efficiency of hazardous materials transportation, including identification of gaps and overlapping functions;
- An international scan of efforts to harmonize hazardous materials safety and security regulations and to share information in support of compatible regulation;
- A comparison of analysis methods used in evaluating safety and security risks to help develop crosscutting risk analysis models to inform decisions; and
- A review of anticipated changes in the types and quantities of hazardous materials being transported and how they are likely to affect safety and security and the need for changes in federal regulatory and budgetary emphasis.

One ambitious proposed project, which is defined in more detail in Annex 4-1, would entail an assessment of opportunities to integrate and supplement safety and security measures for hazardous materials transportation (Project 1). This research could provide the basis for developing a more comprehensive approach to hazardous materials transportation regulation that addresses safety, environment, and security concerns.

Several candidate projects on risk data and analysis are included among the nine projects listed in Annex 4-1. One entails the development of a database on large-truck crashes for use in risk analyses (Project 2). Another would produce recommendations for possible design and funding alternatives for a nationwide system to collect and analyze performance data on bulk containers so that conditional release probabilities could be determined for alternative container designs (Project 3). Another project would produce a manual that shows correlations between incident risks and consequences for shippers and carriers to use in making routing decisions and for public agencies to use in regulatory analysis (Project 4). Another focuses on developing an environmental hazardous assessment system that will allow shippers, carriers, and regulators to compare and classify the environmental hazards posed by materials in transportation more objectively (Project 5).

One of the proposed projects would help in providing the statistical basis for these kinds of risk assessments by examining ways to collect more accurate data for the evaluation of hazardous materials traffic, incident rates, and release probabilities on a systemwide basis, including ways to harmonize existing databases (now maintained by multiple agencies) so that they use more common definitions, assumptions, and frameworks (Project 6).

## PLANNING AND PREPARING FOR EMERGENCIES

Over time, the federal government has taken a more prominent role in encouraging adequate planning and preparation for hazardous materials incidents. Nevertheless, such planning remains largely the responsibility of state and local governments. Since passage of the federal Superfund Amendment and Reauthorization Act of 1986, most local governments, with the assistance of industry, have developed local emergency planning committees (LEPCs) and mutual-aid networks that can provide special equipment and personnel to hazardous materials transportation incidents. State emergency response committees (SERCs) and emergency management agencies coordinate these local efforts across the state to ensure that gaps do not exist. Thus, emergency planning involves thousands of entities across the country, many of which have similar responsibilities, problems, and needs.

Several cooperative research projects were identified by workshop participants to improve emergency planning and preparation for hazardous materials incidents involving transportation. Much of the emphasis of these projects is on improving the information and analytic tools available for such planning. Perhaps the most straightforward was a recommendation for research to survey best practices in the sharing of information on hazardous materials shipments among industry and the public sector. Another called for a baseline examination of how SERCs and LEPCs around the country use hazardous materials traffic data for emergency response planning. Another called for an evaluation of how emergency planners might use information derived from electronic shipping papers to gain a better understanding of the quantities and kinds of hazardous materials passing through their jurisdictions. Project ideas were also proposed to improve the analytic tools available to emergency planners, including a review of nonproprietary risk assessment models that can be made more widely available to public and private

entities and a review of models used to predict the consequences of various hazardous materials scenarios and how to translate these results into planning and support for decision making.

Among the project ideas detailed in Annex 4-1, two are especially pertinent to emergency planning and response. One seeks to identify best practices for estimating hazardous commodity flows for use by state and local emergency response planners in locating response capabilities in the areas most likely to need them (Project 7). Another entails a national assessment of hazardous materials response capabilities, coupled with recommendations on ways to fill any gaps and maintain up-to-date information on coverage (Project 8).

Workshop participants also offered ideas on projects that might be helpful in preparing and planning for emergencies arising from terrorist attacks on hazardous materials shipments. One proposed the development of models to predict possible targets of hijacked vehicles containing hazardous materials. Another called for a review of technologies for tracking the location of tank trucks and railroad tank cars, including possible uses of geographic information systems (GIS) such as the Global Positioning System (GPS) for real-time monitoring of hazardous materials shipments. Another called for case studies of how various segments of the hazardous materials community have implemented security measures, which would be helpful in finding cost-effective approaches.

## SUPPORTING FIRST RESPONSE

The performance of first responders is crucial to the overall system for ensuring the safety and security of hazardous materials shipments. Consequently, many of the federal regulations governing hazardous materials transportation pertain to emergency response, especially to the communication of hazard information to first responders. DOT requires that shipments be accompanied by papers containing information on the quantity of the hazardous material; the material's description, hazard class, and identification number; and a 24-hour emergency telephone number of someone knowledgeable about the material. The regulations also require that packages and containers carrying regulated materials be labeled with similar information and that warning placards be displayed on the vehicles. The color-coded, diamond-shaped placards contain symbols that indicate the presence of particular hazards.

For first responders, who are often local police and firefighters, the sight of a placard on a vehicle or a label on a container may be the only warning of the presence of hazardous materials. Most state and local police and fire departments have copies of DOT's *Emergency Response Guidebook,* which they can consult for basic response information, including initial precautions and protective measures to take. The guidebook is meant to be augmented by expert technical advice, which can be obtained through CHEMTREC and other hot line services provided by industry.[1]

Once a hazardous materials incident is recognized, first responders are trained to take initial protective actions and seek the assistance of those competent and equipped to respond. The strongest preparations tend to be in large communities, which often have special hazardous materials response teams as part of local fire departments or mutual-aid networks. Preparations are usually weakest in rural areas, where local fire departments are often manned by volunteers who may have limited training or equipment to handle hazardous materials incidents. Often state authorities are called in to assist in responding to incidents occurring in rural areas. Some states have established hazardous materials response teams to assist in major emergencies, which may require the involvement of state police, fire marshals, emergency management agencies, and environmental and health agencies.

Shippers and carriers have important roles in responding to emergencies. They are familiar with the materials, the equipment, and the operating environment. Many large carriers (especially railroads) and major chemical suppliers have specially trained emergency response teams on call. Because they operate over fixed routes and carry large quantities of hazardous materials, railroads are more likely than trucking companies to have personnel and equipment available for emergency response. Most railroads work with local jurisdictions in planning for responses to incidents. Many large shippers can also provide emergency response teams, and the chemical industry maintains a national chain of emergency response teams (CHEMNET) that can be deployed in a matter of hours to chemical emergencies around the country.

This abridged description of the system to inform first responders suggests the importance of research that involves the cooperation of

[1] See Chapter 2 for a description of the chemical industry's CHEMTREC and CHEMNET programs.

diverse interests and expertise. For example, decisions about the design of placards, the information in shipping papers, and the content and format of the *Emergency Response Guidebook* require not only sound analysis but also input and advice from those who must apply the information in the field. Emergency response information is an area with a clear need for objective analyses that use the expertise and gain the acceptance of many diverse communities.

Several project ideas were offered by workshop participants concerning improvements in the capabilities of emergency responders, including those arriving first at the scene. One called for an examination of technological and nontechnological means of improving the accuracy, accessibility, and timeliness of hazard information available to public safety officials. Another called for an evaluation of technologies, such as GPS, to develop and maintain a national database of public safety "answering points" along the nation's rail, water, and highway systems for streamlining emergency contacts.

Among the projects detailed in Annex 4-1, one describes what would be an ongoing research activity to keep DOT's *Emergency Response Guidebook* technically current and in a form that meets the needs of emergency responders (Project 9). This is a particularly good example of where cooperative research can confer benefits on all parties involved. DOT developed the *Emergency Response Guidebook,* but its primary users are local police and firefighters. Both developers and users of the information need access to expertise and knowledge gained from wide experience with a range of hazardous agents and response environments. A cooperative project that regularly brings these users together with technical experts on hazardous chemicals, regulators, and carriers and shippers would offer valuable perspectives on ways to improve this important source of response guidance.

## REFERENCE

***Abbreviation***

| | |
|---|---|
| DOT | Department of Transportation |

DOT. 2000. *Departmentwide Program Evaluation of the Hazardous Materials Transportation Program.* Washington, D.C., March.

Annex 4-1

# Example Projects for a Hazardous Materials Transportation Cooperative Research Program

This annex presents nine example projects that could be undertaken by a hazardous materials transportation cooperative research program. The project statements are modeled after those found in the National Cooperative Highway Research Program and the Transit Cooperative Research Program (both of which are described in the next chapter). The project topics were derived from earlier efforts to review the concept of a hazardous materials transportation cooperative research program (as noted in the Preface) and on the basis of the committee members' expertise and experience. They are provided to illustrate the kinds of problems that a cooperative research program might address, the various tasks and participants that would be involved in the research, and the end products that could be expected. They are not offered as priority projects, and some may be inappropriate in scale and complexity for an applied cooperative research program. Approximations of project costs and duration are offered. The nine statements are numbered and titled as follows:

**Data and Analysis for Policy Making and Regulation**

1. Assessment of Opportunities to Integrate and Supplement Safety and Security Measures for Hazardous Materials Transportation
2. Data on Predominant Traffic and Highway Geometric Characteristics in Large-Truck Crashes for Use in Risk Analysis
3. Recommendations for Development of Conditional Release Probabilities for Bulk Containers Involved in Transportation Accidents
4. Development of Correlations Between Incident Risks and Consequences to Aid in Decision-Making Models

5. Development of an Environmental Hazard Assessment System for the Transport of Hazardous Materials
6. Recommendations for Commercial Transportation Incident and Commodity Flow Data Collection and Reporting

**Planning and Preparing for Emergencies**

7. Detailed Information for Conducting Hazardous Materials Commodity Flow Studies
8. National Hazardous Materials Emergency Response Capability Assessment

**Supporting First Response**

9. Transportation Emergency Response Guidelines for Hazardous Materials

## Project 1

### TITLE

Assessment of Opportunities to Integrate and Supplement Safety and Security Measures for Hazardous Materials Transportation (Two-Phase Project)

### OBJECTIVES

#### First Phase

1. Identify areas where safety and security measures are compatible or may complement each other.
2. Identify areas where safety and security measures may conflict or where measures to enhance one may compromise the other.
3. Identify where security requirements warrant attention beyond what is required for safety performance.
4. Determine whether there should be any difference between the response to and remediation of "traditional" hazardous materials incidents and those resulting from terrorist attacks.

5. Outline a comprehensive approach to hazardous cargo transportation that addresses both safety and security issues.

### Second Phase

6. Produce national standards formulae for rational state and local decisions about safety and security risks related to the movement of hazardous materials.
7. Produce a model for reasonable state and local risk response and management plans related to both safety and security needs.

## DESCRIPTION

In all 50 states and U.S. territories, the flow of commerce includes the movement of flammable, explosive, caustic, and biological materials that pose fundamental risks to the public if they are accidentally or deliberately released. At the same time, the continuous flow of these hazardous materials is essential to the strategic functions of the national economy and national defense. Risks to public health and safety are managed, minimized, and mitigated by systems for handling and moving hazardous materials with highly developed safety and accountability features. The excellent record of safety in these systems is largely due to the diligence of shippers and receivers working closely with federal, state, and local regulatory and enforcement agencies.

RSPA promulgates and enforces regulations for the safe transportation of hazardous materials. The regulations are harmonized with the standards and guidance of international organizations such as the United Nations, the International Civil Aviation Organization, and the International Maritime Organization. The carrier regulations are organized according to the transportation modes of rail, highway, air, and water. The modal agencies share in enforcement. All of the modal agencies are under DOT with the exception of USCG, which has transferred to DHS. Environmental Protection Agency (EPA) and Department of Labor (DOL) rules overlap with those for transportation in a few areas, particularly when materials are stored and in waste transport.

The threat of terrorism now requires a distinction that at once must be well measured and well managed. Making this distinction requires explicit

consideration of the extent to which the inherent safety of hazardous materials handling systems translates into satisfactory levels of security for hazardous materials in transit. For example, does a gasoline tank truck moving along a primary highway that is safe in structure and operation require additional protections to reduce vulnerabilities to attack, hijacking, or theft by terror-minded individuals or groups? Is a train consisting of 100 or more tank cars of propane and caustic materials passing through a highly populated area not only safe but also secure from attack?

There are few regulations specifically for hazardous materials transportation security. RSPA has a requirement for security plans. A recommendatory program is administered by FMCSA for highways. TSA set forth new requirements for issuance of hazardous endorsements to commercial driver's licenses. USCG regulations implementing the Maritime Transportation Security Act address certain dangerous cargoes at marine terminals. USCG has requirements for ships carrying certain dangerous cargoes.

Safety and security regulations are promulgated and enforced by at least nine agencies under four departments of the federal government. More security regulations are expected. The multiplicity of regulating agencies gives rise to the risk that the security rules of one will negatively affect a safety issue addressed by the rules of another. It also raises the possibility that advantages to security offered by safety requirements will not be fully appreciated, and vice versa.

## TASKS

### First Phase

1. Review safety-related regulations of all agencies that address hazardous cargo transport and identify those that may affect security.

2. Assess the degree of that impact and whether it enhances or detracts from security.

3. Review security regulations of all agencies related to cargo transport. By using the information developed in Items 1 and 2, determine
   a. Whether the object of the regulation is already addressed by a safety regulation and

b. Whether the security regulation will have a positive, negative, or neutral impact on safety.

### Second Phase

4. Document hazardous materials transit patterns, movements, marshaling, and "at rest" status.
5. Relate this information to population density and proximity to strategic infrastructure. Consider prevailing weather patterns, water flows, and so forth. (The process of focusing on the "presence and inventory" of hazardous materials in transit is likely to be revealing to most communities' leadership.)
6. Identify critical strategically important movements (for example, an attack on a pipeline in a rural area could have crippling effects on the economy).
7. Offer strategies for assessing risks.
8. Offer strategies for addressing and managing risks that go beyond existing safety requirements as needed.

## DELIVERABLES

### First Phase

1. Produce a holistic analysis of existing and proposed regulations and laws that affect the security of hazardous materials in transportation.
2. Identify possible duplicative efforts and expenditure of resources by multiple agencies.
3. Produce indexed, searchable data for use by regulators and legislators.

### Second Phase

4. National standards formulae for rational and objective community-based assessments of hazardous materials movements.
5. Model for state and local risk response and management plans.

### STAKEHOLDERS

- Carriers
- Shippers
- Importers and exporters
- Regulatory agencies
- Legislative staffs
- State and local governments

### COST ESTIMATE (2004 $)

- $500,000 for first phase
- $500,000 for second phase

### PERIOD OF PERFORMANCE

- 18 months for first phase
- 18 months for second phase

## Project 2

### TITLE

Data on Predominant Traffic and Highway Geometric Characteristics in Large-Truck Crashes for Use in Risk Analysis

### OBJECTIVES

1. Compile existing data on the relationship between large-truck crash statistics and highway features and geometric/traffic characteristics.
2. Determine the usefulness of these data in performing risk analysis for large truck–involved crashes and for trucks involving hazardous materials versus other kinds of cargoes.
3. Propose a centralized large-truck crash database for risk analysis.

### DESCRIPTION

Geometric design features and certain traffic characteristics are important in the safe operation of large trucks on highways, particularly on two-lane

highways. Data on these geometric features and traffic characteristics are necessary to conduct risk analysis for various types of trucks traveling on highways with different geometric and traffic characteristics. Although several studies have been conducted on aspects of this topic, the available information is dispersed and presented in an uncoordinated manner. A comprehensive database that can be used directly to assess the risk of various truck types traveling under different conditions of traffic and geometric characteristics is not readily available. The suitability of the existing data for use in risk analysis is also not clear. There is a need to synthesize the available data and place them in a format suitable for risk analysis by type and severity of crash. This effort will determine the extent to which the existing data may be used for risk analysis.

## TASKS

1. Compile existing data on different types of large-truck crashes by type of truck and associated traffic and highway geometric characteristics.
2. Synthesize and present the data in a format suitable for risk analysis.
3. Determine the extent to which the data are suitable for risk analysis.
4. Document gaps and weaknesses in available databases that limit their use in risk analysis.
5. Propose a centralized large-truck database for risk analysis.
6. Develop a recommended research program leading to a centralized database of roadway features and geometric and traffic characteristics associated with large-truck crashes that can be used for risk analysis.

## DELIVERABLES

A report that

1. Documents the existing databases on the traffic and highway geometric features that are associated with large-truck crashes,
2. Documents the extent to which the existing data are suitable for risk analysis,
3. Documents the gaps and weaknesses in the available databases for risk assessment,

4. Describes a proposed centralized large-truck database for risk analysis, and
5. Describes a recommended research program that would lead to a centralized database suitable for risk analysis of the involvement of different types of large trucks in crashes.

### STAKEHOLDERS

- Highway shippers and carriers
- Federal, state, and local regulators
- LEPCs and other interest groups
- Technical and public policy analysts
- Departments of Energy and Defense, as well as other organizations with responsibility for the movement of hazardous materials

### COST ESTIMATE (2004 $)

$550,000

### PERIOD OF PERFORMANCE

24 months

## Project 3

### TITLE

Recommendations for Development of Conditional Release Probabilities for Highway and Intermodal Bulk Containers Involved in Transportation Accidents

### OBJECTIVES

Provide documented recommendations on possible design and funding alternatives for a nationwide system to collect and analyze performance data of highway and intermodal bulk containers involved in transportation accidents, from which conditional release probabilities for various container design specifications (by transport mode) could be developed.

## DESCRIPTION

The expected performance of a package that is involved in a transportation accident is critical in the evaluation of risks. Of particular interest is the performance of bulk packages. Accurate data on the impact of various design specifications on release probability are essential for robust risk analyses and in enabling better packaging decisions by carriers, shippers, and regulators.

A long-standing private-sector initiative managed by the Railway Supply Institute (RSI) and AAR, known as the RSI-AAR Railroad Tank Car Safety Research and Test Project, has collected and analyzed damage reports on tank cars that are involved in railroad accidents, whether or not the damage resulted in a leak of contents. The RSI-AAR project has resulted in conditional release probabilities for tank cars with different design specifications and features, including overall release probabilities as well as probabilities by the location of the leak (shell, head, top or bottom fittings, or multiple locations). It also considers the effect of various mitigation options (such as increasing head or shell thickness, adding protection to valves and fittings, etc.) on lading loss.

However, no such project exists for tank trucks or portable tanks.[2] Risk estimates for these types of containers are often based on widely varying estimates and anecdotal information rather than on statistical or scientific analysis. Direct extrapolation from tank car data to other bulk containers is generally not advisable, since the forces involved in railroad and highway accidents may be of considerably different magnitude, and accident scenarios are quite different. In addition, portable tanks may be shipped by rail, highway, and marine modes, all of which involve different accident potentials and characteristics.

This research project will provide recommendations, guidance, and specifications for the collection and analysis of bulk container performance data. As part of this project, funding alternatives will be identified

[2] DOT recently published a final rule (HM-229) that contains a provision for submission of incident reports when specification cargo tanks are damaged but do not release lading. However, the rule does not base the need to report on the occurrence of an accident of some established definition, does not apply to portable tanks, and is not likely (in its current form) to result in data detail sufficient for the needs of risk analysts and decision makers.

and evaluated. Institutional barriers to data collection will be identified, and recommendations for overcoming them will be made. The project is a necessary and logical extension of other proposed projects involving the definition, collection, and analysis of mode- and infrastructure/location-specific accident data.

Risk managers sometimes face the issue of the selection of transport mode. Conditional release probabilities developed for bulk containers should be reasonably comparable and consistent in terms of definitions. Therefore the project will develop definitions for critical elements and discuss (for the various alternatives proposed) the data or analytical adjustments that may be required to account for modal differences and reporting characteristics. For example, if reports of damaged containers form the basis for the analysis, how will the results be adjusted to consider the broader universe of containers that were involved in accidents (of the same definition) but not damaged?

Through the RSI-AAR project data and analyses, much effort has been expended in structuring a consistent and defendable approach to the development of conditional release probabilities for tank cars involved in accidents. This approach could be applicable to other containers and modes. Other approaches may also be appropriate and should be explored.

The successful implementation of the proposed reporting systems and associated data should support the identification and prioritization of risk reduction actions leading to fewer hazardous materials transportation accidents, releases, and consequences to human or environmental health.

## TASKS

1. Define project mission, scope, objectives, and deliverables.
2. Compile and assess current systems.
3. Compile and assess current data availability, validity, and comparability.
4. Interview stakeholders.
5. Develop draft recommendations.
6. Review draft recommendations with stakeholders and proposed process owners.

7. Refine recommendations.
8. Publish final report.

## DELIVERABLES

1. Recommendations for definitions of critical elements (accident, damage, release, conditional release probability, etc.).
2. Description of current systems and limitations.
3. Description of stakeholder needs.
4. Identification of specific data requirements.
5. Alternatives and recommendations for data collection and analysis processes.
6. Alternatives and recommendations for process owners, funding, managing, and reporting.
7. Final report.
8. Public presentation of recommendations.

## STAKEHOLDERS

- Shippers and associations
- Carriers and associations
- Bulk terminals and associations
- DOT
- National Transportation Safety Board
- Risk analysts

## COST ESTIMATE (2004 $)

$75,000 to $100,000
Note: Since this project will only develop possible frameworks for an actual data collection and analysis program, the cost should not be high.

## PERIOD OF PERFORMANCE

12 months

# Project 4

## TITLE

Development of Correlations Between Incident Risks and Consequences to Aid in Decision-Making Models

## OBJECTIVES

Determination of the components of a model to validate risk and consequence analysis of rail and highway transportation of hazardous materials. The result should be readily adaptable to routing and regulatory analysis decisions.

## DESCRIPTION

Ground transportation of hazardous materials falls within the purview of DOT's regulations. DOT's 11 hazard classes (9 numeric and 2 worded) suffice for DOT purposes; however, risk decisions utilizing those generic categories can lead to overly general conclusions of consequence. Other agencies influence DOT regulations, such as EPA for hazardous substances. Modal considerations and release indices considering packaging requirements are also a component of risk analysis. This study will consider hazard categorization schemes that are constructed in a manner to facilitate consequence analysis.

Consequence analysis needs refinement with new methods of measurement. Fatalities may not be the best expression of consequence. A better measure may be total population exposure. The location of the spill and such information as the type of soil, closeness of aquatic features, and proximity to natural habitats should be taken into account for environmental purposes. On the basis of this refinement of consequence categories and designation of meaningful units of measure, these components can be combined into the final statement of the impact.

With coordination of risk and consequence analysis, qualified decisions can be made as to the routing of products and reductions of the identified risks and consequences. Such a rational approach could also aid in the development of regulations and in reasonable reactions and options to public outcries for mandatory routing decisions.

## TASKS

1. Review previous studies and current in-process efforts.
2. Categorize hazardous materials by consequence.
3. Develop impact of each of the categories in terms of life and environment.
4. Develop appropriate units of measure for the impact categories.
5. Perform quality assurance and reasonability checks on the combinations of hazardous materials categories and consequence estimates.
6. Obtain peer review and stakeholder review where appropriate.
7. Prepare final report.

## DELIVERABLES

Manual providing categories for evaluating hazardous materials and their effects on sensitive receptors (with units of measure).

## STAKEHOLDERS

- Carriers: rail, highway
- Shippers: all
- Regulators: EPA, DOT, DOE, state agencies
- Resource managers: local officials, USCG, Department of Interior, Bureau of Land Management
- Emergency preparedness planners
- Independent researchers and consultants

## COST ESTIMATE (2004 $)

$250,000

## PERIOD OF PERFORMANCE

18 months

# Project 5

## TITLE

Development of an Environmental Hazard Assessment System for the Transport of Hazardous Materials

## OBJECTIVES

Development of a quantitative system or model that will allow carriers, shippers, analysts, and regulators to assess, compare objectively, and classify the environmental hazards posed by materials in transportation.

The specific objectives are as follows:

1. Identify the key parameters that should be used to determine the environmental hazards of a given material.
2. Develop a methodology for an environmental hazard index that provides an accurate estimation of relative hazards.

## DESCRIPTION

DOT's classification system for hazardous materials focuses largely on criteria related to acute injury to human health or damage to property. However, many materials that are benign with regard to these two impacts may harm the environment. The high cost of many hazardous materials spills has been due to environmental impacts. Presently, many materials are classified by DOT as hazardous in transportation only by reference to the EPA hazardous substance list or to several other lists outside DOT. Some materials that may pose a threat to the environment are not included on any of DOT's referenced lists and

thus may not be required to be regulated in transportation at all. In contrast to other DOT-regulated materials, there are no general tests or criteria to determine the extent of environmental hazard they may pose. A comprehensive basis for the quantification and ranking of the environmental hazards posed by various materials in transportation is needed. The development of such a system would provide carriers, shippers, regulators, risk analysts, and the public with an objective basis for evaluating and comparing the environmental risk posed by hazardous materials in transportation.

The system must allow the user to evaluate a large number of products spilled under a wide variety of environmental circumstances. The environmental hazards of concern include damage to natural resources, harm to flora and fauna, destabilization of ecosystems, and effects on human health due to exposure to contaminated soil and water. The system should recognize and account for the cost of the immediate impact on the environment and the cost of cleanup and restoration. It should account for and quantify spillage under a wide variety of environmental circumstances such as location characteristics that affect the consequence of a spill (surface conditions, soil type, groundwater depth, aquatic system characteristics, etc.). Related to this is the capability to quantify the geographic probability distribution of values for each environmental parameter that may interact with characteristics of the spilled material. A standardized set of data requirements, algorithms, and testing criteria should be developed for application to any material of concern. Such a system would adequately account for appropriate North American environmental regulations, as well as any international systems with which it would need to be harmonized.

## TASKS

1. Refine objective, description, tasks, deliverables, and scope.
2. Conduct a comprehensive literature search and review of the state of the art in relevant fields and contact people currently involved in assessing these hazards, and synthesize the results.
3. Characterize the receptors of interest and develop approaches to quantify the impact on each.

4. Characterize and quantify the hazards that apply to each receptor type.
5. Identify material parameters.
6. Develop a classification scheme relating the quantity of material spilled, material parameter values, and spill conditions to types of receptor and hazard combinations.
7. Develop requisite algorithms, models, and parameters.
8. Develop data and use models to analyze a representative group of hazardous materials.
9. Validate classification scheme with appropriate data for actual events.
10. Obtain peer review and stakeholder review where appropriate.
11. Prepare final reports that document methodologies, data, assumptions, model form and usage, interpretation of results, and validation results.

## DELIVERABLES

Reports and software providing detailed descriptions of the form, development, validation, and recommended use of the hazard classification scheme.

## STAKEHOLDERS

- Carriers
- Shippers
- Regulators: EPA, DOT, state agencies
- Resource managers: local officials, local industry, Bureau of Land Management, USCG, Department of Interior
- Emergency preparedness planners
- Independent researchers and consultants

## COST ESTIMATE (2004 $)

$1,000,000

## PERIOD OF PERFORMANCE

36 months

# Project 6

## TITLE

Recommendations for Commercial Transportation Incident and Commodity Flow Data Collection and Reporting

## OBJECTIVES

Provide accurate data for the evaluation of hazardous materials transportation incident rates and release probabilities. Prepare documented recommendations for the collection of nationwide commercial transportation accident frequencies and traffic volumes for improved incident rates, release probabilities, and commodity flow data.

## DESCRIPTION

To assess transportation risks associated with various modal movements of hazardous materials, accurate data on incident rates and release probabilities are critical. A person performing risk assessments or making risk decisions must have answers to the following:

1. How many incidents happen along modal transportation routes each year? (In addition to incident data reported under 49 CFR 171.16, data should be collected from federal, state, and local authorities and other government agencies with incident reporting requirements concerning hazardous materials.)
2. If there is an incident, what are the chances that there will be a release of material?
3. How many miles per year do specific materials or classes of materials move along specific (or characteristic) transportation routes?

This project will provide recommendations, guidance, and specifications for the collection of these critical data. It will identify institutional

barriers to data collection and make recommendations for overcoming them. Because hazardous materials accidents and releases are infrequent based on reporting under 49 CFR 171.16, methods for collecting incident rates, release probabilities, and flow data from all federal, state, and local sources and commercial operations should be explored. The data will then be available for extrapolating and evaluating the risk associated with hazardous materials transportation.

Successful implementation of the reporting system and associated data should support the identification and prioritization of risk reduction actions leading to fewer hazardous materials transportation incidents, releases, and health consequences.

## TASKS

1. Define project mission, scope, objectives, and deliverables.
2. Compile and assess current data availability and validity.
3. Interview stakeholders.
4. Develop draft recommendations.
5. Review draft recommendations with stakeholders and proposed process owners.
6. Refine recommendations and publish report.

## DELIVERABLES

1. Recommended definitions for incidents, accidents, releases, accident-related, non-accident-related, road type, pipeline age, track type, waterway type, container type, commodities covered, quantities covered, and so forth.
2. Assessment and compilation of currently available data.
3. Identification of specific data requirements.
4. Identification of stakeholders.
5. Recommendations for data collection and reporting process owners.

6. Recommendations for data collection frequency and processes for collection.
7. Final report.
8. Public presentation of recommendations.

### STAKEHOLDERS

- Shippers and associations
- Carriers and associations
- Terminals, warehouses, distributors, and associations
- Public, LEPCs, and associations
- State and federal departments including DOT, EPA, DOL, and DHS
- National Transportation Safety Board
- State and local governments
- Risk researchers and contractors

### COST ESTIMATE (2004 $)

$500,000

### PERIOD OF PERFORMANCE

24 months

## Project 7

### TITLE

Detailed Information for Conducting Hazardous Materials Commodity Flow Studies

### OBJECTIVES

Provide information for state and local agencies on methods and information systems that can be used to estimate hazardous materials commodity flows in their jurisdictions.

## DESCRIPTION

While DOT provides a handbook on commodity flow studies, many localities do not have access to reliable statistics on hazardous materials flows to use in these studies. Existing statistical information sources are too broad. They cover flows at the national, regional, and state levels. For local planners, this "macro" level is far too coarse—in both amount and types of materials moving through their jurisdictions—to make meaningful estimates of commodity flows to support decisions about requisite training and preparations for incidents.

## TASKS

1. Collect and review existing hazardous materials commodity flow data from local jurisdictions around the country and examine the methodologies employed.
2. Compare methods of estimating flows and identify best practices.

## DELIVERABLE

A detailed commodity flow survey methodology handbook that explains methods of obtaining information on commodity flows when the available data are too aggregate. The handbook will contain a resource guide to information resources, including large shippers, motor carriers, barge lines, and rail companies, that can provide local information. Information available on the Internet will be included.

## STAKEHOLDERS

- LEPCs
- Local emergency responders
- Shippers
- Carriers

## COST ESTIMATE (2004 $)

$300,000

## PERIOD OF PERFORMANCE

18 months

# Project 8

## TITLE

National Hazardous Materials Emergency Response Capability Assessment

## OBJECTIVES

1. Determine the location and quality of response coverage for hazardous materials incidents.
2. Identify geographic locations where coverage is inadequate.
3. Develop cost-effective strategies for improving response to acceptable levels where deficiencies exist.
4. Create a more systematic and efficient approach for allocating government funding to response needs.

## DESCRIPTION

Various health, safety, and environmental regulations address emergency response planning and preparations for incident management in the event of a hazardous materials release. Although legislation such as the Superfund Amendments and Reauthorization Act mandated that state and local agencies perform these tasks, few attempts have been made to identify response teams, assess their competency to respond to different types of hazardous materials emergencies, or determine how quickly a qualified unit can reach the site of an emergency within its jurisdiction and surrounding areas. As a result, a national profile of the ability of qualified response teams to reach the scene of an incident in a timely fashion is lacking. It is extremely difficult to allocate response resources effectively without knowledge of where improvement needs are greatest.

The project involves integrated use of (*a*) GIS technology, (*b*) survey data collected from individual hazardous materials teams and cleanup

contractors, (*c*) response analysis methodologies to evaluate the capabilities of individual units to handle releases of different hazardous material types, and (*d*) network algorithms to determine optimal routes and corresponding travel times for units to reach spill locations within their jurisdictions. The project results will serve as a benchmark study of the current status of emergency response coverage. It will also establish a method for monitoring changes in response capability over time as well as for directing future resource allocation.

## TASKS

1. Conduct literature review.
2. Develop and implement data collection plan.
3. Select GIS analysis platform.
4. Develop analysis methodology.
5. Perform analysis.
6. Evaluate results.
7. Develop recommendations.
8. Prepare and submit draft final report.
9. Revise and publish final report.

## DELIVERABLES

1. Synthesis report from literature review.
2. Survey form and list of criteria for evaluating response team capabilities.
3. Final report describing data collection and analysis methods, quality of response coverage, identification of coverage deficiencies, recommended improvement strategies, and use of the developed methodology as a tool for future response assessment and resource allocation.
4. Color-coded maps of the country showing geographical areas of response vulnerability for each hazard class.
5. Electronic format of the data for public use.

### STAKEHOLDERS

- Shippers
- Carriers (rail, truck, barge, pipeline, aviation)
- Federal, state, and local regulators/compliance officers
- Utilities
- Waste disposal sites
- Emergency response personnel
- LEPCs and other public interest groups
- Technical and public policy analysts

### COST ESTIMATE (2004 $)

$500,000

### PERIOD OF PERFORMANCE

24 months

## Project 9

### TITLE

Transportation Emergency Response Guidelines for Hazardous Materials

### OBJECTIVES

Provide a consistent guideline document for use by emergency responders and handlers for managing transportation incidents involving hazardous materials. The document should (*a*) define the roles and responsibilities of carriers and shippers in the event of an incident and (*b*) provide procedures that are consistent across all modes, authoritative, and clear to all parties involved.

### DESCRIPTION

Publicly available emergency response guidelines do not cover all transportation modes, are often superficial in scope, and can be poorly documented. The contractor is tasked to prepare comprehensive guideline

documents that cover all types of incidents and all probable types of hazardous materials releases, arranged in a hierarchical manner. This document will cover at least the following:

1. Damage assessment of packaging to determine immediate remedial actions when warranted and subsequent actions as appropriate.
2. Immediate remedial actions, including type of damage control to employ, evacuations, and broadcasting emergency procedures. Protocols that do exist should be included and documented, along with emergency alert and warning systems (such as Emergency Alert Systems and Enhanced 911 Centers) and emergency uses that can be made of electronic bills of lading.
3. Field movement of lading as appropriate.
4. Definition of the roles and responsibilities of carriers, shippers, emergency responders, and other parties in an incident.

## TASKS

1. Perform a literature search to obtain past and present guidelines. The search should include guidelines used by industry and by government agencies, such as the Department of Defense.
2. Review and critique the existing guidelines.
3. Contact associations and institutions that conduct emergency response training.
4. Prepare and present the draft documents to the sponsor for comments and additional direction.
5. Revise and submit final deliverables.

## DELIVERABLES

1. Capability profile of first and final responders' training requirements (qualifications).
2. Equipment requirements.

3. Remedial (immediate and appropriate) actions determination and implementation.
4. Command organization—definition of the roles and responsibilities of carriers and shippers within the context of the National Incident Management System aimed at standardizing incident management practices and procedures.

## STAKEHOLDERS

- Shippers
- Carriers (rail, truck, vessel, pipeline, aviation)
- Federal, state, and local regulators/compliance officers
- LEPCs and public interest groups
- Emergency response personnel, trainers, and trainees

## COST ESTIMATE (2004 $)

$500,000 to $650,000

## PERIOD OF PERFORMANCE

24 months

# 5

# Insights from Other Cooperative Research Programs

The experiences of cooperative research programs elsewhere in the transportation sector and in other industries offer insight into ways to bring about and structure such a program for hazardous materials transportation. Within the transportation sector, two long-standing programs are the National Cooperative Highway Research Program (NCHRP), established in 1962, and the Transit Cooperative Research Program (TCRP), established in 1991. Pipeline companies have cooperated in the sponsoring of research since the 1950s. On a smaller scale, railroads and suppliers of tank cars have sponsored a cooperative research program for more than 30 years. Other examples of cooperative research can be found in the automotive, construction, and electric power industries.

Several of these cooperative research programs are reviewed in this chapter. The focus is on how the programs are financed, governed, and managed. The first two programs reviewed are NCHRP and TCRP. They are examined in detail because they are often held up as models for organizing a cooperative research program for hazardous materials transportation. In addition, the financing, governance, management, and research products of five other cooperative research programs are reviewed: the Pipeline Research Council International (PRCI), the Electric Power Research Institute (EPRI), the Construction Industry Institute (CII), the Health Effects Institute (HEI), and the Railroad Tank Car Safety Research and Test Project of the Association of American Railroads (AAR) and Railway Supply Institute (RSI). The insights gained from these reviews are summarized and referred to in the next chapter

in considering options for structuring a cooperative research program for hazardous materials transportation.[1]

## NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

### Program Inception

To a large extent, the construction, operation, and maintenance of highways have been government responsibilities since the colonial era. For most of the country's history, state and local governments have had primary responsibility for planning, financing, and operating highways. Most states also supported their own highway research and development activities, often in affiliation with state universities.

After World War II, the federal government began to play a more prominent role in highway planning and financing. With the advent of the Interstate highway program, the federal government started conducting more research aimed at building a more uniform and interconnected national system of highways. States remained the owners and operators of the system, and they closely guarded the prerogative to determine where and how highways would be built. Through the American Association of State Highway and Transportation Officials (AASHTO), states had long worked together and with other relevant organizations (such as the National Association of County Officials and the American Society of Civil Engineers) in setting uniform guidelines for many aspects of highway design, construction, and operations.

AASHTO's responsibilities for setting highway standards grew more varied and complex as the Interstate highway system took shape during the 1950s and early 1960s. The building of this system and the setting of standards for uniformity led to many new technical questions and problems shared by highway departments across the country. An AASHTO survey

[1] Much of the information on other cooperative research programs presented in this chapter was drawn from *Special Report 272: Airport Research Needs: Cooperative Solutions* (TRB 2003). In addition, the websites of the various programs were consulted for some of the factual and organizational information presented.

of state highway agencies during the late 1950s revealed more than 100 problems shared by many states concerning topics ranging from highway finance and safety to design and traffic operations (HRB 1960). Because of federal-aid requirements at the time, states devoted at least 1.5 percent of their aid to research and planning. Consequently, a great deal of highway-related research was undertaken, but with much duplication of effort, a wide range of quality, and limited dissemination of results.

Recognizing these shortcomings, AASHTO often helped states pool resources to coordinate some of this research, but each instance required the negotiation of new cooperative agreements and structures for overseeing the research. The survey of research needs convinced AASHTO and its member states of the value of creating a continuing means of pooling resources for research on a national basis. NCHRP was therefore established in 1962 as a result of an agreement among AASHTO, the Federal Highway Administration (FHWA), and the National Research Council's Transportation Research Board (TRB). The agreement called for participating states to allow the federal government to withhold distribution of 5 percent of each state's 1.5 percent share of federal-aid funds that must be used for research and planning. The funds would be transferred to TRB, which AASHTO described as having "recognized objectivity and understanding of research practices," to manage the program (AASHO 1964, 116–119). Individual states could elect to participate or not, and the agreement would have to be re-signed every year on a state-by-state basis.

Each contributing state was given the opportunity to submit problem statements to AASHTO's Standing Committee on Research (SCOR), which was composed entirely of state highway agency representatives. On the basis of these statements and those from other AASHTO technical committees and FHWA, SCOR would select the problems to be the subject of NCHRP research projects that year. Each project needed to be approved by two-thirds of the states participating in the program.

TRB was charged with administering the program by convening expert panels for each project. The panels drew from specialists in universities, industry, and predominantly the state highway agencies themselves. Project panels were tasked with defining the project scope, soliciting and selecting qualified researchers to perform the work, and reviewing the research in progress and the end results. Research results were to be

published in a series of reports made available to the public. The first formal NCHRP report, *Evaluation of Methods of Replacement of Deteriorated Concrete in Structures,* was published in 1964.

## Program Today

NCHRP's purpose and its methods of financing, governance, and management are fundamentally the same today as they were following its creation. The program is still intended to provide products and procedures that are readily applicable to current or emerging problems. A cursory review of publication titles indicates as much: many products are described as "guidelines," "manuals," "handbooks," and "evaluation methods." The typical project is completed within 2 to 3 years and is funded at $300,000 to $400,000, although some are smaller than $100,000 and a few have funding in excess of $600,000.

Aspects of the program that have changed since its inception are the variety of research results and the means by which they are disseminated. Since its first report nearly 40 years ago, NCHRP has published more than 500 reports in 25 problem areas ranging from pavement design to transportation planning. In addition, the program has published more than 300 "synthesis" reports that are based on surveys of highway practice; more than 300 research results "digests," including a special series on legal issues; and more than 50 "Web" and CD documents that contain specialized information and software applications. The digests and Web documents are intended to promote early awareness of project results to encourage implementation.

Table 5-1 provides summary information on NCHRP project areas and products. The information is derived from annual progress reports to the state sponsors and the general public. The progress reports describe ongoing NCHRP work as well as the results of completed projects. They describe the end products of each project and give examples of their use in the field.

Funding for NCHRP continues to be based on voluntary participation by states. The contribution is now 5.5 percent of the 2 percent share of total federal aid that must be devoted to research or planning activity. Since 1962, only a handful of states have elected to withhold contributions to NCHRP in any given year, and all have rejoined the program within 1 to

**TABLE 5-1** Summary of Research Areas and Products of NCHRP, 1962–2001

| Research Field | Problem Areas Covered | Number of Projects[a] | Examples of Final Products |
|---|---|---|---|
| Administration | Economics, law, finance | 35 | Effect of Highway Landscape Development on Nearby Property; Valuation of Travel Time and Predictability of Congested Conditions for Highway User Cost Estimation; Theory and Practice in Inverse Condemnation; Budgeting for State Highway Departments (research results digest) |
| Planning | Forecasting, impact analysis | 74 | Improving Transportation Data for Mobile Source Emissions Estimates; Guidelines for the Development of Wetlands Replacement Areas; Multimodal Transportation Planning Data; Travel Estimation Procedures for Quick Response to Urban Policy Issues; Criteria for Evaluating Alternative Transportation Plans |
| Design | Pavements, bridges, general, roadside, vehicle barrier systems | 136 | Smoothness Specifications for Pavements (Web document); Guidelines for Recycling Pavements; Recommended Specifications for Large-Span Culverts; Bridge Rating Through Nondestructive Load Testing (research results digest); Guardrail Design; Intersection Sight Distance |
| Materials and construction | General, bituminous, specifications, procedures, practices | 134 | Evaluation of Water Sensitivity Tests (also available on CD); Design of Emulsified Asphalt Paving Mixtures; Guidelines for Longitudinal Pavement Profile Measurement; Use of Polymers in Highway Concrete; Long-Term Rehabilitation of Salt-Contaminated Bridge Decks |
| Soils and geology | Soils testing and implementation, soils properties, soil mechanics and foundations | 31 | Instrumentation for Measurement of Moisture; Reinforcement of Earth Slopes and Embankments; Expert System for Stream Stability and Scour Evaluation; Evaluation of Metal Tensioned Systems in Geotechnical Applications; Load Factor Design Criteria for Highway Structure Foundations |
| Maintenance | Snow and ice control, equipment, maintenance of ways and structures | 31 | Evaluation and Development of Methods for Reducing Corrosion of Reinforcing Steel; Economic Evaluation of the Effects of Ice and Frost on Bridge Decks; Evaluating Deferred Maintenance Strategies; Maintenance Contracting; Maintenance Levels-of-Service Guidelines |
| Traffic | Traffic operations and control, illumination and visibility, traffic planning, safety | 115 | Guidelines for Medial and Marginal Access Control of Major Roadways; Optimizing Flow on Existing Street Networks; Determination of Stopping Sight Distance; Highway Fog; Effects of Highway Standards on Safety; Traffic Barrier and Control Treatments for Restricted Work Zones; Methods for Evaluating Highway Safety Improvements |

[a] Projects completed or ongoing from 1962 to 2001.

2 years. FHWA has also remained an active participant. Although it does not have a vote in the programming of funds, it appoints liaison representatives to SCOR and other AASHTO committees, and FHWA experts serve on all NCHRP project panels and can submit problems for consideration.

NCHRP's annual budget, as described earlier, has grown with the increase in federal aid over time. The program's annual funding has risen from about $15 million in the early 1990s to more than $30 million in FY 2004. About 79 percent of the annual program budget is allocated to research contracts, 16 percent to program staffing and related costs, and the remaining 5 percent to panelist travel and report publication and dissemination expenses.

This budget enabled NCHRP to program more than 40 major research projects (each funded at $200,000 or more) in FY 2004. The projects were drawn from more than 120 problem statements submitted to the program. Technical panels develop requests for proposals for each project and perform the evaluations of proposals for consideration in selecting the contractor to perform the research. The selection process is competitive. Panels choose the researcher on the basis of the proposed research plan, a description of the anticipated product, and ideas for disseminating the results. NCHRP provides panelists with guidelines for evaluating the proposals.

## TRANSIT COOPERATIVE RESEARCH PROGRAM

### Program Inception

Unlike highways, public transit systems do not connect to form a national system, since their scope is mostly local and regional. Consequently, the federal government long viewed transit systems as local and state interests. For much of the 20th century, these systems were operated by private entities subject to state and local regulation. During the 1960s, however, the federal government began providing state and local governments with aid for transit planning and for purchasing transit properties from the failing private companies. Coincidentally, the newly created Urban Mass Transit Administration [later renamed the Federal Transit Administration (FTA)] began sponsoring transit-related research, primarily to develop the technical knowledge needed to guide its growing financial contribution to transit infrastructure and equipment.

FTA's research filled a vacuum, but it was not enough. By the 1980s, transit systems across the country were experiencing a growing need for even more practical research to address the problems created by aging bus fleets, rail cars, and infrastructure. Transit systems that had been upgraded with the help of federal funds during the 1960s and 1970s were becoming more costly to operate and maintain. Transit agencies were eager to find ways to improve, even if only incrementally, their existing operations and equipment.

A 1987 TRB study committee consisting of transit operators and other research and industry experts noted the absence of problem-solving research in the transit industry. The committee concluded that new mechanisms were needed for such work to be undertaken in a continuing and concerted fashion (TRB 1987). It recommended that an operator-guided research program with many of the same characteristics as NCHRP be created and that transit operators take the lead in setting the program's research agenda through majority representation on the program's governing board. The committee proposed the creation of a cooperative research program that would be financed from a mandatory ½ percent set-aside of federal transit funding; would emphasize applied, problem-solving research; and would fill the gaps in FTA's technology-oriented R&D program.

With the collective support of the transit industry reached through the American Public Transportation Association (APTA), Congress authorized funding for a national Transit Cooperative Research Program in the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA; Public Law 102-240). The act called for the program to be governed by an independent board and managed by TRB.

In following through on the provisions of the act, FTA charged APTA with appointing TCRP's independent governing board under the auspices of the association's nonprofit Transit Development Corporation. Named the Transit Oversight and Project Selection (TOPS) Committee, the 24-member board consisted of 16 members appointed from public transit agencies and 8 appointed from transit suppliers, consultants, and universities. The committee was given responsibility to solicit research needs, formulate the annual research portfolio, and monitor project and program progress. TRB was tasked with managing the program in a manner simi-

lar to its management of NCHRP—by convening independent technical panels to select and oversee the work of outside contract researchers.

In authorizing TCRP, Congress originally specified funding for the program equivalent to 0.3 percent of total federal transit funding during the 6-year authorization period. Had this funding scheme been implemented, it would have provided the program with nearly $90 million in total, ranging from $8.9 million the first year (FY 1992) to $21 million in the last year of ISTEA authority (FY 1997). Congress appropriated $8.9 million for the program's first year. However, in subsequent years, it disregarded the original percentage formula and continued to appropriate about $8 million per year to the program. Appropriations over the 6 years were equivalent to about 55 percent of the original amount authorized.

TOPS organized the program into nine research fields ranging from transit operations to human resources and administration. It then held a series of workshops to identify and screen candidate research problems. TOPS allowed submissions of problem statements from all interested parties, including FTA, universities, and transit suppliers and consultants. This was a departure from the practice of NCHRP, which solicits problem statements only from state highway agencies, AASHTO committees, and FHWA. During its first 6-year authorizing period, TOPS received more than 800 project problem statements, and it was able to fund about 12 percent.

Like NCHRP projects, TCRP projects were designed to produce full reports, abbreviated digests of research results, and survey-based syntheses of practice. The first TCRP report, *Artificial Intelligence for Transit Railcar Diagnostics,* was published in 1994, and 138 reports of various kinds were produced during the program's first 6-year authorization.

## Program Today

In 1998, Congress reauthorized TCRP for fiscal years 1998 to 2003.[2] In doing so, it formally abandoned the idea of a percentage-based funding formula and, instead, set annual funding at "not less than $8,250,000." Hence, in real terms the program continued to experience a decline in

[2] Section 5338(d) of the Transportation Equity Act for the 21st Century, Public Law 105-178.

funding, which has fallen by more than 30 percent after adjustment for inflation since 1992.

Though it is federally funded, TCRP has remained an industry-driven and -guided enterprise. Without the active support and involvement of the transit industry, the program would not exist. Since 1992, TCRP has received approximately 1,600 problem statements, and about 32 percent of these statements have originated from public transit agencies. The second- and third-largest sources of project ideas are transit consultants (16 percent) and universities (13 percent). FTA has contributed about 10 percent of the project ideas. Problem statements are also routinely submitted by TRB standing committees, APTA committees, and state transportation agencies. For the most part, TCRP's open process for soliciting problem statements has proved successful in generating a diverse selection of project ideas.

Since its beginning, TCRP has funded more than 300 research projects. Table 5-2 summarizes the research output, which includes more than 100 published reports, more than 75 digests, and more than 50 syntheses of practice. Like NCHRP, TCRP emphasizes applied research, and its report titles often contain the words "handbook," "user manual," and "guidelines." It has also diversified its products and its means of dissemination to include Web documents, software, and CDs.

## LESSONS FROM NCHRP AND TCRP

NCHRP and TCRP are structured to find solutions to problems that are shared by operators of highway and transit systems, respectively. In the case of NCHRP, state highway agencies cooperate in identifying their common research needs and then voluntarily pool some of their federal-aid funds to address them. In the case of TCRP, the federal government provides direct funding for the program, but transit agencies are largely responsible for programming the research.

The two programs are thus guided by practitioners, who identify needed research, make sure the research agenda is focused on meeting these needs, and assist with the conduct of the research and the dissemination of the research products. One result is that highway and transit operators are imbued with a sense of ownership of the research programs.

**TABLE 5-2** Summary of Research Areas and Products of TCRP, 1992–2001

| Research Field | Problem Areas Covered | Number of Published Project Reports, Digests, and Syntheses[a] | Example Products |
|---|---|---|---|
| Operations | Scheduling, vehicle operations, control systems, fare collection, safety and security | 50 | Transit Scheduling—Basic and Advanced Manuals; Safe Operating Procedures for Alternative Fuel Buses; Integration of Light Rail Transit into City Streets; Emergency Preparedness for Transit Terrorism (synthesis of practice) |
| Service configuration | System planning, specialized services, service performance, marketing | 36 | A Handbook of Proven Marketing Strategies for Public Transit; Transit Advertising Revenues—New Sources and Structures (synthesis of practice); Workbook for Estimating Demand for Rural Passenger Transportation; ADA Paratransit Eligibility Certification Practices (synthesis of practice); Improving Public Transportation Access to Large Airports |
| Vehicle engineering | Buses, vans, rail cars, people-mover vehicles, vehicle components | 24 | Understanding and Applying Advanced On-Board Bus Electronics; Low-Floor Transit Buses (synthesis of practice); Hybrid-Electric Transit Buses—Status, Issues, and Benefits; Wheel and Rail Vibration Absorber Testing and Demonstration |
| Engineering of fixed facilities | Buildings, rail operating facilities, passenger stations, bus stops | 11 | Track Design Handbook for Light Rail Transit; Visual Impact of Overhead Contact Systems for Electric Transit Buses; Performance of Direct-Fixation Track Structure Design Guidelines and Software (available on CD) |
| Maintenance | Vehicle servicing, vehicle inspections, repairs, rebuilding, maintenance of facilities, maintenance management | 7 | Application of Artificial Intelligence to Rail Car Maintenance; Closing the Knowledge Gap for Transit Maintenance Employees; Demonstration of Artificial Intelligence for Transit Railcar Diagnostics |

*(continued on next page)*

**TABLE 5-2** (*continued*) Summary of Research Areas and Products of TCRP, 1992–2001

| Research Field | Problem Areas Covered | Number of Published Project Reports, Digests, and Syntheses[a] | Example Products |
|---|---|---|---|
| Human resources | Recruitment, training, job classification, salary administration, labor relations | 20 | Identification of the Critical Workforce Development Issues in the Transit Industry (research results digest); A Challenged Employment System: Hiring, Training, Performance Evaluation, and Retention of Bus Operators (synthesis of practice); Part-Time Transit Operators: The Trends and Impacts; Drug and Alcohol Testing—A Survey of Labor-Management Relations (research results digest) |
| Administration | Finances, procurement, risk management, law, management information | 16 | Alternative-Fuel Transit Bus Hazard Assessment Model (software on CD); The Role of Performance-Based Measures in Allocating Funding for Transit Operations (synthesis of practice); Measuring Customer Satisfaction and Service Quality—A Handbook for the Transit Industry |
| Policy and planning | Policy analysis, planning, economics, environmental analysis | 39 | Transit Capacity and Quality of Service Manual (Web document and on CD); Integrating School Bus and Public Transportation Services in Non-Urban Communities; Management Toolkit for Rural and Small Urban Transportation Systems; Improving Public Transportation to Large Airports |

[a] Through 2001.

Programmed by operators, the research is more likely to be responsive to the needs of the end users of research. Practitioners also serve on the expert panels that oversee and guide individual research projects. In this capacity, they help ensure that the research products are useful and strengthen the credibility of the research among users.

The programs differ mainly in the way they are financed. NCHRP is paid for by state highway agencies, who voluntarily contribute a percentage of their federal-aid funds. The contribution takes place after the federal funds have been appropriated by Congress, which gives the states exclusive control over NCHRP programming.[3] This funding approach has allowed NCHRP to grow over time at a rate commensurate with growth in the overall federal-aid highway program. States have the discretion to change funding levels as they see fit. TCRP, in contrast, receives funding directly from the federal government—essentially a line item in FTA's annual budget. Consequently, transit operators do not have control over the size of the TCRP research budget and must lobby for additional funds from Congress. While NCHRP funding levels have risen to allow the program to fund research on more than one-third of problem statements submitted by sponsoring highway agencies, TCRP's budget has remained static. It is now capable of funding research for about 1 of every 10 problem statements submitted by the transit industry.

The above experience could lead to the conclusion that NCHRP's funding scheme is preferable. However, TCRP serves a much more fragmented industry, which consists of thousands of operators, hundreds of which receive federal funds in any given year. Collecting voluntary contributions from these operators would be far more complicated and costly to administer than doing so for 50 state highway agencies. While relying on Congress to set aside federal-aid funds each year may have hindered the program in growing to a level desired by transit agencies, the option of voluntary contributions from hundreds or even thousands of transit operators may be unrealistic.

[3] Of course, FHWA has a stewardship role in ensuring that the federal funds are used for legitimate research purposes.

## EXAMPLES OF OTHER COOPERATIVE RESEARCH PROGRAMS

NCHRP and TCRP are well-known cooperative research programs, but they are not the only ones. The five other programs that are reviewed below offer alternative models for financing, governing, and managing cooperative research.

### Pipeline Research Council International

PRCI was established in 1952 by 15 natural gas transmission pipeline companies needing to solve the commonly encountered problem of brittle fractures in pipelines. Satisfied with the results of the initial research, the sponsoring companies continued the program and expanded the scope of research to cover other problem areas associated with the design, operations, and maintenance of pipelines. As the scope of the program expanded, other pipeline companies, including those carrying crude oil and petroleum products, joined PRCI as sponsors.

#### *Finance*

PRCI derives its revenues mainly from individual member subscriptions, which are calculated on the basis of transmission line mileage. Membership is open to all companies that own or operate pipeline systems anywhere in the world. The base membership fee is approximately $100,000 per year, plus $7 to $8 per line mile. Members join for 3-year subscriptions, which give them access to all PRCI research products.

Revenue generated from the subscriptions provides PRCI with about $12 million in core research funds. In addition, the program has been able to attract another $8 million in supplemental funding of individual research projects from member and nonmember organizations, including government agencies. Such cofunding allows nonmembers who may have a narrow area of interest to participate in the program on a periodic and selective basis. It gives them a stake in the program and frees more of PRCI's core research funds for other projects of interest to dues-paying subscribers.

#### *Governance*

Each subscribing company, regardless of the amount it pays in dues, is represented on PRCI's board of directors. The board, which currently

has 35 members, is responsible for setting PRCI's policies, establishing funding levels, and programming the research budget. The board meets twice each year and is supported by a nine-member executive committee that develops policy and program recommendations for action by the board. The executive committee also functions as a steering committee and exercises certain decision-making functions delegated by the board of directors.

***Management***

The planning, execution, and management of specific research projects is handled by six technical committees. The committees consist of technical representatives assigned by the subscribing companies. The committees cover the following areas: (*a*) materials; (*b*) design, construction, and operations; (*c*) corrosion and inspection; (*d*) compressor and pump station; (*e*) measurement; and (*f*) underground storage. In assessing research needs and determining funding for individual projects, the board of directors relies on recommendations from these technical committees, which meet three times annually.

The research is conducted by contractors selected by the technical committees and PRCI staff. The technical committees assign members to oversee the progress of specific research projects. These volunteers have an important role in project management because PRCI maintains a small support staff to assist with program administration, planning, and project management.

***Research Products***

Before the results of research are disseminated, they must be reviewed by the appropriate technical committee and approved by the board of directors. The emphasis is on ensuring that the research products are credible and can be applied immediately in the field by subscribing organizations. The following are examples of PRCI research products:

- *Pipeline In-Service Repair Manual,*
- *Design Guidelines for High-Strength Pipe Fittings,*
- *Criteria for Dent Acceptability in Off-Shore Pipelines,*
- *New Technique to Assess Level of Cathodic Protection in Underground Pipe Systems,*

- *Methods to Measure Wear in Pipeline Engines and Compressors,*
- *Pipeline In-Service Relocation Engineering Manual,* and
- *Compressor Station Maintenance Cost Analysis.*

As these examples illustrate, the results of PRCI research often take the form of practical products, such as manuals, guidelines, design criteria, and recommended practices.

## Electric Power Research Institute

EPRI was founded in 1973 as a nonprofit energy research consortium by electric utilities and their suppliers. The intent was to create a research program that would further understanding of issues pertinent to many entities in the electric power industry and to develop technologies, marketing methods, and training tools that could be shared widely.

### *Finance*

Participation in EPRI is open to all organizations involved in the energy industry, including all power utilities, power producers, energy service companies, engineering service companies, energy suppliers, transmission and distribution companies, and government organizations that sponsor or perform research. Program funding is provided through a mix of full and partial membership subscriptions, contributions on a project-by-project basis, and revenues from the sale of research and technology products. Larger utilities and energy suppliers tend to be full members. They subscribe to all products because their interests often cut across EPRI's research areas. Organizations with more selective interests, such as a design engineering firm, are more likely to contribute to specific research program areas and thus join as partial members. Anyone with a specific research interest may choose to provide supplemental funding for individual EPRI research projects in that area.

### *Governance*

EPRI is guided by two boards. The board of directors is composed of representatives from 30 subscribing organizations. This board oversees management of EPRI's affairs and activities. It approves the financial

plan and proposes the annual research program. A second board consists of 24 individuals from public utility commissions, environmental groups, universities, and public agencies. Its role, which is more advisory in nature, is to review the proposed research program and counsel the board of directors on ways to better address environmental, societal, and public policy issues through research. Since many electric utilities are publicly regulated, this advisory board's role is to ensure that the funds contributed to EPRI are used wisely.

***Management***

The EPRI staff, headquartered in Palo Alto, California, consists of scores of scientists and engineers who manage hundreds of ongoing projects. The projects are performed by contractors, including equipment suppliers, public and private laboratories, universities, and independent research organizations. The staff is also responsible for overseeing projects cofunded by EPRI in collaboration with other research organizations.

***Research Products***

EPRI research projects cover a wide spectrum of needs, from the development of specific products to scientific research on the health and environmental effects of electricity production. As an example of the former, EPRI projects have developed computer software to design and operate energy delivery systems. As an example of the latter, projects have examined the science and policy implications of such issues as electromagnetic field effects and global climate change.

## Construction Industry Institute

CII conducts cooperative research for more than 90 member organizations from the construction field, including contractors, architectural firms, and materials and service suppliers. Some public agencies with construction responsibilities, such as the U.S. Army Corps of Engineers, also participate. It was established in 1983 in response to a study by the Business Roundtable, which recommended more collaborative research to improve the performance of the construction industry. It sponsors mostly university studies of ways to improve the planning and execution of major construction projects.

***Finance***

Projects are funded primarily from dues paid by CII members. Most research is funded as part of joint ventures and partnerships with other organizations to maximize the number of projects financed through member dues.

***Governance***

A board of advisors sets the institute's research agenda and oversees all program activities. Each subscribing member is entitled to voting membership on the board, which meets twice per year. An executive committee develops recommendations for action by the board and is delegated certain routine decision-making responsibilities. Inasmuch as the board is responsible for setting the research agenda, the parties paying for the research have a direct role in ensuring that the program focuses on their needs and concerns. If the research does not provide useful results, the sponsors can withdraw funding.

***Management***

The board of advisors selects the members of the committees, teams, and councils of CII. These bodies oversee specific research projects and review the end results before approving dissemination to subscribing members. While the projects themselves are conducted by university researchers, CII maintains a small professional staff to administer the program, disseminate the reports, and arrange special functions such as conferences. CII operates from the University of Texas at Austin.

***Research Products***

Results from CII research are intended to be highly practical and readily translatable into improvements in construction practices. Examples of research products include reports on innovative crew-scheduling techniques, contractor compensation strategies, processes for environmental remediation management, tools for materials management, and design for maintainability. The products are often titled as guidebooks, workbooks, tool kits, and best practices. This reflects the emphasis of the program on providing end products that are of direct relevance to CII subscribers.

## Health Effects Institute

HEI is a nonprofit research program sponsored jointly by the Environmental Protection Agency (EPA) and more than two dozen automobile manufacturers and parts suppliers. It was chartered in 1980 to conduct impartial scientific research on the health effects of motor vehicle emissions. The joint participation of industry and government in the program and the processes described below to ensure research objectivity and credibility were viewed as essential in providing the information needed to support regulatory decisions and their acceptance.

### *Finance*

HEI receives about half its funds from EPA and the other half from the cosponsoring automotive companies. Sometimes additional funds are obtained from public and private sources to help finance specific projects.

### *Governance*

HEI is guided by a governing board of six to eight members made up exclusively of prominent individuals from outside the automotive sector who are believed to be independent and beyond reproach. This board serves largely in a stewardship capacity for the program. Its members are not direct users of the research, which is a difference from the governing boards of the other cooperative programs described above. This third-party form of governance has the advantage of shielding HEI from concerns that its research is biased or advocacy oriented. Objectivity is an especially important quality for research aimed at influencing policy, especially in contentious matters such as environmental and health policies that can have significant economic implications.

### *Management*

Most of HEI's research is conducted by researchers at universities and research centers, both in the United States and abroad. The research program is developed and overseen by two independent scientific committees. The Health Research Committee works with the institute's scientific staff to develop and manage HEI's research program. The Health Review Committee, which has no role in selecting or overseeing studies, works with the institute's scientific staff to evaluate and interpret the results of HEI studies and related research.

### *Research Products*

HEI has sponsored more than 170 studies and published more than 100 reports since its founding. Much of the research has been aimed at expanding the base of knowledge in subject areas related to automotive emissions and human health. Examples of HEI reports include *Effects of Methanol Vapor on Human Neurobehavioral Measures, Nitrogen Dioxide and Respiratory Illness in Children, Methods Development for Epidemiologic Investigations of the Health Effects of Prolonged Ozone Exposure,* and *Development of Samplers for Measuring Human Exposure to Ozone.* Collectively, this research is intended to expand the knowledge base to inform public policies. Individual research projects are rarely designed to address pending regulatory matters.

## RSI-AAR Railroad Tank Car Safety Research and Test Project

Since 1970, two major railroad trade associations, RSI and AAR, have cosponsored the Railroad Tank Car Safety Research and Test Project. The purpose of this research program, established after a series of fatal tank car accidents during the 1960s, is to gain a better understanding of the causes of tank car releases of hazardous materials during accidents and to develop engineering countermeasures.

### *Finance*

RSI and AAR provide the funds for the program, including financial resources and in-kind contributions of test facilities and staff support. The annual program budget varies but is generally under $750,000. Each year, RSI and AAR develop research objectives and a budget. RSI contributes 77 percent and AAR contributes 23 percent. Often these funds are augmented by contributions for specific research projects from third parties such as the Federal Railroad Administration (FRA), Transport Canada, and other industry associations.

### *Governance*

Approval of the budget and general oversight of research activities are responsibilities of the Project Review Committee, which consists of the presidents of the six supporting RSI members and three AAR representatives. The chairmanship of the Project Review Committee rotates

among the RSI representatives, while an AAR representative serves as vice chairman.

***Management***

Direct oversight of the program is handled by the RSI Engineering and Technical Subcommittee and AAR technical staff. All program activities are managed on a day-to-day basis by a project director. When the project began in 1970, it had a full-time research staff. Today all research is performed by contractors and the project director.

***Results and Products***

During its more than 30 years of existence, the project has played an important role in determining the predominant causes of tank car failures and in identifying measures to reduce and mitigate failures. Its focus from the start was on developing an extensive accident database for use in identifying the causes of releases from tank cars and on assessing protections such as head shields, shelf couplers, and thermal insulation. The database now contains information on more than 39,000 tank cars damaged in more than 25,000 incidents and continues to be important for informing decisions on tank car operating practices, designs, and safety regulations. In recent years, the project has augmented the accident data with other databases, including detailed records of tank car inspection results.

The project's ability to quantify safety problems and the effects of various safety proposals has led to informed decisions on a variety of issues, such as the steels used in tank cars and the protections afforded environmentally hazardous chemicals moved by tank car. Results of the project are widely viewed by industry and government regulators as comprehensive and credible. Consequently, the project is often called on to conduct other research with cofunding from FRA and other government agencies. Examples of such research are full-scale crash tests, examinations of alternative tank car inspection methods, and the collection of data on tank car in-service loads and impacts. Such collaboration not only enables the leveraging of research funds but also produces greater acceptance of the results by industry and government.

## SUMMARY

The seven cooperative research programs reviewed in this chapter suggest a number of ways to organize and structure a cooperative research program for hazardous materials transportation. Variations among the programs in financing, governance, and management reflect differences in program size and mission, the nature and structure of the industries involved, and the roles of the public and private sectors. Some characteristics are shared across all of the programs, as noted below.

### Finance

Most of the programs are financed in a pooled manner by multiple sources. In some cases, such as NCHRP, many public entities (states) contribute funds to the program. In other cases (e.g., CII, PRCI, EPRI, and the RSI-AAR Railroad Tank Car Safety Research and Test Project), most of the program funds are pooled by private entities. One program, HEI, is paid for mainly through a combination of private- and public-sector funds. TCRP is the only program that is funded through a single source, an annual appropriation by Congress.

Having reliable means of financing is important to all of the programs for year-to-year continuity of the program and in maintaining a competent professional staff to administer the program. However, all of the programs accept additional funds from supplemental sources on a project-by-project basis. Such supplemental funding offers a way to leverage and enlarge the total amount of resources available for R&D. Reliance on voluntary financing—both core and supplementary—can ensure that the program will be efficient and responsive to the needs of the main users of the research.

### Governance

In most cases, the financing of the cooperative research programs has a direct bearing on how the programs are governed. For the most part, the sponsoring entities are charged with guiding and overseeing the program. These functions include defining the research agenda and evaluating the effectiveness of the research in meeting sponsor needs. All of the programs are directed by a governing board of one kind or another. In all but two

cases, TCRP and HEI, members of the governing board are drawn predominantly or entirely from the organizations pooling the funds. In this way, the sponsors have direct control over the program, an arrangement that tends to result in research that is highly practical and applied in nature.

In the case of TCRP, funding is provided by Congress, but the governing board consists primarily of transit agencies, who are the users of the research. This results in a program that emphasizes applied research. Transit agencies are the driving force behind continued funding of TCRP by Congress. In the absence of this transit agency support, the federal research funds might well be used for other federal transit programs. HEI is unique among the cooperative programs in that its governing board consists of individuals with no links to the industry or government sponsors of the program. The board acts in a stewardship role, which is deemed necessary for a research program focused primarily on advancing the science underpinning public policy.

## Management

All of the cooperative programs are structured to produce research that is fair and objective. Credibility is essential for research that will be used to inform policy and regulatory decisions and to support standard-setting and industry practices. To ensure that the research is performed with a high degree of technical competence, the cooperative research programs contract the majority of their work on a competitive basis to qualified research organizations. Reliance on contract work, as opposed to investing in in-house research staff and facilities, allows for the appropriate expertise to be drawn on and has the advantage of allowing more flexibility in the kind of research performed as priorities change from year to year.

Most of the programs have technical committees that oversee the contract work on a project-by-project basis from beginning to end, including technical peer review. Because of the involvement of the users of the research on these project committees, projects are more likely to yield results that are practical. Indeed, the members of the technical and oversight committees serve as links between the researchers and the users of the research, which facilitates the dissemination of research products.

The organizations charged with managing the programs vary from large stand-alone institutions established specifically for the program

(e.g., EPRI, PRCI) to administration by universities (CII) and established research institutions (TCRP, NCHRP). With the exception of the smaller RSI-AAR program, the cooperative programs are administered by neutral parties whose main mission is research. A management organization that is viewed as unbiased and focused on sound research has the advantage of being perceived as neutral by the parties that are likely to use the research results.

## REFERENCES

***Abbreviations***

| | |
|---|---|
| AASHO | American Association of State Highway Officials |
| HRB | Highway Research Board |
| TRB | Transportation Research Board |

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# 6

# Options for Program Finance, Governance, and Management

As indicated in Chapter 1, the central aims of this study are to

- Determine whether there is a need for a national cooperative research program for hazardous materials transportation;
- Examine possible ways of structuring a cooperative research program, in part by drawing on the experience of other programs in financing, governing, and managing cooperative research;
- Identify options for program finance, governance, and management; and
- Offer practical advice on whether and how best to pursue a cooperative research program for hazardous materials transportation.

Much of the report so far has focused on the first two aims: assessing the need for a program and examining ways of structuring a program.

Chapter 5 discussed the experiences of several long-standing cooperative research programs within and outside the transportation sector to gain insight into possible ways of structuring such a program for hazardous materials transportation. Program financing possibilities range from voluntary contributions by individual organizations to annual federal appropriations. There are likewise many possibilities for governing and managing a cooperative research program.

This chapter attempts to go a step further by examining several specific options for financing, managing, and governing a cooperative research program for hazardous materials transportation. The options presented are not comprehensive, but they cover a range of approaches. The advantages and disadvantages of each are described in light of insights gained from reviewing other cooperative research programs. The committee offers its advice on which, if any, of these approaches should be pursued in Chapter 7.

## FINANCE OPTIONS

The experience of other cooperative research programs suggests that program finances should be

- Generally predictable from year to year, which will allow for program continuity and longer-range planning of research;
- Capable of supporting multiyear research projects and covering areas of interest to a broad range of stakeholders in the hazardous materials sector;
- Structured so that users of the research develop a sense of ownership of the program and have a stake in ensuring that the program yields useful results; and
- Structured to create incentives for program efficiency.

Three options for program finance are reviewed below. The first two are patterned after finance approaches in other cooperative research programs. The third is more specific to the hazardous materials sector and posits the use of an existing revenue source to help finance the program. It illustrates how program financing can entail difficult and sometimes controversial choices. The three options are

1. Federal sponsorship through annual appropriations;
2. Voluntary pooling of funds by many organizations, including federal agencies, private companies, trade associations, and state and local governments; and
3. Revenues raised from federally imposed and broadly based user fees, exemplified by the Hazardous Materials Registration Fee.

All three of these options are presumed to be the main means of financing the program. In each case, supplemental sources of funds could be sought for particular projects of interest to individual government agencies, private companies, or other users. However, a program with excessive or exclusive reliance on project-by-project funding could become difficult to sustain and administer and subject to large fluctuations in program activity and resources. Furthermore, to ensure the credibility of the research and encourage broad participation rather than

specialization, the core funding should be insulated from special interests to the extent possible.

## Option 1: Federal Appropriation

In this option, Congress is assumed to authorize the creation of a cooperative research program and to finance it through annual appropriations administered through one or more federal agencies. It is modeled after the funding approach used for the Transit Cooperative Research Program (TCRP) and administered through the Federal Transit Administration. Federal funding in this way could be justified on the grounds that ensuring the safety and security of hazardous materials transportation is in the national interest.

On the basis of TCRP experience, the following are advantages of this approach:

- Deriving funds from a single source (i.e., Congress) limits the administrative burden of collecting funds, especially in comparison with funding by multiple sources.
- Federal funding may sustain a core program and prove helpful in attracting supplemental funding by others.
- Federal funding may be perceived as ensuring program objectivity and broader coverage of research needs within the hazardous materials sector, including the needs of those with limited means of financing the program, such as local public safety agencies.

The following are disadvantages of this approach:

- It is subject to the year-to-year uncertainties associated with the federal budget process and the changing priorities of federal decision makers.
- The earmarking of funds to specific projects could dilute both the funding total and the integrity of the research selection process.
- Federal agencies may view the program as competing for scarce research funds.
- Those charged with administering the funds may seek to control the program agenda.

- In not paying for the program directly, prospective users of the research may have limited incentive to commit time and energy to the program, which could weaken stakeholder involvement.

## Option 2: Voluntary Pooling of Funds

In this option, the likely users of the research are assumed to finance a program through the pooling of funds on a voluntary basis. The sponsors may be federal agencies with direct responsibility for hazardous materials safety and security, including the Research and Special Programs Administration, the other operating agencies of the Department of Transportation (DOT), and the U.S. Coast Guard and other agencies of the Department of Homeland Security. Core sponsors from the private sector might include large shippers and carriers of hazardous materials and their industry associations, such as the Association of American Railroads, the American Trucking Associations, and the American Chemistry Council. Other potential sponsors from government might include state and local agencies responsible for enforcement and emergency planning and response.

Models for such a voluntary approach for pooling program funds include the National Cooperative Highway Research Program (NCHRP), the Construction Industry Institute (CII), the Health Effects Institute (HEI), and the Electric Power Research Institute (EPRI).

The following are among the advantages of this approach:

- Ownership of the program by end users will ensure that they take a strong interest in the efficiency of the program, its responsiveness to real problems and needs, and the dissemination of results.
- Funding by multiple contributors will help ensure a varied research agenda with problems framed and addressed from multiple perspectives. No single entity will be able to exert disproportionate influence on the program.
- Year-to-year fluctuations in the contributions of any one sponsor or subset of sponsors may not threaten the financial viability of the program if there is a large base of voluntary contributors.

Among the disadvantages of this approach are

- The potential for significant administrative costs associated with seeking and collecting contributions from multiple sources, especially if the funding base is broad;

- Limits on the legal or financial ability of some organizations to contribute, including federal agencies, which may require congressional authorization to make regular contributions; and
- The real-world problem of "free riders"—those who are capable of contributing to the program but who will not do so if their access to the research results is unrestricted.

### Option 3: Broad-Based Financing by a User Fee

This option is a derivative of Option 1, under which Congress authorizes a program and appropriates funds. In this case, it is assumed that the funds are derived from revenues tied directly to the hazardous materials transportation sector. In Option 1, no specific source of funds is identified, and the choices that would need to be made in funding priorities are therefore neglected. Option 3 goes a step further by identifying a source of funds to illustrate the choices required in federal financing.

The Hazardous Materials Registration Fee Program is discussed briefly in Chapter 2. Congress requires most shippers and carriers of hazardous materials and wastes to file an annual registration statement with DOT. By law, DOT is allowed to set a registration fee of between $250 and $5,000 per year. It has elected to do so by using a two-tier formula that distinguishes between large and small businesses. Of the approximately 40,000 companies that register each year, about 85 percent are defined as small businesses and subject to a lower registration fee. The registration fee is currently $300 per year for small businesses and $2,000 per year for others. The fee generates about $13 million per year. The funds generated from the fee are used for various purposes; the main use, as required by Congress, is to fund the Hazardous Materials Emergency Preparedness (HMEP) Grant Program. States and localities apply for these grants to enhance emergency planning and training activities. Consideration is given here to using these registration revenues to fund a cooperative research program by either using a portion of the revenue generated from existing registration fees or raising the fee to yield supplemental revenue to help pay for the program. In either instance, congressional action would be required to allow this alternative use of registration fee revenues.

The Hazardous Materials Registration Fee Program offers a way to approximate the user fee needed to pay for a cooperative research program

of varying size. Each $1 million that would be used to pay for a cooperative research program would be equivalent to 1/13th, or about 7.7 percent, of the funds now raised through the Hazardous Materials Registration Fee Program. This percentage is equivalent to $23 of the $300 registration fee paid by small businesses and $154 of the $2,000 registration fee paid by others. Hence, raising the fee by about 8 percent, or $25 for small businesses and $150 for others, would generate about $1 million in annual revenues for cooperative research without reducing funds available for hazardous materials planning grants. Increases in the fee could be weighted toward larger businesses to avoid burdening small businesses.

Among the advantages of a user fee approach to program financing are

- The potential for year-to-year reliability in program funding, especially if the fees are placed in a trust fund for use in research;
- A strong sense of ownership of the program by a cross section of the hazardous materials transportation community that contribute fees;
- Spreading of the cost burden of the program, especially if the fee covers carriers, shippers, container manufacturers, and others in the hazardous materials industry that would benefit from the research; and
- The establishment of a connection between those who create societal risks by causing the transport of hazardous materials and the contribution to research aimed at reducing these risks.

The following are among the disadvantages of this approach:

- Collecting the user fee could be administratively burdensome unless an existing fee structure and program are used.
- Those required to pay the fee are likely to raise objections to it unless they are assured that the revenues generated will indeed be used to meet practical research needs and that the fee will not become onerous.
- State and local emergency planners can be expected to object to use of the Hazardous Materials Registration Fee for funding if this approach threatens funding levels for the HMEP Grant Program.

## GOVERNANCE OPTIONS

Most research programs are guided by a well-articulated mission. It may be to find practical solutions to pressing problems or to further the understanding and knowledge needed for longer-term problem-solving

or technological advancement. Keeping a program focused on its core mission can be challenging and is often the responsibility of a governing board. Much like the board of directors of a corporation, this body's role is to establish the policies and strategic direction of the research program so that it can best achieve its mission. The governing body of a research program typically has the following overarching responsibilities:

- Establish the program's strategic goals and monitor the program's progress toward those goals.
- Ensure that processes are in place to produce sound research.
- Articulate expectations about research products and their dissemination.
- Engage with other research and development programs that have complementary functions.

Setting up such a governing board would require many decisions concerning who will appoint the members, the size and composition of the membership, and board voting and decision-making procedures. Such organizational details are not fully explored here, but they are nevertheless important. Whatever form the board takes, its composition must reflect the program's core mission; if the mission is to produce solutions to pressing problems in the field, then having a significant number of board members drawn from industry and other users of the research results is desirable. A key responsibility of the governing board is to ensure ample involvement of the users of research in all phases of the program. Hence, the participation of users on the governing board will be crucial if the program is to produce results that will be widely accepted and applied.

The cooperative research programs reviewed in this report offer various models of governing boards. Each is structured differently, but all have many of the same basic roles and responsibilities. The following options are considered here:

- Governance exclusively by those sponsoring the program,
- Governance by a broad base of users of the research, and
- Governance by a third party acting in a stewardship capacity.

While many forms of governance are possible, these three are helpful in illustrating a wide array of pros and cons associated with various options.

A comparison of them indicates the importance of carefully structuring governance to reflect program aims.

### Option 1: Governance Exclusively by Program Sponsors

NCHRP provides a model of a governing board made up exclusively of organizations contributing program funds. Some other cooperative research programs are governed in a similar manner, including CII and the Pipeline Research Council International. This model confers the strong sense of ownership that is desirable in engaging the user community and ensuring that the program remains focused on meeting user needs. In effect, those who sponsor the program are also responsible for ensuring its success. A disadvantage of this approach is that the helpful views and expertise of nonsponsors may be neglected. For example, a cooperative research program sponsored and governed exclusively by industry or federal agencies might sacrifice the insights and expertise of state and local emergency response agencies that do not have the means to help sponsor the program.

### Option 2: Governance by a Broad Base of Users of the Research

The governing board of TCRP is composed mostly of transit system operators, but it is supplemented by many other public transportation interests, including federal agency officials, transit suppliers, and university researchers. Because Congress appropriates all of the funds for the program, none of the members of the TCRP governing board can be described as a direct financial sponsor of the program. The stakeholders' sense of ownership is therefore instilled through TCRP's inclusive form of governance, which has other advantages as well. In particular, the participation on the governing board of university researchers and federal agencies, in addition to transit operators, provides an avenue for additional perspectives and expertise, enlarges the scope of ideas for research, and broadens support for the program. A disadvantage of such an open form of governance is that the program's research focus could become diluted over time and drift away from seeking solutions to the practical problems of transit agencies. This has not proved to be a problem for TCRP, where transit operators constitute a slight majority of the governing board's members.

### Option 3: Governance by a Third Party Acting in a Stewardship Capacity

Perhaps the model that differs the most from the two user-oriented models described above is third-party governance. HEI offers such a model. It is guided by a governing board of distinguished individuals drawn from outside the industry and field of research. HEI board members are not direct users of the research. They serve in a stewardship capacity. Their main role is to ensure the objectivity and credibility of the research program, since the results are intended to influence public policy. This method of governance runs a risk that the program will become remote to the needs of users of research. To overcome this potential drawback, EPRI has instituted what might be described as a hybrid form of governance. One governing board consisting exclusively of program sponsors proposes the research agenda, while a second advisory board consisting of public interest groups and other nonsponsors reviews the proposed agenda and offers additional views on research needs. An advantage of this mixed approach is that it expands the perspective on problems needing research. A disadvantage is that multiple boards run the risk of becoming unwieldy, slow to make decisions, and costly to organize and administer.

## MANAGEMENT OPTIONS

Depending on the structure, size, and mission of the program, the entity charged with managing it will have many responsibilities such as processing contracts and research agreements, supporting and arranging meetings of the governing board and any technical panels formed for individual projects, administering program funds, and disseminating the results of research. How well the program is managed will affect user confidence in the objectivity and soundness of the research.

The choice of a host organization to fulfill these management responsibilities will involve a number of considerations. Among them are the following:

- Can the management organization coordinate the involvement of many stakeholders while being perceived as fair and not having an inherent bias toward one group or industry segment?

- Is the conduct of research an important mission of the management organization and thus likely to be accorded priority, or is research a side activity that may be viewed as a distraction from the organization's main mission?
- Can the organization bring administrative and technical expertise to bear from a range of disciplines that will be needed to define, oversee, and ensure quality control for research projects covering many problem areas?
- Can the organization disseminate research results through a wide variety of means that will be accessible to users?

Numerous other issues would have to be considered in selecting an organization to manage the program. For instance, the organization may need legal authority to accept and administer federal funds. If a new organization is to be established to manage the program, consideration must be given to the start-up expenses and time associated with creating it and to the challenges associated with building trust within the research and user communities. Another consideration is whether the program is best managed in a centralized way by a single entity or under a more decentralized format, such as a consortium of research institutions.

The cooperative research programs examined in this study are managed in a number of ways. Each offers a model for hosting and managing a hazardous materials transportation cooperative research program. The three organizational options considered here are management by

- A research management organization;
- A nonprofit trade, educational, or professional society; and
- A university or university consortium.

## Option 1: Research Management Organization

Both NCHRP and TCRP are managed by the Transportation Research Board (TRB) of the National Academies, an independent, nonprofit research organization widely recognized as impartial by the research community and government. Because TRB's core mission is to facilitate the conduct of research and the dissemination of results, it has a staff of research managers and an extensive publication and dissemination capacity. It has developed a wide constituency in the research and prac-

titioner communities. These are advantages that using an existing independent research management organization can bring in administering the program. A disadvantage of this approach is that maintaining a professional staff and publications capacity can be expensive.

A related option is to create a new stand-alone organization to manage the research program. The overall structure and management processes of such an organization could be tailored to fit the specific needs of the cooperative research program. New organizations, unencumbered by past associations, have the opportunity to build confidence and trust within the user community. A disadvantage is that creating such a new organization can entail significant start-up time and costs. Gaining name recognition, establishing ties within the stakeholder communities, and building user confidence in the research processes and products will take even more time.

### Option 2: Nonprofit Industry, Professional, or Educational Association

The cooperative research program could be managed by an existing nonprofit industry, professional, or educational organization. Examples of the first are the Association of American Railroads and the American Chemistry Council. Examples of the second and third are the International Association of Fire Chiefs and the Dangerous Goods Advisory Council, both of which provide training and education on hazardous materials. Organizations such as these,[1] with established ties to important parts of the hazardous materials community, can use their connections to ensure stakeholder participation in the research and to disseminate research results through their ongoing training programs, conferences, and publications.

The widespread recognition and participation among stakeholders that such industry organizations enjoy are advantages of this management option. However, most of these organizations lack a core research mission and an accompanying management structure that would support a significant research program. Each would need to make a substantial investment in research management staff and quality control methods.

[1] See Chapter 2 for a description of several organizations with prominent roles in the hazardous materials transportation sector.

Perhaps more important, the missions and constituencies of professional, educational, and industry associations are often narrow. Some have advocacy missions, and their study methodologies and results may be perceived as being biased toward association positions. A cooperative research program must engender the confidence and attract the participation of individuals and organizations from a range of stakeholder groups. Management by an organization associated with a narrow set of interests could prove problematic in achieving this outcome.

### Option 3: University Management

The nation's universities present another option for managing a cooperative research program. The research program could be administered by a single university research institute or by a consortium of institutes with some centralization of management. Universities manage everything from small research programs to national laboratories. This option has the advantage that research is a core mission of universities, and the results of university research are generally viewed as sound and objective. However, close ties to the stakeholder communities, which are essential for an applied research program, are not normally associated with the university setting. Another possible drawback is that university researchers are themselves likely candidates to perform much of the research. Conducting research, rather than managing and disseminating it, tends to be the strength of universities. The mixing of these roles may prove counterproductive to ensuring that the best-qualified researchers are available to the program.

## SUMMARY

Finance, governance, and management stand out as important features of existing cooperative research programs.

Whatever financing approach is used in a future hazardous materials cooperative research program must yield fairly predictable streams of revenue at levels that can sustain a program covering a wide array of research topics of interest to a broad base of users. If users of the research help pay for the program, they are more likely to develop a sense of program ownership that prompts an interest in and commitment to the program.

How a program is governed will be determined in large part by how it is financed. Program finance and governance cannot be viewed separately. Those paying for the program are likely to demand a prominent role in governing it. The governance of the program should ensure that the program produces high-quality research and that the research results meet the needs of users and are disseminated to them. The program must receive strong guidance from those who understand the problems needing research and who are in a position to use the research results. Achieving this outcome may require a role in program governance by those users of research who cannot contribute finances to the program but can offer important perspectives on research needs and can implement the results.

Effective management is essential to the success of the program. The organization managing the program will need to be capable of coordinating the involvement of many stakeholders and should be perceived as fair and as lacking a bias toward one group or industry segment. It will need to be able to bring to bear administrative and technical expertise from a range of disciplines to define, oversee, and ensure quality control for research projects covering many problem areas. It will need the capability to disseminate research results through a wide variety of means accessible to a diverse body of users.

# 7

# Envisioned Program and Next Steps

This chapter presents the committee's conclusions about the need for cooperative research in the field of hazardous materials transportation, its vision for structuring a national program to help meet this need, and its recommendations for bringing about such a program.

## MOUNTING NEED FOR COOPERATIVE RESEARCH

The committee concludes that cooperative research for hazardous materials transportation is more than a good idea in principle. It has become essential to managing the complex risks associated with hazardous materials transportation on a systemwide basis. Prompting this conclusion are the following findings:

- *Safety, security, and environmental concerns associated with the transportation of hazardous materials are growing in number and complexity.*

Hazardous materials are substances that are flammable, explosive, or toxic or have other properties that would threaten humans if released. The threat stems not only from accidental releases but from a concern that terrorists will target these materials to cause harm to public health and safety and to the economy.

More than 15 percent of the freight tonnage moved in the United States is regulated as hazardous by the Department of Transportation. The challenge of ensuring the safety and security of hazardous materials is complicated by the large volume and ubiquity of these shipments, which are found in nearly all modes of transportation, all regions of the country, and all segments of the economy. Ensuring safety and security is necessary because many of these materials are vital to commerce and the daily lives of Americans.

Federal involvement in the regulation of hazardous materials transportation began nearly a century ago. The original purpose was to protect the public from the dangers of catastrophic accidents, mainly from fires and explosions involving a small range of volatile materials transported in large quantities by rail. The range of concern gradually expanded to include materials whose main risk is to transportation workers and emergency personnel responding to a crash or accidental release. During the past three decades the scope of concern has expanded to include materials whose release may harm the environment or present long-term risks to human health. Of particular concern today is the potential for hazardous materials to be used as an instrument for terrorist attack.

- *Managing the risks associated with the transportation of hazardous materials is necessarily a joint effort involving many entities from industry and government.*

Ensuring the safe and secure transportation of hazardous materials requires the efforts of carriers in nearly all modes of transportation, shippers of a wide range of products, and government agencies at all jurisdictional levels. The main responsibility is that of shippers and carriers, which follow their own good practices and long-standing rules and standards put in place by industry, the federal government, and international bodies. Because releases in transportation occur on occasion, this responsibility extends to state and local police and fire officials, who are often first to arrive on the scene of a release and who must act quickly to minimize harm. Moreover, state and local authorities must work with industry and federal agencies to ensure the security of those shipments passing through critical infrastructure and population centers. Even within the federal government, more than a dozen agencies have regulatory, enforcement, operational, and other responsibilities pertaining to hazardous materials transportation. All of these entities have much at stake in providing a safe and secure system for transporting hazardous materials.

- *Few means are available for the parties responsible for hazardous materials transportation to work together in seeking solutions to shared and related problems.*

All parties responsible for the transportation of hazardous materials require information to support their decisions. Which routes and modes

of transportation are safest, most secure, and pose the least risk to the environment? Which materials are suited for which type of packaging? Which emergency preparations are most prudent given the nature of the materials passing through the transportation system? Which shipments merit extra security attention? These are examples of the kinds of decisions that industry and government must make on a regular basis.

Such decisions are often made independently by thousands of public and private entities, but their ramifications can be far-reaching. Decisions to move hazardous materials in one mode versus another, for example, can affect the emergency preparations needed in various parts of the transportation system and in the communities in which the transportation facilities are located. Changes in material packaging requirements can lead to the diversion of hazardous cargoes to different transportation vehicles, modes, and routes, which may have safety and security implications.

Good decisions demand good information. They require data and analytic tools for weighing options and understanding causal relationships and systemwide effects. The promise of a cooperative research program is that it will allow such problems to be addressed from a wider range of perspectives. It will allow the consolidation of resources to seek solutions more efficiently, as opposed to piecemeal and duplicative efforts. It will lead to greater acceptance of research results by the many entities involved because each will participate in the process. And it will lead to more widespread dissemination of the results and their use in the field. By cooperating in the setting of the research agenda and in guiding individual research projects, the diverse parties responsible for hazardous materials safety and security will have a dependable way to work together in finding solutions to their problems.

## GUIDEPOSTS IN STRUCTURING A COOPERATIVE PROGRAM

The experience of cooperative research programs in other fields suggests that for such a program to be successful for hazardous materials transportation, it should involve a broad array of likely users of the research to guide and govern the program, set the research agenda, oversee individual research projects, and disseminate the end products of research.

Users of the research must have a sense of ownership of the program. Carriers, shippers, and emergency responders are important end users of the research. They must be convinced that their problems and research needs are being addressed by the program and that their expertise and perspectives are being brought to bear. The results of the research are not only more likely to be accepted under these circumstances but more likely to meet actual needs.

Existing cooperative research programs indicate that a sense of ownership cannot be conveyed by simply offering stakeholders an advisory capacity or other indirect role in program development and guidance. It must be instilled in a more comprehensive manner, from the way the program is financed and governed to how it is managed.

## Finance

Direct financing of the program by stakeholders is desirable because it establishes program ownership in the most straightforward and tangible way. Those who sponsor the program are most likely to participate in it and remain engaged. In helping pay for the research, they will have a strong incentive to ensure that projects are targeted to meet their needs, practical to implement, and widely disseminated within their respective communities. Therefore, it is important that sponsors not be drawn from a single industry group or segment. In that case the program could gravitate to a narrow set of interests and lose the perspectives of many parties.

Experience suggests that some form of federal involvement in program financing may be needed to ensure broad-based participation by stakeholders, especially those without the means to contribute to the program. The nature of federal involvement may range from the collection of revenues from stakeholder groups to pay for part of the program to an appropriation of general funds to pay for all or part of the program. At least some government involvement in program financing can be justified because research can lead to improvements in the efficiency and overall performance of government regulatory, planning, and operating activities pertaining to hazardous materials transportation, including the performance of emergency response. Another rationale is that the public as a whole will benefit from safety and security improvements gained through cooperative research. Still, there are equity grounds for deriving

at least some of the funds from industry stakeholders, since they cause the transport of hazardous materials in the first place and thus create the underlying risks that cooperative research will seek to alleviate. Coupling funding of the program with its governance creates the sense of ownership and commitment that has proved to be so important to making cooperative research programs work.

## Governance

Those who finance the program will have much to say about how the program is governed. Indeed, the sponsors can be expected to demand a prominent role in setting the annual research agenda, overseeing performance, and guiding the overall direction of the program. Most cooperative research programs have established governing boards that serve in this capacity. A governing board made up largely of program sponsors can be expected to pay close attention to program performance. In this regard, such an approach is ideal. However, where there is a diverse set of stakeholders with important perspectives but varying financial resources, it may be advantageous to involve nonsponsors in program governance. Such is likely to be the case for hazardous materials transportation. In particular, state and local emergency planning and response organizations may not have the means to help finance the program, but they would need to participate in its governance.

## Management

How the program is managed on a day-to-day basis, as well as the design and functioning of the research process itself, is integral to the success of the program. The experience of other cooperative programs indicates that research that is conducted and managed in an independent manner will engender the confidence of the stakeholders who will be expected to use the results. Competition in the awarding of research contracts and peer reviews of completed work are common features of successful cooperative programs. The organization managing the program must therefore be able to coordinate the involvement of many stakeholders. At the same time it must be perceived as fair and as not having an inherent bias toward one

group or industry segment. It must be able to draw technical expertise from a range of stakeholder groups and disciplines to define, oversee, and ensure quality control for research projects covering many problem areas. And it must be able to disseminate research results widely.

## ENVISIONING A FULL-SCALE PROGRAM

The committee finds that a cooperative research program for hazardous materials transportation is warranted. The principles for program financing, governance, and management outlined above set the basic parameters for designing a program. The following represents the committee's vision of how a full-scale hazardous materials transportation cooperative research program could be financed, governed, and managed.

### Federal and Stakeholder Financing

The diversity of stakeholders in hazardous materials transportation means that no single industry segment is likely to have the incentive to fund cooperative research, and some will not have the financial means to do so. The federal government regulates hazardous materials transportation because of the broad public interest in ensuring its safety and security. A federal appropriation of funds to help pay for a hazardous materials transportation cooperative research program can be rationalized on the same public interest grounds.

**Federally appropriated funds would provide core financing of the overall program of research, perhaps coupled with supplemental funds contributed on a discretionary basis by stakeholders for individual projects.** In the committee's view, the problems and research needs associated with hazardous materials transportation are at least as complex and numerous as those associated with public transit, which receives federal appropriations for cooperative research on the order of $8 million per year. **The committee believes that a cooperative research program comparable in magnitude with that of the cooperative research program for public transit, on the order of $5 million to $10 million per year, can be justified to ensure the safety and security of hazardous materials in transportation.**

If the program proves successful over a period of 3 to 5 years, an increasing portion of program funding may be derived in a more direct manner from stakeholders and users of the research. The Hazardous Materials Registration Fee is one possible funding source already being collected from carriers, shippers, and others in the hazardous materials transportation industry. The fee now varies from $300 per year for small businesses to $2,000 per year for larger businesses. It generates about $13 million per year in federal revenues, most of which is appropriated to states and localities to strengthen their preparedness for hazardous materials emergencies. Raising the fee by about 8 percent, or $25 for small business and $150 for others, would generate about $1 million in annual revenues for cooperative research. **Increasing stakeholder financing of the program over time, even if it is discretionary, is key to fostering a sense of ownership of the program by stakeholders and ultimately ensuring that the research products remain useful.**

## Governance by a Broad Base of Stakeholders

**The program should be guided by a governing board that is largely independent and composed primarily of the end users of research, who will be responsible for soliciting research needs, prioritizing them, and setting the program's research agenda.** The governing board should ensure that the products of research are useful and well disseminated within the broad array of stakeholder communities. **A majority of the board members should be shippers, carriers, suppliers, and state and local emergency managers and responders,** because these are the significant end users of research. **The board should also have representation from the federal agencies that have programmatic, operational, and regulatory responsibilities for hazardous materials transportation safety, security, and environmental protection.** These agencies will likewise gain from cooperating in research with one another as well as with other segments of the industry.

## Management Modeled on Existing Cooperative Programs

Without knowing how a hazardous materials transportation program would be financed and governed, it is premature to lay out precisely how

and by whom the program should be managed. However, experience with existing cooperative research programs indicates that certain key features of a research process will be integral to the success of the program. First, **individual research projects should be conducted by contractors selected on a competitive basis.** Contract research, as opposed to investment in specialized research facilities and the hiring of in-house staff, will allow for greater flexibility in the program. A competitive process for selecting contractors on the basis of both qualifications and cost will encourage quality and efficiency, build program credibility, and enable more research projects to be undertaken with a limited research budget. Second, **technical panels should be responsible for defining the scope of individual research projects, developing requests for proposals from researchers, selecting the researchers to perform the work, overseeing and reviewing the work, and assisting with dissemination of the final product.** The technical panels should include end users of the research as well as technical experts from academia, the private sector, and government. Third, **the organization managing this process should be perceived as independent and focused on research as a main organizational mission—characteristics that are essential in building trust.** As a corollary to this point, the host organization should be known for research products that meet scientific and professional standards of quality and should have the capability to disseminate these products widely. The experience of existing cooperative research programs suggests that 15 to 20 percent of the program budget will need to be set aside for these critical management and oversight functions.

## NEXT STEPS: PILOTING THE CONCEPT

The program outlined above would require a dedicated effort not only from research advocates but also from the stakeholder communities. However, the benefits of research are not always apparent to those focused on day-to-day operations and concerns. The committee recognizes this practicality and the challenge of securing support for a cooperative research program absent tangible evidence of its utility. **The building of support may require a smaller-scale effort that demonstrates the functioning of the program and yields some early and useful research results.**

A pilot test of the hazardous materials transportation cooperative research program is needed. **The committee therefore urges each of the four agencies that sponsored this study to contribute $250,000 in research funds to create a pooled fund of $1 million for cooperative research.** The four agencies may seek additional contributions to enlarge the pool from other federal agencies, including the Department of Homeland Security, the Federal Aviation Administration, and the Department of Energy. A $1 million fund should be sufficient to pay for three or four research projects that are carefully selected to yield results that are timely and useful. A number of candidate research projects are identified in this report to illustrate research topics that may be suited to a full-scale program. A pilot program would need to focus on projects costing between $100,000 and $300,000 and capable of being completed in 12 to 18 months. Some of the projects may be precursors to larger research projects identified in this report, such as literature analyses and syntheses of practice in the field.

**The sponsoring agencies should ensure that a broad-based committee of stakeholders is formed to identify needed research and advise on how the pooled research funds should be programmed to meet these priority needs.** The stakeholder committee, acting in a manner similar to a program governing body, should represent a cross section of the hazardous materials shipping and carrier communities as well as experts in emergency response, risk management, and hazardous materials transportation safety and security. This committee should identify and define a series of individual research projects and recommend funding for those with the greatest potential for yielding practical solutions to important problems in the field. The projects selected for the pilot program should be of interest to a large number of stakeholders and promise usable products to practitioners in a short period of time. **Each research project should be guided by an oversight panel that includes both technical experts and practitioners from the stakeholder communities.** The panels for the pilot program need not be large or elaborate. They may consist of four or five members of the larger stakeholder committee, supplemented by one or two outside experts as needed. The panels will select contractors to perform the work on the basis of merit. To the extent possible, the pilot program should take into account the

important guideposts for structuring a full-scale cooperative research program, as described earlier in the report.

In the end, the value of the research should speak for itself. If the research results from the pilot program are useful, the cooperative research concept can be expected to generate stakeholder interest in pursuing a larger-scale program. **A formal critique of the pilot program should be undertaken by the sponsoring agencies along with the stakeholder committee.**

The successful programs in other fields suggest that stakeholder involvement and interest in cooperative research must be present at inception. A pilot program can help establish stakeholder ownership from the start.

APPENDIX

# Workshop to Assess the Feasibility of a Hazardous Materials Transportation Cooperative Research Program

*July 1, 2004*

**National Academies Keck Center, Room 100, 500 Fifth Street, NW, Washington, D.C.**

8:45 a.m. Opening Remarks on Workshop Format and Goals
*Robert Gallamore*, Chair

9:00 a.m. Kickoff Address
*Emil Frankel,* Assistant Secretary for Transportation Policy

9:10 a.m. Origins of Hazardous Materials Cooperative Research Program Concept
*Douglas Reeves,* Research and Special Programs Administration

9:20 a.m. Discussion Panel 1
Candidate Problems for Cooperative Research
*Christopher Barkan,* moderator
*Ron Brinson,* committee member
*Edward Chapman,* committee member
*Cherry Burke,* committee member
*Benson Bowditch,* committee member
*Gordon Veerman,* committee member
Six guest panelists from industry and agencies

10:40 a.m. Overview of Existing Cooperative Research Programs
*Robert Reilly,* TRB Director of Cooperative Research

11:00 a.m. Discussion Panel 2
Options for Financing, Governing, and Managing an HM-CRP
*Michael Bronzini,* moderator
*Nicholas Garber,* committee member
*Bruce Bugg,* committee member
*Terrance Egan,* committee member
*Michael Moreland,* committee member
Six guest panelists from industry and agencies

1:15 p.m. Plenary Discussion: Open Forum and Summary
*Robert Gallamore,* Chairman
*Jonathan Gifford,* George Mason University

2:30 p.m. Adjournment

# Study Committee Biographical Information

**Robert E. Gallamore,** *Chair,* is Director of the Transportation Center and Professor of Managerial Economics and Decision Sciences in the Kellogg School of Management, Northwestern University. Before joining the university in August 2001, he was an executive on loan from Union Pacific Railroad to the Transportation Technology Center in Pueblo, Colorado, where he was Assistant Vice President of Communications Technologies and General Manager of the North American Joint Positive Train Control Program. He has also served in several positions with the federal government, including Deputy Federal Railroad Administrator and Associate Administrator for Planning at the Urban Mass Transportation Administration. Dr. Gallamore recently served as chair of the Transportation Research Board's (TRB's) Freight Transportation Information Systems Security Committee and as a member of TRB's Committee for a Review of the National Transportation Science and Technology Strategy and the Steering Committee for a Conference on Railroad Research Needs. He also served on the Transportation Panel of the Committee on Science and Technology for Countering Terrorism. He received a doctorate in political economy and government from Harvard University.

**Christopher P. L. Barkan** is Associate Professor in the Department of Civil and Environmental Engineering at the University of Illinois, where he is responsible for the university's railroad engineering research and academic programs. He also serves as the director of the Association of American Railroads' (AAR's) Affiliated Laboratory at the university. His research focuses on railroad safety and risk analyses with an emphasis on derailment prevention, tank car design, and hazardous materials transportation. He has served on the TRB Transportation of Hazardous Materials Committee and is currently a member of the Railroad Track Structure System Design Committee and the chair of the TRB Rail Group. Before joining the university in 1998, he was Director of Risk Engineering

in the Safety and Operations Division of AAR. He continues as Deputy Project Director of the Railway Supply Institute–AAR Railroad Tank Car Safety Research and Test Project, a cooperative program of the tank car and railroad industries studying ways to improve tank car safety. He received his B.A. from Goddard College and his M.S. and Ph.D. in biology from the State University of New York at Albany.

**Benson A. Bowditch, Jr.,** is General Manager for Security and Compliance, CP Ships, Tampa, Florida. CP Ships is the parent company of Lykes Lines, TMM Lines, Italia Line, Contship, ANZDL, Canada Maritime, and Cast, which operate fleets consisting largely of containerships. Before attaining his current position in 1995, he was Manager of the Compliance Department, where he was responsible for regulatory compliance in all areas, including the hazardous cargo program. From 1990 to 1995, he was Manager of the Marine Division and Manager of Operations for West Gulf in Houston, Texas. In these positions, he was responsible for vessel operations, readiness, and manning, as well as cargo and terminal operations. He served as Port Captain in Houston and New Orleans from 1976 to 1989, positions that included responsibility for organizing responses to oil releases and other hazardous materials spills. He began his career as a sea deck officer on break-bulk cargo ships. In that position he was responsible for the prevention of oil pollution and the safe handling of hazardous cargoes. He has a bachelor's degree in marine science from the Maine Maritime Academy.

**J. Ron Brinson** retired in April 2002 as President and CEO of the Port of New Orleans, a position he held for more than 15 years. The Port of New Orleans handles a significant amount of hazardous materials, particularly shipments of crude, refined petroleum products, and industrial chemicals. The deepwater port is a major transfer point for cargoes, since it connects the Mississippi River System with the Gulf of Mexico and is served by six Class I railroads. Before taking the New Orleans position, he had served for 7 years as President and CEO of the American Association of Port Authorities, where he directed the education and training program for port authority managers and congressional and governmental relations. He began his port management career in Charleston, South Carolina, in 1974. On his retirement from the Port of New Orleans, he

accepted an appointment from Louisiana Governor Mike Foster to work with the state Millennium Port Commission to develop a large state container port at a site closer to open water. He is a former chair of the National Waterways Conference and served on the TRB Executive Committee from 1989 to 1992.

**Michael S. Bronzini** is Dewberry Chair Professor in the Department of Civil, Environmental, and Infrastructure Engineering, George Mason University. He previously served as Director of the Center for Transportation Analysis at Oak Ridge National Laboratory. From 1986 to 1990, he was Professor and Head of Civil Engineering for Pennsylvania State University. His areas of expertise are transportation network analysis, marine and intermodal transportation, and transportation economics. He has served as chair of the Inland Water Transportation Committee and the Committee for the Study on Landside Access to U.S. Ports and on several other TRB and National Research Council (NRC) committees. He is a National Associate of the National Academies. He holds a Ph.D. in civil engineering from Pennsylvania State University.

**O. Bruce Bugg** is Captain in the Georgia Department of Motor Vehicle Safety, where he serves as Special Projects Coordinator. He has served with the state of Georgia since 1986. He conducts safety and hazardous materials inspections and assists with accident and hazardous materials incident investigations. He oversees internal computer support for the Law Enforcement Division and the agency's SAFETYNET crash and inspection database. He holds state certificates as a law enforcement instructor and hazardous materials instructor. He instructs on cargo tank and enhanced radioactive inspection procedures and teaches at several regional Georgia Public Safety Academies and the Georgia State Patrol Academy. In 2003, he was named Chair of the Commercial Vehicle Safety Alliance's (CVSA's) Hazardous Materials Committee. In 2004, he was elected National Chair of the Cooperative Hazardous Materials Enforcement Development training program. He is a member of the American Society for Law Enforcement Training and the International Police Association. He has a B.A. degree from Georgia State University in Atlanta.

**Cheryl (Cherry) Burke** is a Senior Consultant in DuPont's Safety, Health, and Environment Excellence Center. She joined DuPont in 1983,

and her career has focused on risk in one form or another, initially on chronic risks and occupational health and more recently on acute risks related to the transportation of hazardous materials. In her current position, she is an internal consultant to DuPont's many businesses, with a focus on distribution safety and risk management. She is a member of DuPont's integrated emergency response team and is trained to a Hazmat Technician level. She is a member of TRB's Transportation of Hazardous Materials Committee and past chair of the American Chemistry Council's Distribution Risk Management Task Group. She works extensively with the American Chemistry Council, AAR, and other organizations in the evaluation and reduction of safety and security risks in hazardous materials transportation. She holds a bachelor's degree in biology from the University of Connecticut, a master's degree in epidemiology and biostatistics from the University of Michigan, and a doctorate in epidemiology from the University of Michigan.

**Edward R. Chapman** is Director of Hazardous Materials, Burlington Northern and Santa Fe Railway. During his 26 years in the railroad industry, he has held line and staff positions in industrial engineering, safety, budgets, system emergency operations centers, and hazardous materials. His present responsibilities include hazardous materials transportation training, compliance, emergency response, and risk reduction. He serves on committees of AAR and the American Chemistry Council. He was a member of the TRB Committee for the Assessment of a National Hazardous Materials Shipments Identification System. He is certified as a technician-level emergency responder and locomotive engineer. He holds a B.S. degree in industrial engineering from Texas A&M University.

**Terrence M. I. Egan** is Manager of the Mitigation, Analysis, and Plans Unit of the Washington Sate Military Department's Emergency Management Division. In this position he is responsible for coordinating state mitigation strategies with hazard analyses and response and recovery plans. Before joining the state government, he served for 20 years in the U.S. Air Force, where he held a number of command and staff positions. He retired as a lieutenant colonel. He served the Washington State Department of Transportation as manager of maintenance and operations training. He is a past chair of the Emergency Management Assistance Compact Executive Task Force. The membership of this state-to-state mutual-aid compact

includes 48 states, two territories, and the District of Columbia. He has a B.A. degree in political science, an M.A. degree in public administration, and a doctorate in education.

**Nicholas J. Garber** is Professor of Civil Engineering at the University of Virginia. For the past 20 years, he has been engaged in research in the areas of traffic operations and highway safety. Before joining the university in 1980, he was Professor of Civil Engineering and Dean of the Faculty at the University of Sierra Leone. Before that, he taught at the State University of New York at Buffalo and was a design engineer in several consulting engineering firms. He has served on several NRC committees, including the TRB Committee for the Study of the Regulation of Weights, Lengths, and Widths of Commercial Motor Vehicles, the Committee for Guidance on Setting and Enforcing Speed Limits, and the Work Zone Traffic Control Committee. He was elected to the National Academy of Engineering in 2004 and is a member of the 2005 TRB Executive Committee. Dr. Garber earned a B.S. degree in civil engineering from the University of London and master's and doctoral degrees from Carnegie Mellon University.

**Patrick Kelley** is Safety Specialist for ABF Freight Systems, Inc., a nationwide less-than-truckload trucking company. He is responsible for ensuring that the company remains in compliance with federal, state, and local hazardous materials regulations. He shares responsibility for managing spills, including taking cleanup actions and reporting to required agencies. He handles waste disposal and waste reporting associated with damaged freight and vehicle accidents. He is a member of CVSA's hazardous materials committee, the American Trucking Associations' hazardous materials and occupational safety and health committees, and the River City Safety and Environmental Council. Before joining ABF in 1999, he was Fleet Manager for USA Truck of Van Buren, Arkansas, where he supervised approximately 55 drivers. He earned a B.A. degree in environmental management and safety.

**Michael Moreland** is Manager of Hazardous Materials Transportation for Occidental Chemicals Corporation. He is responsible for regulatory compliance in all modes of transportation, including pipelines. Before joining Occidental, he was President of Moreland, Inc., a transportation compliance and training company specializing in nuclear materials

transportation. He is active in the Dangerous Goods Advisory Council (DGAC) and the American Chemistry Council. He holds a B.S. degree in nuclear engineering.

**Michael Morrissette** is Vice President and Director of Technical Services for DGAC, which is a nonprofit educational organization devoted to promoting safety in the domestic and international transportation of hazardous materials. It fulfills its mission by providing education through hazardous materials/dangerous goods training and conferences, technical assistance, and information to the private and public sectors. Before joining DGAC in 1995, Morrissette served with the U.S. Coast Guard in a number of positions dealing with the maritime transport of hazardous materials. He is responsible for monitoring regulatory and legislative developments affecting hazardous materials transportation, and he participates in international bodies that regulate hazardous materials movements. He holds a B.S. degree in chemistry from the University of Wisconsin and an M.S. degree in health science from Johns Hopkins University.

**Gordon L. Veerman** is Chief of the Argonne National Laboratory Fire Department, which consists of a professional force of two dozen uniformed personnel responsible for providing fire prevention and protection, emergency medical services, and hazardous materials response for the laboratory and surrounding communities through mutual aid. He has served in the department since 1962 and was appointed Fire Chief in 1976. During his career, he has consulted extensively on the fire protection of special facilities, including nuclear power plants, explosives manufacturing facilities, and hydroelectric plants. He has lectured and instructed at numerous firefighting schools and training programs, including the State University of New York at Binghamton, the International Association of Fire Chiefs (IAFC), and the National Safety Council. He is a member of the Fire Safety Committee of the U.S. Department of Energy, the IAFC Hazardous Materials Committee, and the U.S. Environmental Protection Agency's President Stakeholders Committee. He has a B.A. degree in fire science management from Lewis University.