





## TRB Special Report 313: Framing Surface Transportation Research for the Nation's Future

ISBN  
978-0-309-29490-4

120 pages  
8 1/2 x 11  
PAPERBACK (2013)

Committee on National Research Frameworks: Application to Transportation; Transportation Research Board

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# Framing Surface Transportation Research for the Nation's Future



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**SPECIAL REPORT 313**

# Framing Surface Transportation Research for the Nation's Future

Committee on National Research Frameworks:  
Application to Transportation

TRANSPORTATION RESEARCH BOARD  
*OF THE NATIONAL ACADEMIES*

Transportation Research Board  
Washington, D.C.  
2014  
[www.TRB.org](http://www.TRB.org)

## Transportation Research Board Special Report 313

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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 report was sponsored by state departments of transportation through the National Cooperative Highway Research Program.

### Library of Congress Cataloging-in-Publication Data

Framing surface transportation research for the nation's future / Committee on National Research Frameworks, Application to Transportation.

pages cm — (Transportation Research Board special report ; 313)

Includes bibliographical references and index.

ISBN 978-0-309-29490-4 (alk. paper)

1. Transportation—Research—Economic aspects—United States. 2. Transportation—Research—United States—Management. 3. Transportation—Research—Management. 4. Research—United States—Management. I. National Research Council (U.S.). Transportation Research Board. Committee on National Research Frameworks, Application to Transportation, issuing body. II. Series: Special report (National Research Council (U.S.). Transportation Research Board) ; 313.

HE192.55.U6F73 2013

388.072'073—dc23

2013049670

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*Transportation Research Board Staff*

**Jill Wilson**, Study Director





## Preface

In recent years, the U.S. economic climate has exerted increasing pressure on both public- and private-sector research budgets to limit or reduce spending, even though research is critical to the nation's future prosperity and the well-being of its inhabitants. At the same time, the United States, like many of its competitors in Europe and Asia, has increasingly sought to base research investment decisions on evidence about potential outcomes and impacts and on the use of best practices. In the public sector in particular, increasingly formalized requirements for strategic planning and quantitative evidence of performance seek to ensure that research dollars are well spent. Efforts across the federal government are exploring improved ways of evaluating research investments and seeking a better understanding of how best to create usable knowledge through research.

In the transportation sector, concerns about the adverse effects of constraints on research budgets are by no means new. During a 1995 forum on future directions in transportation research and development (R&D), participants expressed concern about likely declines in transportation innovation should major reductions in federal research budgets occur.<sup>1</sup> More recently, research managers at state departments of transportation have sought improved ways of ensuring that their research investments, although constrained, are cost-effective and lead to productive outcomes.

Given this background, the state departments of transportation, through the National Cooperative Highway Research Program, asked the

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<sup>1</sup> Transportation Research Board. 1995. *Conference Proceedings 9: Forum on Future Directions in Transportation R&D*. TRB, National Research Council, Washington, D.C.

Transportation Research Board (TRB) to take on a related assignment: to consider whether and how the lessons learned from transportation research in other countries, and from research in domestic nontransportation sectors, might be used to improve surface transportation research in the United States. Such improvements would help ensure that related budgets, under sometimes severe constraints, are used as beneficially as possible.

To conduct the study, TRB assembled a committee of 12 members under the leadership of Sue McNeil, professor of civil and environmental engineering at the University of Delaware. Committee members were chosen for their expertise in transportation research management across academia, government, industry, and other sectors; R&D strategic planning; innovation and technology transfer; and research models and crossnational perspectives.

The committee convened eight meetings between November 2010 and November 2012 (see Appendix A). Two workshops, held in conjunction with the third and fourth meetings, were attended by invited speakers from transportation research organizations in other countries and from nontransportation research organizations in the United States. The workshops were structured to facilitate informal discussions among participants and to foster a lively and open exchange of information and ideas.

The committee also undertook information-gathering activities during the 90th and 91st TRB annual meetings held in Washington, D.C., in January 2011 and January 2012, respectively. Committee members met informally with individuals from foreign transportation research organizations, and a two-part session on national research frameworks provided (a) further input from transportation research managers from other countries and (b) an opportunity to gather suggestions from U.S. stakeholders about possible improvements to the nation's surface transportation research enterprise (see Appendix A).

## ACKNOWLEDGMENTS

The committee thanks the many individuals and organizations that contributed to this study through formal presentations, correspondence, telephone calls, and informal discussions. Special thanks go to the guest speakers from transportation research organizations in other countries

who gave generously of their time in traveling to and participating in the committee's workshops in Washington, D.C., in July and October 2011. The contributions of U.S. Department of Transportation representatives Debra Elston (Federal Highway Administration) and Kevin Womack (Research and Innovative Technology Administration) are gratefully acknowledged. The committee also thanks Andy Lemer, Cooperative Research Programs, TRB, for his advice and encouragement throughout the study, and Jack Jernigan, Federal Highway Administration, for his informative responses to requests for information.

Jill Wilson managed the study under the supervision of Stephen R. Godwin, Director of TRB's Studies and Special Programs Division. Dr. Wilson also drafted major portions of the final report under the committee's guidance. Amelia Mathis and Mai Quynh Le were responsible for meeting logistics and also assisted in communicating with committee members.

This report has been reviewed in draft form by individuals chosen for their diverse perspectives and technical expertise, in accordance with procedures approved by the Report Review Committee of the National Research Council (NRC). The purpose of this review was to provide candid and critical comments to assist TRB in making the report as sound as possible and to ensure that it 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.

The NRC thanks the following individuals for their review of this report: Mort Downey, Parsons Brinckerhoff, Vienna, Virginia; Anson Jack, Rail Safety and Standards Board, London, United Kingdom; Paul Kern, The Cohen Group, Washington, D.C.; Herbert Levinson, transportation consultant, Wallingford, Connecticut; Harold (Skip) Paul, Louisiana Transportation Research Center, Baton Rouge; Ralf Resch, Allgemeiner Deutscher Automobil-Club, Munich, Germany; Bernard Robertson, DaimlerChrysler Corporation (retired), Bloomfield Hills, Michigan; Kumares Sinha, Purdue University, West Lafayette, Indiana; and James Turner, Association of Public and Land-grant Universities, Washington, D.C. 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 National Academy of Engineering member Elisabeth Drake, Massachusetts Institute of Technology (retired), and National Academy of Sciences member Susan Hanson, Clark University. Appointed by the 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 content of the report rests solely with the authoring committee and the institution.

Suzanne Schneider, Associate Executive Director, TRB, and Karen Febey, Senior Report Review Officer, TRB, managed the report review process. The report was edited by Steven J. Marcus and copyedited by Elaine Eldridge; the prepublication files for posting to the TRB website were formatted and prepared by Jennifer J. Weeks; the editorial production was done by Janet M. McNaughton; and the book design and production were coordinated by Juanita Green, under the supervision of Javy Awan, Director of Publications, TRB.

# Contents

<b>Executive Summary</b>	<b>1</b>
<b>1 Introduction</b>	<b>5</b>
Role of Research	6
Making Wise Research Investments	8
Charge to the Committee	10
Committee's Approach	12
Organization of the Report	14
<b>2 Building Blocks of National Research Frameworks</b>	<b>17</b>
Framework Functions	18
Framework Attributes	23
<b>3 Current State of U.S. Surface Transportation Research</b>	<b>36</b>
U.S. Surface Transportation Research Enterprise	36
Selected Research Programs	44
Strengths and Weaknesses of Current Research Framework	59
Opportunities for Improvement	65
<b>4 Transportation Research Frameworks in Other Countries</b>	<b>70</b>
Committee's Strategy for Gathering Information	70
Transportation Research Organizations	72
Approaches to Research Functions	77
Lessons Learned	86
Highlights	91

<b>5 Research Frameworks in Domestic Nontransportation Sectors</b>	<b>95</b>
Committee's Strategy for Gathering Information	96
Research Organizations	97
Approaches to Research Functions	101
Lessons Learned	109
<b>6 Recommendations</b>	<b>113</b>
Value of a National Research Framework	113
Build and Implement a New National Research Framework	116
Build a More Productive Federal Research Enterprise	127
Raise Awareness of Surface Transportation Research	140
Concluding Observations	144
<b>Appendices</b>	
<b>A Committee Meetings and Other Activities</b>	<b>148</b>
<b>B Workshop Discussion Papers</b>	<b>154</b>
<b>Study Committee Biographical Information</b>	<b>159</b>

## Executive Summary

Over the years, surface transportation in the United States has seen numerous major improvements and policy innovations informed by research: safer and more fuel-efficient automobiles; more durable and economical pavement designs; real-time tracking of cargo shipments; and a resurgence of freight rail following deregulation of the railroad industry, to cite but a few examples. Leaders within the transportation community have questioned, however, whether the current U.S. approach to surface transportation research will lead to the innovations in transportation services and policies needed to support national goals for economic development, safety, mobility, competitiveness, and sustainability in the 21st century. The issue is rendered all the more pressing by the policy stances of a number of the United States' competitors in Europe and Asia. These nations not only place greater emphasis on transportation research as a vital means of achieving economic, societal, and environmental goals; they also have effective frameworks for prioritizing, funding, assembling, and coordinating research activities.

In 2008, U.S. transportation research experts undertook a scanning tour of European and Asian countries, and what they saw during the tour highlighted the potential of alternative research frameworks for improving the effectiveness of transportation research in the United States. Subsequently the state departments of transportation, through the National Cooperative Highway Research Program, asked the Transportation Research Board to convene an expert committee for a follow-up assignment: to describe and evaluate potential frameworks and institutional models for surface transportation research<sup>1</sup> in the United

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<sup>1</sup> To render its task tractable with available resources, the committee focused on highways, rail, and public transportation.



States that would be based on experience in the transportation sector internationally and in nontransportation sectors domestically.

The U.S. surface transportation research enterprise at present is characterized by a diversity of participants, activities, and funding sources; and it is highly decentralized, with most research programs initiated from the bottom up. As a result, much of the research aims at specific problems identified by sponsors and is relatively short term and applied in nature. Such research has led to important transportation improvements, but the imbalance between bottom-up and top-down approaches leads to missed opportunities. The U.S. system too frequently lacks clear linkages between research and national goals, and it tends to focus on solving narrowly defined problems at the expense of basic and advanced research that could form the basis for exploring broader crosscutting issues and developing innovative solutions to long-term challenges. Moreover, because research activities remain largely uncoordinated and fragmented, the integrative systems-level research needed to support national goals receives insufficient attention.

## **A NEW NATIONAL RESEARCH FRAMEWORK**

A new and more cohesive national framework offers the opportunity to strengthen U.S. surface transportation research by establishing a holistic approach to problem solving and by building greater connectivity among researchers and research activities. To help create such a framework, the committee considered its desirable attributes, devised a framework concept, and recommended the necessary steps to develop the concept into a new national research framework (illustrated in Figure ES-1).

The committee recommends that a group of influential organizations, led by the Standing Committee on Research of the American Association of State Highway and Transportation Officials and comprised of representatives from the public, private, academic, and nonprofit sectors, should launch the framework initiative. This leadership group should assume responsibility for a national summit, which, based on the framework concept, would explore effective strategies for addressing major challenges that face surface transportation research. A subsequent report



**FIGURE ES-1** Steps leading to a new national research framework.

from the summit convener would examine ways of implementing the framework and funding its programs.

## **A MORE PRODUCTIVE FEDERAL RESEARCH ENTERPRISE**

The committee recommends actions to be taken by the federal government in support of the transition to a new national research framework for surface transportation. These actions would also help build a more productive federal research enterprise.

The U.S. Department of Transportation (U.S. DOT) has primary responsibility for the health of the nation's transportation system, but other federal departments, such as Energy and Defense, also devote considerable resources to surface transportation–related research in support of their missions. To make better use of federal resources, the White House Office of Science and Technology Policy should create a task force to explore potential synergies and gains from greater coordination among pertinent agencies.

For the U.S. DOT to be an important player in the new national research framework, as befits its mission, the department needs to strengthen its

overall research culture and capacity. In addition, the department should engage more fully with the research community; such engagement would help the U.S. DOT to leverage the investments in technical and policy areas made by other federal departments as well as by states, industry, and academia. One option the Secretary of Transportation may wish to consider for furthering progress toward both these objectives is to establish the position of chief scientist within the Office of the Secretary. This individual could serve as a science and technology advisor to the Secretary and be the U.S. DOT's champion for research.

Finally, federally funded research should more explicitly and intensively explore high-risk, high-payoff opportunities for "quantum leaps" in transportation performance. In that spirit, the committee recommends the establishment of a broad and robust program of basic and advanced research encompassing the many disciplines relevant to surface transportation. To help ensure its longevity, the program should be embedded in a culture that values research.

Replacing the current fragmented assemblage of activities and funding by a more cohesive research framework is not without challenges. For example, there is no current organization or research group that could effectively serve the multimodal leadership, stewardship, and funding roles that the framework calls for. But by working together, surface transportation leaders and the research community have an opportunity to build a more productive research enterprise in support of national goals. The end result will be a more cohesive and coordinated national research framework.

## 1

## Introduction

Transportation is a major sector of the U.S. economy, with transportation-related goods and services accounting for some 10.2 percent of the gross domestic product in 2011<sup>1</sup> (RITA 2013). Transportation also plays a key role in determining quality of life, with a wide variety of transportation services supporting both personal mobility and economic prosperity. But because of economic transformations and population growth, both at home and abroad, U.S. transportation needs have changed dramatically over the past half-century. International trade has mushroomed, going from 13 percent of the U.S. economy in 1990 to 30 percent in 2010, and trade patterns continue to evolve in response to globalization of the marketplace and evolving supply chains (AASHTO 2010).

Demand for domestic transportation services has also changed as a result of population growth and shifting demographics. The population of the United States rose from 181 million in 1960 to 309 million in 2010, and the mean age has been steadily increasing (U.S. Census Bureau 2013). This aging trend is projected to continue, with those 65 and older expected to constitute about 19 percent of the nation's people in 2030 (U.S. Census Bureau 2008). The resulting changes in work and lifestyle patterns, including nontraditional retirements in which individuals continue to work part-time beyond retirement age, are likely to have substantial impacts on travel patterns and demands<sup>2</sup> (ICF International 2008).

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<sup>1</sup> This is the most recent year for which complete figures are available.

<sup>2</sup> Other examples of major trends shaping the future and their interrelationships with transportation are discussed in the report *Long Range Strategic Issues Facing the Transportation Industry* (ICF International 2008).

## ROLE OF RESEARCH

The impacts of transportation research touch the lives of all Americans. For example, today's highway pavements, built with highly mechanized processes and materials that meet rigorous quality standards, are "incredibly more durable, more resistant to traffic and weather, safer, smoother, quieter, and more economical" than those of the 1950s, which were "essentially hand-built from native materials of uncertain quality" (TRB 1996, 10). These improvements in highway pavements were based on research, as were major advances in traffic control, trucking, highway safety, railroad freight, motor vehicle fuel efficiency and emissions reductions, and public transportation during the second half of the 20th century (TRB 1996). Unlike medical research, however, transportation studies are often not perceived by the general public as an important part of the nation's research agenda.

Despite major progress in U.S. transportation systems and services, particularly since the 1950s and 1960s, further improvements are needed if the nation is to continue competing effectively in the global marketplace and enhancing its inhabitants' quality of life while simultaneously meeting increasingly stringent requirements for sustainability. The surface transportation system in particular is a major target for overhaul, given that the nation's cars, light trucks, and medium- and heavy-duty trucks account for more than 85 percent of the transportation sector's petroleum use and associated carbon dioxide emissions (TRB 2011b). Examples of challenges facing the U.S. surface transportation system are listed in Box 1-1.<sup>3</sup>

Research is expected to play a major role in addressing the challenges facing U.S. surface transportation, and technological developments are likely to influence this research in two ways. First, new technologies may offer new solutions to transportation problems, as in the case of ongoing efforts using communications technology to improve road safety by alerting motorists to impending collisions or dangerous road conditions. These efforts depend on connected vehicle technology, a form of dedicated short-range wireless communication that allows vehicles

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<sup>3</sup> In accordance with the committee's charge (see the third section of this chapter), this report focuses on surface transportation rather than on transportation as a whole.

BOX 1-1

## Examples of Challenges Facing the U.S. Surface Transportation System

- **Congestion.** In 2011, the urban auto commuter traveling during peak periods experienced an average total of 38 hours of congestion-related delays—equivalent to four vacation days (Schrank et al. 2012). The best available estimates of the truck hours of delay for the worst truck-freight bottlenecks show that “each of the top 10 highway-interchange bottlenecks cause over a million truck-hours of delay per year, costing \$19 billion overall” (AASHTO 2010, iii).
- **Safety.** “Nearly every high-income country is today reducing annual traffic fatalities and fatality rates faster than is the United States, and several countries where fatality rates per kilometer of travel were higher than in the United States 20 years ago are now below the U.S. rate” (TRB 2011a, 12).
- **Mobility.** “For old, young, poor, or disabled people, for whom personal vehicles may not be a viable option, today’s [public] transportation system is neither convenient nor accessible” (Bradley et al. 2011, 40).
- **Transportation security.** Since September 11, 2001, the United States has invested heavily in improved transportation security, both for passengers and freight, but the high price and the resultant barriers to international commerce and global trade raise significant concerns (Mueller and Stewart 2011).
- **Environmental quality.** Highway vehicles are responsible for the majority of greenhouse gas emissions in the transportation sector. Furthermore, carbon dioxide emissions from highway vehicles increased by 23.5 percent between 1990 and 2011, the largest percentage increase for any mode of transportation over the same period (Davis et al. 2013).

to communicate with each other and with nearby infrastructure ([www.its.dot.gov/safety\\_pilot/pdf/safetypilot\\_nhtsa\\_factsheet.pdf](http://www.its.dot.gov/safety_pilot/pdf/safetypilot_nhtsa_factsheet.pdf)). Second, technological developments may modify the nature of transportation challenges themselves. For example, new natural gas extraction technologies, notably shale gas extraction (fracking), have resulted in “enough domestic natural gas to greatly increase its use for the transportation sector without significantly affecting the traditional natural gas markets” (NRC 2013, 8). This increased availability of low-cost domestic natural gas could stimulate interest, and research, into greater use of natural gas as a fuel for light-duty vehicles, particularly if environmental issues associated with fracking were to be resolved.

## **MAKING WISE RESEARCH INVESTMENTS**

Given the critical role of research in increasing transportation's quality, availability, and affordability, it is essential that the nation's investments in transportation research make the most out of every dollar spent. The challenge facing decision makers, particularly in the current resource-constrained environment, is made all the more difficult by the multifaceted and complex nature of transportation research; by today's research agenda, which often appears fragmented and disorganized; and by the messy nature of the innovation process (Skinner 1997).

### **Multifaceted and Complex Research**

Transportation is an “area of human activity that involves an incredibly diverse array of technologies and systems” (Skinner 1997, 4). It addresses vehicles, fuels, infrastructure, and transportation users, as well as the interactions among them. Transportation also cuts across many fields of knowledge, from traditional transportation disciplines such as engineering and materials science to less traditional areas, such as information technology, behavioral science, human health, and the environment. The outcomes of transportation research are similarly diverse, leading not only to a wide range of tangible achievements (such as bridge designs, quiet pavements, and alternative-fuel vehicles), but also to new or improved methods and strategies for supplying, operating, and managing transportation systems

and services (such as traffic-simulation models and pay-at-the-pump insurance).

## **Fragmented Agenda**

The U.S. transportation enterprise is highly decentralized, involving “tens of thousands of institutional and corporate participants” in the public, private, and academic sectors (Skinner 1997, 4). Much of its research responds to the specific needs of individual organizations or groups of organizations, such as transportation providers, automobile manufacturers, and state departments of transportation, and it is often focused on individual modes (e.g., highway or rail) rather than on broader system-wide needs. Faced with this patchwork of diverse and localized research activities and lacking a clear, comprehensive, and integrated picture of regional or national needs, decision makers face challenges in identifying and prioritizing the research required to support development of the U.S. multimodal transportation system as a whole.

## **The Nature of Innovation**

Decisions about research investments are also complicated by the often haphazard way in which knowledge gained through research finds its way into practical real-life applications. Innovation in transportation is frequently a two-steps-forward-one-step-back process rather than a neat and orderly transition from knowledge acquisition to knowledge implementation (Skinner 1997). Different types of knowledge tend to have different paths and likelihoods of deployment, with technological advances often more apt to be quickly embraced than policy innovations. In the former case, deployment depends mainly on the potential costs and benefits, but in the latter it is typically a function of the public response and political decision making. Moreover, many potential policy innovations are controversial or simply not amenable at present to widespread acceptance. For example, congestion pricing, a concept developed in the 1920s, is attracting more attention now that transponder technology is available for cost-effective implementation, funding constraints are growing ever tighter, and fewer options are available for solving the nation's increasingly serious congestion problems. Nonetheless, congestion pricing



continues to raise questions about equity, or fairness, as well as privacy (TRB 2011c).

Research into policy options can provide a much-needed means of exploring opportunities and implementing them when and where they make the most sense. For electric vehicles and advanced fuels, for example, investigating a portfolio of alternatives allows researchers to retain sufficient flexibility to accommodate a variety of future scenarios and to identify the options that are technically and economically feasible in each case (Christensen 2011).

Given the challenges facing transportation and the need for more rapid and efficient research, development, and deployment, this report looks to other nations and other sectors to identify possible models and strategies to improve U.S. surface transportation research. In efforts to broaden and, when possible, optimize the U.S. transportation research agenda there is no need (pun fully intended) to reinvent the wheel. The purpose of this report is thus to explore opportunities for improving the productivity of U.S. expenditures on surface transportation research by building on lessons learned from transportation research in other countries and from research in nontransportation sectors in the United States.

## **CHARGE TO THE COMMITTEE**

In April 2008, a team of transportation research and policy experts from the United States visited Belgium (home of the European Commission), France, Japan, the Netherlands, South Korea, and Sweden to review and assess the administrative practices of transportation research programs (Elston et al. 2009). Originating from discussions among research managers at state departments of transportation, and responding to their commitment to “improving the effectiveness of research-program activities and increasing the stewardship of the resources directed to research” (Elston et al. 2009, 1), this scanning tour sought policy options and process advances that could potentially enhance the organization and outcomes of transportation research in the United States.

The scanning team identified various successful practices in the host countries that could potentially be applied to the United States, and the

team developed an implementation plan that identified major items and strategies for putting such practices into action (Elston et al. 2009). Two of these items—developing a nationally coordinated transportation research framework<sup>4</sup> and strengthening the innovation process—were developed into National Cooperative Highway Research Program problem statements. These objectives were combined into a single project, and the Standing Committee on Research of the American Association of State Highway and Transportation Officials (AASHTO) subsequently referred this project to the Policy Studies Division of the Transportation Research Board (TRB).

The Policy Studies Division then organized the Committee on National Research Frameworks: Application to Transportation, which was tasked with considering whether and how experience in the development of strategic research frameworks in the transportation sector internationally and in nontransportation sectors domestically could be applied to surface transportation research in the United States. In particular, the committee was asked to

- Identify and assess promising models and frameworks for transportation research, development, and deployment (RD&D, or simply “research”)<sup>5</sup> in other nations;
- Identify and assess U.S. examples of national RD&D strategic planning in sectors other than transportation; and
- Describe and evaluate potential frameworks and institutional models for the United States for transportation RD&D, including agenda setting, coordination, partnerships, and knowledge creation and application.

The term “research framework” is used extensively in the report on the 2008 scanning tour (Elston et al. 2009), but it is never defined explicitly by the report’s authors. Further, because the committee was unable to find a widely accepted definition of the term in the scientific and technological

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<sup>4</sup> See the definition of “research framework” below.

<sup>5</sup> For ease of reading, the term “research” is used throughout this report as shorthand for RD&D, unless otherwise noted. The different activities leading to innovation (such as basic research, applied research, and development) are defined in Chapter 3, both generally and in the transportation context.

literature, it elected to adopt the implicit definition used by the scanning team. For the purposes of the present report, therefore, a research framework is defined as comprising the social, political, and organizational structures within which research is conducted and the processes by which it is accomplished. The concept of a research framework is discussed in detail in Chapter 2.

Consistent with its charge, the committee addressed certain areas of surface transportation research rather than transportation research in general. In addition, to render its task more tractable with available resources, the committee focused on highways, rail, and public transportation and excluded pipelines, inland waterways, and coastal shipping, even though these latter modes fall within the conventional scope of surface transportation.

## COMMITTEE'S APPROACH

From the outset, the committee's intent was to identify ways of improving the inefficient practices and processes of the current U.S. surface transportation research enterprise while retaining its effective aspects. To inform this approach, the committee conducted a high-level appraisal of the American approach to transportation research, as it is, to identify its strengths (i.e., features to be retained) and weaknesses (opportunities for improvement). In subsequent discussions with representatives of research organizations in other nations and other sectors, the committee sought to correct those weaknesses by discerning potentially useful approaches and procedures that, if applied to U.S. surface transportation research (perhaps in modified form), could enhance it.

In seeking to learn from transportation research organizations overseas, the committee was wary of inappropriate transfers of policies from one country to another. Dolowitz and Marsh (2000) identify three factors that can contribute to the failure of policy transfer efforts in general:

- **Uninformed transfer.** The borrowing country has insufficient information about the policy or institution and how it operates in the originating country;
- **Incomplete transfer.** Elements crucial to the success of the policy in the originating country are not transferred to the borrowing country; and

- **Inappropriate transfer.** Insufficient attention is paid to the differences between the economic, social, political, and ideological contexts of the transferring and borrowing countries.

Thus, when considering the transfer of successful policies from other countries to the United States, factors that merit careful attention include the different decision-making processes in those countries' governmental systems; the influence of parliamentary systems of government in particular (which combine executive and legislative functions); and the countries' basic cultures, which may place greater emphasis on societal (as opposed to individual) good than is standard practice in the United States. Such differences do not necessarily imply that successful policies from other countries are inapplicable to the United States, but rather that introducing them here may not be straightforward. For example, a recent report comparing traffic safety strategies in the United States and other industrialized countries noted that "no country's institutions match the thousands of U.S. entities with independent authority for public safety and for road maintenance and operation" (TRB 2011a, 215). As a result, certain safety strategies that are effective in countries with highly centralized governments and a national police force responsible for traffic-law enforcement may be difficult to implement in the United States.

One of the challenges that the committee faced in developing its recommendations, therefore, was to suggest actions that could improve the U.S. surface transportation enterprise but that also would be feasible within the constraints imposed by current U.S. institutional structures and budgetary processes. Other expert groups have concluded that major structural and procedural changes are needed if the nation's surface transportation system is to meet future demands for the safe, efficient, and sustainable movement of people and goods. The National Surface Transportation Policy and Revenue Study Commission, for example, endorsed "changes in the structure of the USDOT [U.S. Department of Transportation] that would reinforce the functional orientation of . . . new recommended programs rather than the current modal orientation" (NSTPRSC 2007, 37). However, in the present study the committee was not charged with reorganizing federal agencies or with investigating changes to related congressional budgetary processes. Hence the report's recommendations

entail practical steps that, in the committee's judgment, are potentially achievable within the current institutional and political contexts.

## ORGANIZATION OF THE REPORT

Chapter 2 describes the functions (e.g., agenda setting and research evaluation) that make up a research framework and presents attributes (e.g., stakeholder involvement and support of research partnerships) that the committee identified as influential in a framework's performance. Chapter 3 summarizes the main features of the current U.S. surface transportation research enterprise, presents examples of the different types of programs that constitute the research portfolio, and identifies strengths and weaknesses of the current system along with opportunities for improvement. Chapter 4 outlines the committee's strategy for gathering information on transportation research organizations in other countries, briefly describes the organizations considered, and highlights features of these research frameworks that might help strengthen surface transportation research in the United States. Similarly, Chapter 5 explains the committee's approach to gathering information on research frameworks in domestic nontransportation sectors, describes the organizations and initiatives considered, and presents the lessons learned.

Chapter 6, the final chapter, discusses the potential value to the United States of a cohesive national surface transportation research framework that, as in many other countries, links transportation and transportation research to broad national goals. The committee offers its recommendations for building and implementing such a U.S. framework, enumerating in particular its proposed actions for strengthening the federal role.

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### *Abbreviations*

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NRC	National Research Council
NSTPRSC	National Surface Transportation Policy and Revenue Study Commission
RITA	Research and Innovative Technology Administration
TRB	Transportation Research Board

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## 2

## Building Blocks of National Research Frameworks

The character and productivity of research are influenced by context and process. The social, political, and organizational contexts within which research is conducted in a given country (or group of affiliated countries, such as the European Union) and the processes by which the research is accomplished constitute a “research framework,” as defined in Chapter 1 for the purposes of this report.

Chapter 2 sets the stage for the committee’s examination of the current research framework for surface transportation in the United States, the research frameworks for other countries’ transportation sectors, and the research frameworks for nontransportation sectors domestically. Specifically, this chapter describes the research functions that form a national research framework, and it identifies and discusses the attributes associated with each research function that the committee considers most important for an effective U.S. national research framework for surface transportation.

Research frameworks inherently involve trade-offs. For example, frameworks that encourage collaboration among many research partners may foster creativity and accelerate innovation, but these frameworks also involve a degree of administrative complexity that limits the ability of the research community to respond quickly to urgent problems. Some frameworks encourage broad multidisciplinary inquiry; others favor research that is narrow in scope. Some frameworks foster major initiatives, and others focus on arrays of smaller efforts that target specific problems. Legislation, funding allocations, and the needs, interests, and capabilities of the organizations that support and conduct the research will all influence which type of framework prevails for a given sector or country. In the committee’s judgment, the best framework for any national or geographic domain is



one that uses available resources to support and stimulate a vibrant research enterprise that most effectively meets the needs of the research sponsors and the society at large.

## FRAMEWORK FUNCTIONS

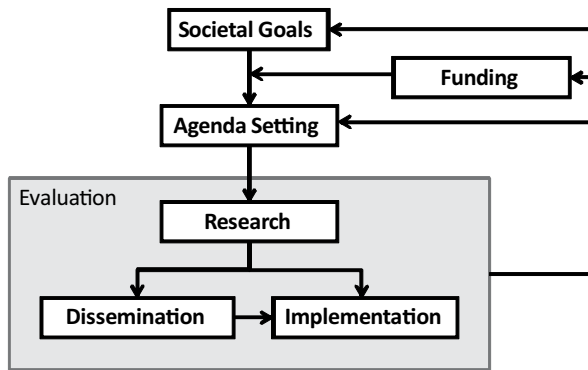
A national research framework encompasses the following essential research functions:

- Identification of the role of research in achieving societal goals;
- Research agenda setting;
- Distribution of funding for specific research activities;
- Conduct of research;
- Research evaluation;
- Dissemination of results; and
- Implementation of new knowledge in the form of new or improved products, processes, or policies.

These framework functions are discussed in the following paragraphs, with emphasis on an overall perspective. The committee recognizes that different entities conduct research in different ways and with differing objectives, and the relative importance of the framework functions may vary accordingly. For example, private-sector organizations are typically not interested in disseminating their research results if this activity threatens their competitive advantage, and public-sector entities are likely to place greater direct emphasis on societal goals than their private-sector counterparts do.

The functions listed should be viewed as elements linked by multiple feedback loops, as illustrated schematically in Figure 2-1, rather than as a linear sequence of steps leading from a clearly defined starting point to a clearly defined end point. Moreover, the functions are not independent activities isolated from one another. Evaluation, for example, is a valuable activity throughout the entire research and innovation process, both for tracking and improving the various functions and for communicating their benefits to a range of audiences (Ruegg and Jordan 2007).

However, to identify useful lessons from other countries' and sectors' frameworks, the committee found it helpful to examine how individual functions were addressed. This subdivision by function not only



**FIGURE 2-1** Schematic representation of the research functions of a national research framework.

facilitated the task of comparing different frameworks but also provided opportunities to select specific effective practices used by other countries and sectors in the event that wholesale adoption of alternative frameworks appeared undesirable or unrealistic.

### Identification of the Role of Research in Achieving Societal Goals

Addressing societal goals often involves not only political and financial measures but also research in science and technology to generate new knowledge, processes, and products that are supportive of those goals. Technical experts, including government employees and external advisers, are charged with linking policies—sometimes formulated at the highest levels—to research needs, thereby providing guidance for research planning.

In practice, societal goals, whether formally articulated in public policy documents or implicit in statutes and regulations, influence research activities both directly and indirectly. For example, the allocation of federal, state, and local government funding for specific research areas, inspired by national goals for issues such as road safety and economic prosperity, has an obvious direct effect on the scope and nature of research efforts in those areas. Private-sector research, although aiming first and foremost to maximize profits, is nonetheless indirectly influenced by statutes, regulations, and standards focused on the public good.

To the extent that such research leads to improved products valued by consumers, it may also increase profitability.

## **Research Agenda Setting**

The process of identifying and prioritizing the specific research activities that make up a research agenda is complex. A top-down approach is generally used if the research responds to formally articulated societal goals or other national objectives. In contrast, a bottom-up approach identifies research needs based on problems that stakeholders (typically, specific organizations) have encountered in pursuing their own objectives. Research needs identified through a bottom-up process may well be consistent with national goals, even if initially they are not identified as such. For example, research by or for transit agencies to improve riders' experience may lead to increased ridership, thereby increasing throughput in major corridors and better utilizing the nation's investment in public transit services.

Both top-down and bottom-up approaches to research agenda setting usually involve extensive consultation with experts and a variety of stakeholders to determine what is already known, what products and processes are available or under development, and what new knowledge, products, and processes are required. A research agenda is not simply an inventory of research needs, however; it also suggests priorities aimed at informing decisions about how to allocate scarce resources. Establishing those priorities requires in-depth and objective analyses of issues such as risk, technological readiness, schedule, and cost. In addition to prospective assessments of anticipated benefits, retrospective evaluations of earlier research may be used to gauge the challenges and risks associated with proposed research activities.

## **Distribution of Funding for Specific Research Activities**

### ***Balanced Portfolio***

Experts in research policy and management generally agree that a research portfolio should contain a balance of all types of activity (including research, development, and demonstration) directed at innovation. Funding research activities at various stages along the research pipeline ensures that a continuous source of different types of knowledge is available to support such innovation. Portfolios may include activities aimed at incremental

improvements, as well as activities that seek major advances with potential for high payoff, although the latter category “tends to be risk[ier] and typically requires longer to complete” than the former (TRB 2001, 7).

### ***Funding Strategies***

Among scientific communities, the tradition of open competition and peer review is widely considered not only the best way for ensuring high-quality research, but also for arriving at sound research-funding decisions (Brach and Wachs 2005). In practice, however, public-sector research-funding organizations employ a variety of approaches for allocating funds to specific research activities and for identifying qualified researchers. Associated mechanisms involve varying degrees of competition among researchers and may even eliminate competition altogether, as in the case of congressional earmarks.<sup>1</sup>

The extent to which funding recipients themselves define the research to be conducted also varies widely. Often researchers play little or no role in delineating the scope of applied or incremental research; that is largely the research sponsors' responsibility. But investigator-initiated research, in which researchers propose topics and methods within broad areas identified by the funding organization, is often seen as particularly valuable in seeking innovative (i.e., nonincremental) solutions to problems.

## **Conduct of Research**

### ***Complex Process***

Practical experience indicates not only that research involves extensive iteration, but also that the distinctions between research categories (e.g., basic research, applied research, and development) are often blurred. Such categories describe the types of activities involved and the nature of the knowledge sought (see Chapter 3), but they can be misleading because they tend to imply a strict sequence from research to demonstration to ultimate deployment. The reality, however, is far more nuanced and the innovation process is “inherently messy” (Skinner 1997, 4).

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<sup>1</sup> Earmarking of research funds is said to occur when Congress designates a research area or project, a funding amount, and a recipient organization that will receive the funds and conduct the research (Brach and Wachs 2005). A moratorium on congressionally directed funding (i.e., earmarks) introduced in the 112th Congress currently remains in place.

### ***Coordination and Cooperation Among Diverse Participants***

Mission-oriented research involves not only researchers but also a wide range of other stakeholders, including those who apply the research results to develop new or improved products and those who use such products to solve practical problems. Coordination among stakeholders can ensure that resources are wisely used when research activities are funded and performed by multiple organizations, each with its own distinct priorities and perspectives. Making information about research activities readily available to interested parties is an effective way to achieve such coordination. When organizations have similar or overlapping objectives, cooperative research programs offer the opportunity to leverage scarce resources.

### **Research Evaluation**

Research evaluation helps ensure that funds are used judiciously in pursuit of defined objectives; it also helps to document and communicate benefits as well as gauge the ultimate effectiveness of research initiatives. The extensive literature on research evaluation and performance assessment discusses the challenges faced and the methods available; see, for example, Turner (2010) and Ruegg and Jordan (2007).

Various evaluation methods address different types of questions about research activities. Peer review and expert judgment, for example, promote the quality and effectiveness of research; research managers often engage expert groups to monitor and assess progress while research activities are under way. Evaluation methods that highlight the outcomes and impacts of research initiatives, such as an economic case study or a history linking research to important industry developments, are more valuable for briefing senior managers, members of Congress, and other high-level decision makers (Ruegg and Jordan 2007). Evaluation methods that examine whether a product works, what it achieves, and its costs are particularly useful for assessing the potential for implementation of a new device or other research product.

### **Dissemination of Results**

Knowledge gained through research must be shared if it is to help solve problems or stimulate pursuit of further knowledge. Assorted

mechanisms help researchers meaningfully communicate their results to different audiences.

The results of basic research are often shared with other researchers through publication in journals, participation in conferences and workshops, and membership in groups with common interests, such as professional societies. The results of applied research, by contrast, are shared not only with other researchers but also with those who apply new knowledge to solve practical problems.<sup>2</sup> Many conferences are designed to commingle researchers and practitioners, facilitate exchange of information about completed research, exhibit and demonstrate research products, and inform researchers about problems being faced by practitioners. Organizations may be explicitly tasked with such knowledge delivery or with the development of standards that move research into practice.

### **Implementation of New Knowledge**

Implementation of research results is influenced not only by the availability of new knowledge but also by economic, political, and social environments. Moreover, different areas of research lead to different types of knowledge and thus to different practical applications.

The challenges of implementation depend, for example, on the nature of the adopter (e.g., public sector versus private sector), the magnitude and nature of the change, and the type of knowledge involved (e.g., technological advance versus policy innovation). As a consequence, some results are incorporated into products or processes relatively quickly, while others may experience a time lag of many years between the availability of new knowledge and its eventual application.

## **FRAMEWORK ATTRIBUTES**

To inform its assessment of alternative frameworks, the committee identified attributes corresponding to each framework function that it deemed influential in determining how well a framework performs in a given context. The framework attributes listed in Table 2-1 were

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<sup>2</sup> In the case of patentable materials, dissemination may be restricted to avoid a loss of economic value to the company or university conducting the research.

**TABLE 2-1** Framework Attributes by Function

Function	Attribute
Identification of the role of research in achieving societal goals	<ul style="list-style-type: none"> <li>• Articulates societal goals and the role of research in achieving them</li> <li>• Engages an inclusive set of stakeholders in a timely and cost-effective manner</li> <li>• Reflects a top-down as well as a bottom-up approach</li> <li>• Monitors and fosters assessment of related work in the United States and around the world</li> </ul>
Research agenda setting	<ul style="list-style-type: none"> <li>• Addresses how the field of endeavor affects national priorities for the economy and societal well-being</li> <li>• Provides strategic guidance to relevant national industries, public agencies, and educational institutions</li> <li>• Engages an inclusive set of stakeholders in a timely and cost-effective manner</li> <li>• Supports appropriate collaboration and partnerships among public, private, and academic sectors</li> <li>• Encourages synergies among different disciplines</li> <li>• Reflects a top-down as well as a bottom-up approach</li> <li>• Supports organizational goals</li> <li>• Reflects short-, mid, and long-term issues and plans</li> <li>• Generates a comprehensive research agenda and funds a balanced research portfolio that includes basic, advanced, and applied research</li> <li>• Values champions for their instrumental role in research program focus and their support of the innovation process</li> <li>• Monitors and fosters assessment of related work in the United States and around the world</li> <li>• Embraces strategies for implementation and addresses intellectual property issues</li> <li>• Reflects lessons learned from previous research</li> </ul>
Distribution of funding for specific research activities	<ul style="list-style-type: none"> <li>• Engages an inclusive set of stakeholders in a timely and cost-effective manner</li> <li>• Generates a comprehensive research agenda and funds a balanced research portfolio that includes basic, advanced, and applied research</li> <li>• Engages researchers from universities, agencies, and industry</li> <li>• Promotes quality research through peer-review selection processes and stakeholder reviews of work in progress</li> <li>• Encourages synergies among different disciplines</li> <li>• Values champions for their instrumental role in research program focus and their support of the innovation process</li> <li>• Provides data or evidence that can readily be used for evaluations of ongoing and completed research</li> <li>• Provides institutional structures, incentives, human capital, and financial resources needed to support successful implementation</li> <li>• Develops experts as human capital and educates the next generation of professionals</li> <li>• Demonstrates positive return on investment or measurable improvement in the performance of systems and services</li> <li>• Leverages and supplements knowledge being developed elsewhere</li> <li>• Monitors and fosters assessment of related work in the United States and around the world</li> </ul>

**TABLE 2-1** (continued) Framework Attributes by Function

Function	Attribute
Conduct of research	<ul style="list-style-type: none"> <li>• Engages an inclusive set of stakeholders in a timely and cost-effective manner</li> <li>• Engages researchers from universities, agencies, and industry</li> <li>• Values champions for their instrumental role in research program focus and their support of the innovation process</li> <li>• Generates a comprehensive research agenda and funds a balanced research portfolio that includes basic, advanced, and applied research</li> <li>• Embraces strategies for implementation and addresses intellectual property issues</li> <li>• Supports appropriate collaboration and partnerships among public, private, and academic sectors</li> <li>• Fosters effective working relationships and cooperation among researchers, sponsors, practitioners, industry, and others</li> <li>• Promotes quality research through peer-review selection processes and stakeholder reviews of work in progress</li> <li>• Provides institutional structures, incentives, human capital, and financial resources needed to support successful implementation</li> <li>• Develops experts as human capital and educates the next generation of professionals</li> <li>• Encourages synergies among different disciplines</li> <li>• Monitors and fosters assessment of related work in the United States and around the world</li> </ul>
Research evaluation	<ul style="list-style-type: none"> <li>• Engages an inclusive set of stakeholders in a timely and cost-effective manner</li> <li>• Generates a comprehensive research agenda and funds a balanced research portfolio that includes basic, advanced, and applied research</li> <li>• Promotes quality research through peer-review processes and stakeholder reviews of work in progress</li> <li>• Demonstrates positive return on investment or measurable improvement in the performance of systems and services</li> <li>• Provides data or evidence that can readily be used for evaluations of ongoing and completed research</li> <li>• Monitors and fosters assessment of related work in the United States and around the world</li> <li>• Incorporates prospective and retrospective evaluation</li> <li>• Tracks impacts of research outcomes (products, processes, policies) over the long term</li> </ul>
Dissemination of results	<ul style="list-style-type: none"> <li>• Engages an inclusive set of stakeholders in a timely and cost-effective manner</li> <li>• Engages researchers from universities, agencies, and industry</li> <li>• Embraces strategies for implementation and addresses intellectual property issues</li> </ul>

*(continued on next page)*



**TABLE 2-1** (continued) Framework Attributes by Function

Function	Attribute
Implementation of new knowledge	<ul style="list-style-type: none"> <li>• Communicates new knowledge and its impacts to a variety of audiences with audience-specific messages and in appropriate social and political contexts</li> </ul>
	<ul style="list-style-type: none"> <li>• Values champions for their instrumental role in research program focus and their support of the innovation process</li> </ul>
	<ul style="list-style-type: none"> <li>• Develops experts as human capital and educates the next generation of professionals</li> </ul>
	<ul style="list-style-type: none"> <li>• Supports appropriate collaboration and partnerships among public, private, and academic sectors</li> </ul>
	<ul style="list-style-type: none"> <li>• Engages public awareness and support</li> </ul>
	<ul style="list-style-type: none"> <li>• Engages an inclusive set of stakeholders in a timely and cost-effective manner</li> </ul>
	<ul style="list-style-type: none"> <li>• Supports appropriate collaboration and partnerships among public, private, and academic sectors</li> </ul>
	<ul style="list-style-type: none"> <li>• Engages research providers from universities, agencies, and industry</li> </ul>
	<ul style="list-style-type: none"> <li>• Embraces strategies for implementation and addresses intellectual property issues</li> </ul>
	<ul style="list-style-type: none"> <li>• Provides institutional structures, incentives, human capital, and financial resources needed to support successful implementation</li> </ul>
<ul style="list-style-type: none"> <li>• Provides incentives for implementation that address social, jurisdictional, institutional, and political challenges</li> </ul>	
<ul style="list-style-type: none"> <li>• Develops experts as human capital and educates the next generation of professionals</li> </ul>	
<ul style="list-style-type: none"> <li>• Communicates new knowledge and its impacts to a variety of audiences with audience-specific messages and in appropriate social and political contexts</li> </ul>	

drawn initially from the committee members' collective experience and expertise. These attributes were subsequently refined to reflect what the committee learned from its examinations of (a) the strengths and weaknesses of U.S. surface transportation research, (b) other countries' transportation research frameworks, and (c) the research frameworks of U.S. nontransportation sectors. Several attributes are associated with many functions, reflecting the cohesive nature of the complete research process, from research agenda setting to implementation of new knowledge; other attributes apply only to one or a few functions.

From the comprehensive list of attributes in Table 2-1, the committee selected those it deemed most critical to establishing an effective

national framework for transportation research in the United States. Table 2-2 lists those critical attributes and identifies the research functions for which they are most relevant. However, given the diversity of sponsors, researchers, decision makers, and practitioners who are potentially guided by a national research framework, a restrictive interpretation of each critical attribute would be inappropriate. Rather, users of the framework need the flexibility to apply the framework through the lens that is most pertinent to them. It would also be inappropriate to prioritize these attributes, as no single one is more important than another under all circumstances.

The paragraphs below discuss the importance and value of each of the 12 critical attributes listed in Table 2-2. Subsequent chapters provide additional context for these attributes through lessons learned from other countries and sectors, with specific examples to illustrate key points.

### **1. Engages an Inclusive Set of Stakeholders in a Timely and Cost-Effective Manner**

Today's transportation challenges require wide ranges of expertise, experience, and perspective to generate the best solutions. By engaging a diverse set of stakeholders from the public, private, and academic sectors who are steeped in the many disciplines related to transportation, the resulting research activities are more likely to succeed in supporting societal goals.

Stakeholder participation brings value to all functions within the research framework, but it is especially critical to research agenda setting. The participation of a broad set of stakeholders helps ensure that the research agenda addresses national goals, reflects long-, mid-, and short-term research priorities, and enables synergies among different disciplines. Such participation also facilitates collaboration between public, private, and academic sectors throughout the other framework functions and the consensus required to commit funds to a comprehensive research program.

The potentially high cost associated with involving many people in numerous research functions can be a possible barrier to success. But

**TABLE 2-2 Critical Attributes of a National Transportation Research Framework**

Attribute	Research Function						
	Identification of Role of Research in Achieving Societal Goals	Research Agenda Setting	Distribution of Funding for Specific Research Activities	Conduct of Research	Research Evaluation	Dissemination of Results	Implementation of New Knowledge
1. Engages an inclusive set of stakeholders in a timely and cost-effective manner	✓	✓	✓	✓	✓	✓	✓
2. Supports appropriate collaboration and partnerships among public, private, and academic sectors		✓		✓		✓	✓
3. Reflects a top-down as well as a bottom-up approach	✓	✓					
4. Generates a comprehensive research agenda and funds a balanced research portfolio that includes basic, advanced, and applied research		✓	✓	✓	✓		
5. Engages researchers from universities, agencies, and industry			✓	✓		✓	✓
6. Promotes quality research through peer-review selection processes and stakeholder reviews of work in progress			✓	✓	✓		

7. Monitors and fosters assessment of related work in the United States and around the world	✓	✓	✓	✓	✓	✓
8. Embraces strategies for implementation and addresses intellectual property issues	✓	✓	✓	✓	✓	✓
9. Provides the institutional structures, incentives, human capital, and financial resources needed to support successful implementation	✓	✓	✓	✓	✓	✓
10. Develops experts as human capital and educates the next generation of professionals	✓	✓	✓	✓	✓	✓
11. Communicates new knowledge and its impacts to a variety of audiences with audience-specific messages and in appropriate social and political contexts	✓	✓	✓	✓	✓	✓
12. Demonstrates positive return on investment or measurable improvement in the performance of systems and services	✓	✓	✓	✓	✓	✓

if the collaboration processes are well designed, they may engage stakeholders in a timely, affordable, and cost-effective manner.

## **2. Supports Appropriate Collaboration and Partnerships Among Public, Private, and Academic Sectors**

When organizations have similar or overlapping research objectives, collaborating or creating partnerships to achieve shared goals may be beneficial. Multiple groups working together are able to leverage scarce human and financial resources, which helps ensure that these resources are used wisely and effectively. Collaboration also encourages the engagement of diverse expertise, experience, and perspectives, thereby presenting opportunities to bring needed skills to a research program. Appropriate partnerships in which participants have the flexibility to determine the type and level of collaboration that makes sense for the specific situation create a result that is greater than the sum of the parts.

## **3. Reflects a Top-Down as Well as a Bottom-Up Approach**

Identifying and meeting the broad array of transportation research needs cannot be driven exclusively by high-level, long-term, strategic research initiatives or by short-range, applied, and incremental research activities. Both approaches are needed to ensure that research reflects the evolving demands and opportunities associated with environmental, technological, and social changes. A top-down approach reflects the larger societal vision and responds to broader issues; a bottom-up approach captures specific concerns and practical issues identified by stakeholders. Exclusive reliance on a top-down approach risks missing opportunities for the immediate solution of practical problems. Exclusive reliance on a bottom-up approach may neglect topics of industry-wide, national, or global importance. A framework that encourages both approaches and that allows for interaction between them is best able to address the breadth and depth of research needs. In addition, research users include all levels of government, the private sector, and users of the transportation system, and integrating top-down and bottom-up approaches appears to be the most promising way of engaging all stakeholders.

#### **4. Generates a Comprehensive Research Agenda and Funds a Balanced Research Portfolio That Includes Basic, Advanced, and Applied Research**

The benefits of research, whether expressed in new products, processes, knowledge, or policies, depend on continuous flows of discovery and innovation, often characterized as the “research pipeline.” Tomorrow’s innovation depends on today’s new research perspectives, approaches, and findings that represent and integrate a wide range of disciplines, topics, modes, and processes. The research pipeline also needs elements of basic, advanced, and applied research. With such elements in place, the enterprise can address research questions, accumulate knowledge, and derive and evaluate solutions.

#### **5. Engages Researchers from Universities, Agencies, and Industry**

Research is conducted by educational institutions, government agencies, and private companies (including independent research contractors), with each of these sectors having its own particular research interests and capabilities. Educational institutions’ research tends to take a long-term view, and the role of research in training may be as important as its role in problem solving. Government agencies, by contrast, often have a short- to medium-term view; their research typically addresses issues of a technological or political nature. Federal laboratories may well be the last repository of large research groups able to explore major problems as a team. Private industry tends to carry out research that is highly applied and that often crosses over into product development. Although most of this industrial effort focuses on the short term, it may include elements of long-range research for strategic purposes. In addition, independent contractors undertake a variety of research efforts for both government agencies and private industry.

Given these differences in research perspectives, it is critical that a national research framework actively engages all three sectors.

#### **6. Promotes Quality Research Through Peer-Review Selection Processes and Stakeholder Reviews of Work in Progress**

One of the pillars of scholarly research is the peer-review process, which seeks to ensure quality research. Peer review typically examines not only

the credentials of the researchers themselves, but also the context of the proposed or ongoing research, its inherent strategies, the validity of the research methods used, related activities of other investigators (for comparison), evaluation approaches, and the research's intended applications.

Researchers have a wide range of experience with peer review. Academic researchers publishing in scholarly journals are generally familiar with the process. Government agencies also adopt elements of peer review in their research selection and progress evaluation procedures; independent oversight by expert panels, for example, is common. Private industry uses panels of external scientific advisers to review its research agendas and provide guidance on an enterprise's research and development strategy. Although most often applied to research selection and progress evaluation, in whatever sector, the principles of peer review can be applied to virtually all aspects of the research process.

## **7. Monitors and Fosters Assessment of Related Work in the United States and Around the World**

Although the term "national research framework" implies a national focus, a country's highly productive research enterprise must also be informed by research at the local, state, and international levels. Awareness of the full range of ongoing, completed, and planned research is essential to a nation's agenda setting, research design, and interpretation of results. The monitoring and assessment of U.S. research, in particular, must be continuous if it is to keep pace with a rapidly expanding international research community. In addition, benchmarking U.S. research activities against those of other countries offers opportunities to learn about best practices adopted elsewhere.

## **8. Embraces Strategies for Implementation and Addresses Intellectual Property Issues**

Compelling societal needs, as well as the expectations of research sponsors and the public at large, demand that research embrace application of results as part of its life cycle. A robust research framework takes advantage of all available means (including publication, demonstration,

commercialization, standards development, training, and policy analysis, design, and implementation) to advance research to deployment. Implementation mechanisms should thus be envisioned, planned, and initiated from the inception of research to beyond its completion.

An effective framework also treats intellectual property as a valuable asset for motivating research and advancing its application. The framework encourages stewardship of intellectual property, whether nationally or internationally and at both the precompetitive and competitive stages, to promote adoption and additional development of the resulting technology.

## **9. Provides the Institutional Structures, Incentives, Human Capital, and Financial Resources Needed to Support Successful Implementation**

Successful implementation of the results of research depends on a variety of factors, some of which, such as the type of change involved or the nature of the adopter, may introduce unpredictability into the implementation function. But regardless of the specific factors in each case, four elements are essential to successful implementation: institutional structures, incentives, human capital, and financial resources.

That is, in an environment for successful implementation, (*a*) institutions sustain a culture that supports innovation and risk taking, allows for failure, and provides a leadership structure that holds staff accountable for implementation; (*b*) financial and other incentives encourage adopters to risk implementing new knowledge; (*c*) sufficient human capital is in place to champion, disseminate, communicate, demonstrate, practice, and train adopters; and (*d*) adequate financial resources are committed to ensuring that implementation efforts have the opportunity to succeed.

## **10. Develops Experts as Human Capital and Educates the Next Generation of Professionals**

At educational institutions, a major function of research is the training of professionals for careers in relevant fields. Government agencies and industry need practitioners, researchers, and managers whose value to



the employer derives in large part from their academic training. Government and industry can likewise contribute directly by providing internal training opportunities and sponsoring programs or events at academic institutions.

### **11. Communicates New Knowledge and Its Impacts to a Variety of Audiences with Audience-Specific Messages and in Appropriate Social and Political Contexts**

Historically, research results have been communicated through reports written for an academic or technical readership, but this approach often fails to convey the impacts of the research to other audiences who also would benefit from the new knowledge. Examples of such audiences and their unique information needs include policy makers, who must understand the potential policy impacts of the results; practitioners, who must use the new knowledge in their daily work; and the media, which seek to convey new knowledge to the general public.

Communication experts, skilled at extracting research results from technical reports and transforming them into key messages tailored to specific audiences' information needs, are critical players on a research institution's team. Their well-crafted communication products can explain the research, document its potential benefits, report on its ultimate effectiveness, and inform policy makers about how the research may help to achieve societal goals.

### **12. Demonstrates Positive Return on Investment or Measurable Improvement in the Performance of Systems and Services**

Research sponsors, including the general public, are increasingly concerned with realizing tangible value from their research investments. Although research evaluation often remains informal and ad hoc, the systematic measurement of research benefits could better quantify value. By acquiring the requisite data in each case and using appropriate information systems, research providers may enhance performance measurement and analysis sufficiently to articulate the payoff of research initiatives.

The committee drew on the research functions and attributes described above in identifying the strengths and weaknesses of the current U.S. surface transportation research enterprise (Chapter 3) and in analyzing the information it gathered from other countries' transportation research organizations (Chapter 4) and from U.S. nontransportation research organizations (Chapter 5).

## REFERENCES

### *Abbreviation*

TRB            Transportation Research Board

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## 3

## Current State of U.S. Surface Transportation Research

To identify lessons learned from other frameworks and to evaluate their suitability for strengthening surface transportation research in the United States (as discussed in Chapters 4 and 5), the committee first established a baseline by examining the present U.S. surface transportation research enterprise. This chapter summarizes the committee's review of that enterprise according to principal funding sources: the federal government, state and local governments, industry, or foundations. It offers selected examples of ongoing and completed surface transportation research programs to illustrate their range of research activities. Finally, the strengths and weaknesses of the current research framework are discussed as a precursor to identifying areas for improvement (Chapter 6).

### U.S. SURFACE TRANSPORTATION RESEARCH ENTERPRISE

Research on surface transportation in the United States today is diverse and decentralized, reflecting the nature of the overall transportation system itself. The highway industry, for example, includes "federal, state, and local government agencies responsible for constructing, operating, and maintaining U.S. highways, as well as scores of private companies of various sizes and specialties that carry out much highway design and most highway construction work; [they also] supply materials, equipment, and services used by the public agencies" (TRB 2001a, 16). Surface transportation research is not limited to the infrastructural issues that were critical in the early days of building the nation's rail, highway, and transit systems. Transportation research now involves many disciplines, of which engineering is but one. For example, research aimed at achieving a better understanding of how people and businesses use the

transportation system requires experts knowledgeable in areas such as economics, behavioral sciences, information technology, political science, and public administration.

Surface transportation research in the United States involves actors and organizations not only from governments but from academia, the private sector, and associations, foundations, and other nonprofit organizations. Each of these diverse stakeholders has its own priorities and faces its own set of challenges. As a result, U.S. surface transportation research often appears to be fragmented and relatively disorganized, particularly compared with defense research (Skinner 1997) or with transportation research in smaller countries with no federal–state divide (Elston et al. 2009).

The following four subsections provide an overview of activities and programs supported by major funders in the federal government, state and local governments, industry, and foundations. But the entity funding research is not necessarily, of course, the entity that conducts the research. Thus, when considering the desirable attributes of a national research framework, it is important to note that organizations engaged in the nation's surface transportation research may have differing perspectives, depending on whether they fund research, provide research, or both. Universities, for example, are not major research funders, although they are among the most important research providers. By contrast, both the federal government and private industry fund research and also conduct some of this research in-house. Box 3-1 lists four major categories of research providers and offers examples of the studies they perform.

## **Federal Government**

The U.S. Department of Transportation (U.S. DOT) is the principal entity within the federal government tasked with supporting the nation's transportation system. The department undertakes research in support of its mission, which requires it to ensure a transportation system “[meeting] vital national interests and [enhancing] the quality of life of the American people, today and into the future” (<http://www.dot.gov/mission/about-us>). Other federal departments, including the Department of Energy (DOE) and Department of Defense (DOD), also fund and conduct surface transportation–related research in support of their missions.

BOX 3-1

## **Examples of U.S. Providers of Research Relevant to Surface Transportation**

### **Federal Government**

- The national laboratories conduct significant amounts of federally funded transportation-related research. For example, the Department of Energy's National Renewable Energy Laboratory conducts research on alternative fuels and power-trains, including fuel cells and batteries (Christensen 2011); the Department of Defense has dual-use (military-civilian) research under way in its National Automotive Center (<http://tardec.army.mil/business/national-automotive-center.aspx>).
- The U.S. DOT's Research and Innovative Technology Administration (RITA) conducts research across a number of transportation-related areas through its Volpe National Transportation Systems Center (<http://www.volpe.dot.gov/coi/index.html>).
- The Department of Commerce's National Institute of Standards and Technology conducts research on materials and manufacturing at its Center for Automotive Lightweighting ([http://www.nist.gov/mml/msed/materials\\_performance/sheet\\_metal\\_forming.cfm](http://www.nist.gov/mml/msed/materials_performance/sheet_metal_forming.cfm)).

### **Academia**

Universities and affiliated entities are heavily engaged in transportation research through contracts with transportation service providers, private industry, and federal and state governments (e.g., through RITA's University Transportation Centers program).

**Industry**

- U.S. automotive manufacturers and suppliers perform in-house research.
- Nontraditional firms are engaged in transportation-related research (e.g., Google's much-publicized efforts involving a driverless vehicle).

**Independent Contractors**

Various independent research and development contractors (often organized as nonprofits) are also part of the transportation research landscape, undertaking a range of research activities for government and industry clients; examples include Battelle ([www.battelle.org](http://www.battelle.org)) and Southwest Research Institute ([www.swri.org/](http://www.swri.org/)).

***U.S. DOT***

Much of the U.S. DOT's support for surface transportation research derives from the department's modal administrations (<http://www.dot.gov/administrations>), namely, the Federal Transit Administration (FTA), the Federal Railroad Administration, the National Highway Traffic Safety Administration, the Pipeline and Hazardous Materials Safety Administration, the Federal Motor Carrier Safety Administration, and, notably, the Federal Highway Administration (FHWA) (see Table 3-1). Of particular interest in the context of a national framework for surface transportation research, however, are the programs of the Research and Innovative Technology Administration (RITA), which are not constrained to be modally focused. RITA was established in 2004, and one of its responsibilities is to coordinate, facilitate, and review U.S. DOT research programs. [Resources for this activity are relatively modest, however, because much of RITA's budget is committed to the University Transportation Centers (UTC) and Intelligent Transportation Systems (ITS) programs.]

**TABLE 3-1** U.S. DOT Support Enacted for Surface Transportation Research, FY 2010

Agency or Office	Budget (\$ millions)	Budget as Percentage of Total <sup>a</sup>	Major Programs (≥\$5 million)	Program Budget (\$ millions)
FHWA	291	30.7	Surface transportation research	195
			Training and education	25
			SHRP 2	48
FTA	60	6.3	National program	44
			TCRP	10
FRA	42	4.4	Rail R&D	38
RITA	227	23.9	UTC	82
			BTS	27
			ITS	108
OST	18	1.9		
NHTSA	110	11.6	Research and analysis	61
PHMSA	10	1.1		
FMCSA	7	0.7		
State DOTs and SP&R <sup>b</sup>	183	19.3	NCHRP	40
Total	948	100.0		678

NOTE: FHWA = Federal Highway Administration; SHRP 2 = Strategic Highway Research Program 2; FTA = Federal Transit Administration; TCRP = Transit Cooperative Research Program; FRA = Federal Railroad Administration; R&D = research and development; RITA = Research and Innovative Technology Administration; UTC = University Transportation Centers; BTS = Bureau of Transportation Statistics; ITS = Intelligent Transportation Systems; OST = Office of the Secretary of Transportation; NHTSA = National Highway Traffic Safety Administration; PHMSA = Pipeline and Hazardous Materials Safety Administration; FMCSA = Federal Motor Carrier Safety Administration; NCHRP = National Cooperative Highway Research Program; SP&R = State Planning and Research program.

<sup>a</sup>Percentages may not sum to 100.0 because of rounding errors.

<sup>b</sup>The SP&R program, a major component of the U.S. DOT's research budget, is included because federal funds constitute a substantial part of this program's funding.

SOURCE: Adapted from an analysis of the U.S. DOT's FY 2010 research budget by TRB staff.

RITA's strategic plan for the five-year period from 2012 to 2017 supports the U.S. DOT's strategic goals with corresponding research focus areas. The plan "takes a department-wide, systems-level view of the multimodal transportation system and presents strategies . . . that go beyond a modal-oriented and modal-funded perspective" (RITA 2012, 6). Important but limited stakeholder contributions, together with input from all the modal administrations, contributed to the plan, which strongly emphasizes performance measures, data-driven decision making, and outcomes.

The 2012 passage of P.L. 112-141, the Moving Ahead for Progress in the 21st Century Act (MAP-21), eliminated earmarks, emphasized competition and peer review, and placed other constraints on the U.S. DOT's research programs. In the committee's judgment, these changes could enhance RITA's ability both to influence the directions, priorities, and funding of the U.S. DOT's research and to direct research toward departmental goals in ways not previously possible.

### ***Other Federal Departments***

Federal agencies other than the U.S. DOT provide substantial funding for research in surface transportation. DOE, for example, supports research on transportation fuels and propulsion systems. A 2009 report notes that DOE investments in transportation "dwarf those of U.S. DOT" (TRB 2009, 23); the report's authors estimated that DOE's research investment related to transportation exceeded \$500 million for FY 2009. In support of the defense establishment's mission, DOD also funds a variety of transportation research activities. For example, the U.S. Transportation Command is responsible for improving all aspects of transportation, from manufacture to delivery to the soldier in the field; the Defense Advanced Research Projects Agency sponsors revolutionary "high-risk-high-payoff" research aimed at bridging the gap between fundamental discoveries and their military applications; and the Cold Regions Research and Engineering Laboratory supports research on pavements, structures, materials, and construction for arctic regions.

Additional federal agencies support research related to transportation, albeit at more modest levels than do DOE and DOD. They include the U.S. Environmental Protection Agency (EPA), which funds research on environmental topics related to transportation, including the health effects of motor vehicle emissions and the development of emissions



control technologies; and the National Science Foundation (NSF), which supports basic research in a wide range of areas relevant to transportation, such as economics, information technology, and civil infrastructure systems (TRB 2008a; Nelson 2011).

However, although departments other than the U.S. DOT contribute to the federal investment in surface transportation research, they do not identify transportation research explicitly in their programs and budgets. Rather, such research is subsumed by goals more directly linked to each agency's mission. As a result, it is difficult to calculate how much the federal government invests in transportation research overall, how much is devoted specifically to surface transportation research, and the breakdown of this research investment across federal departments. Estimates of this breakdown cited by Brach (2005) vary considerably because of data limitations and inconsistencies. The committee's recommendations do not depend on a detailed analysis of recent budget data. Available data suggest, however, that the U.S. DOT's contribution is far from being the dominant component of the nation's federal investment in surface transportation research.

## **State and Local Governments**

Many state DOTs support research related to their state's transportation system. The California DOT (Caltrans), for example, has a comprehensive research program that explores innovations in methods, materials, and technologies, although this program has been shrinking in recent years, due in part to the state's budget problems. The program aims to provide effective management of public facilities and services, protect public investment in transportation infrastructure, and enhance and expand mobility options (<http://www.dot.ca.gov/newtech>). Less populous states have more modest research programs, but with similar objectives.

State DOT research programs are funded primarily through the federal State Planning and Research (SP&R) program, which sets aside 2 percent from selected categories of federal highway aid; each state is required to use a minimum of 25 percent of its SP&R funding for research purposes. Total state DOT research funding actually exceeds this statutory minimum. In 2006, states spent an estimated \$326 million on highway research—\$160 million more than the SP&R minimum of

\$166 million (TRB 2008a). Some observers have suggested that this extra amount has likely declined in recent years as a result of the recession and associated constraints on state budgets, but the committee could not obtain data to confirm or refute this supposition.

Some anecdotal evidence suggests that local and regional agencies are becoming more involved in research, as in the case of the Chicago Transit Authority's collaborative multiyear research effort with the University of Illinois–Chicago and the Massachusetts Institute of Technology (Progressive Railroading 2001). However, data limitations prevented the committee from assessing the extent and scope of such efforts.

## Industry

Companies throughout the transportation sector support research initiatives both individually and through partnership arrangements. Characterizing these private-sector research programs is challenging, however, because of the scope of the transportation domain, the often proprietary nature of the work, and the very limited disclosures of the financial and human capital being invested in the programs. Although individual automotive companies report substantial investments in research—on the order of \$5 billion per company annually [e.g., see Ford Motor Company (2012)]—the inclusion of engineering and development in this figure can mask and likely dominates the investment in basic and applied research.

An important phenomenon over the last three decades has been the advent of partnerships among private-sector entities, universities, and government agencies as a result of the 1984 Cooperative Research Act (<http://www.uscar.org/guest/about/>). These precompetitive research initiatives, which sometimes include multiple competing companies, may be organized by either a public-sector or private-sector entity. Funding from the private sector is often in the form of in-kind contributions, but it may also include research contracts or direct contributions to academic institutions. An example of such a collaboration, the 21st Century Truck Partnership (21CTP), is discussed below. In the case of the railroad industry, collaborative research efforts involving government, railroads, suppliers, and academia also contribute to solving problems facing a mature industry where “the easy-to-solve problems already have been addressed” (Tunna and Butler 2013, 3).

## Foundations

Various U.S. and international foundations, including the Rockefeller Foundation and the Volvo Research and Education Foundation, fund surface transportation research at universities in the United States. The Volvo Research and Education Foundation, for example, funds ten Centers of Excellence around the world, including centers at the University of California at Berkeley, Columbia University, the University of Southern California, and Rensselaer Polytechnic Institute (<http://www.vref.se/>), to conduct research on future urban transport. These centers receive modest funding for a start-up period (less than \$1 million per year for five years), which gives participating universities the opportunity to propose more ambitious research and education initiatives on topics that existing federal, state, or industry programs do not already address.

## SELECTED RESEARCH PROGRAMS

In this section, brief descriptions of selected surface transportation-related research programs illustrate the range of research being conducted under various funding arrangements and with the involvement of diverse participants. The ongoing and completed major activities examined by the committee are presented below under the headings “Focused Research Programs of Limited Duration” and “Research Programs Funded on a Continuing Basis.” Individual programs are listed in Box 3-2.

Research activities are not created equal. They vary in their characteristics, such as level of risk and time frame. Box 3-3 defines the terms for research types that are used throughout the transportation community and beyond.

### Focused Research Programs of Limited Duration

#### *Strategic Highway Research Program*

The Strategic Highway Research Program (SHRP) was conceived in 1984 as a means of increasing the funding and focus of highway research (TRB 1984). Subsequently, over 200 stakeholders were involved in a two-year planning study funded by FHWA and the National Cooperative Highway

BOX 3-2

## **Examples of U.S. Research Programs Related to Surface Transportation**

### **Focused Research Programs of Limited Duration**

- Strategic Highway Research Program (SHRP)
- National Automated Highway System Research Program (NAHSRP)
- 21st Century Truck Partnership (21CTP)

### **Research Programs Funded on a Continuing Basis**

- State Planning and Research (SP&R) Program
- Transit Cooperative Research Program (TCRP)
- Intelligent Transportation Systems (ITS) Program
- Association of American Railroads (AAR) Research Program
- University Transportation Centers (UTC) Program
- Exploratory Advanced Research (EAR) Program

Research Program (NCHRP) and overseen by an expert committee. The resulting report (TRB 1986), together with an agreement by the American Association of State Highway and Transportation Officials (AASHTO) to divert 0.25 percent from state federal-aid highway funds, led to congressional authorization of the SHRP applied research initiative in 1987. Some \$150 million (or about \$308 million in 2012 dollars) was provided over a five-year period for a highly strategic research program aimed at significantly improving the performance, durability, safety, and efficiency of the nation's highways.

Over 100 research products were developed, and an aggressive implementation program, funded through federal and state contributions, encouraged the deployment of these products. Educational and technical assistance activities were critical parts of the deployment process. A 2001 report provides examples from state DOTs of actual benefits derived from the implementation of SHRP products, noting that the

BOX 3-3

## Research Categories

- **Basic research.** “The objective of basic research is to gain more comprehensive knowledge or understanding of the subject under study without specific applications in mind. Although basic research may not have specific applications as its goal, it can be directed [to] fields of present or potential interest. This is often the case with basic research performed by industry or mission-driven federal agencies” (NSB 2008, 4-9).
- **Applied research.** “The objective of applied research is to gain knowledge or understanding to meet a specific recognized need. In industry, applied research includes investigations to discover new scientific knowledge that has specific commercial objectives with respect to products, processes, or services” (NSB 2008, 4-9).
- **Development.** “Development is the systematic use of the knowledge or understanding, gained from research, [that is] directed toward the production of useful materials, devices, systems, or methods, including the design and development of prototypes and processes” (NSB 2008, 4-9).
- **Advanced transportation research.** According to P.L. 109-59, the 2005 Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU), advanced transportation research lies at the interface between basic research and applied research, drawing on longer-term, higher-risk basic research that may offer potential breakthroughs for transportation systems. For example, advanced transportation research uses basic research results from nanotechnology for coatings to prevent metal fatigue in rails or bridges, or from molecular chemistry to create self-healing asphalt pavement. It also creates tools for analyzing and predicting the performance of transportation systems not yet envisioned, such as

new paradigms for public transportation. Finally, advanced transportation research informs policy alternatives for a future that is complex and uncertain; for example, it may identify the impacts of transportation on climate or the implications of changing demographics for future travel behavior and demand.

- **Implementation (or deployment) in transportation.** Implementation in transportation is defined as the process through which the results of applied research and development are taken up in practical applications. Examples include the placement of safety systems (e.g., blind-spot warning) into vehicles; the incorporation of advanced design and measurement techniques (e.g., Superpave) into state DOT construction standards; and the establishment of interoperability standards and systems for electronic tolling (e.g., E-ZPass).

extent and pace of implementation of SHRP results “are the best indicators of the program’s success” (TRB 2001b, 37).

Box 3-4 lists important characteristics of the SHRP initiative that may, in the committee’s judgment, provide valuable lessons for the strategic applied research component of future national transportation research frameworks. The ongoing SHRP 2 program, initiated in 2006, builds on the same research framework and operating model as did SHRP, suggesting that this framework and model are viewed by the stakeholders as effective for a major focused program of applied research.

### ***National Automated Highway System Research Program***

Transportation leaders have long envisioned wide-ranging benefits from the application, singly or combined, of rapidly advancing information, communications, and control technologies to the nation’s highway system. In 1991, P.L. 102-240, the Intermodal Surface Transportation Efficiency Act (ISTEA), included the Intelligent Vehicle–Highway Systems

BOX 3-4

### **Important Characteristics of SHRP Initiative**

1. The research was defined in terms of a clear vision of high-priority national needs.
2. The program was guided by experts and stakeholders from concept and definition, through selection of researchers and evaluation of results, to implementation.
3. The use of a special unit of the National Academies to manage the program brought to bear the benefits of an established expert-committee process and mechanisms for impartial expert review at all stages of the program.
4. Partnerships with the user community and other stakeholders were integral throughout.
5. The program organization and decision-making structure had the flexibility to permit redirection of projects when research outcomes or funding changes so indicated.
6. Early buy-in by funding agencies and implementers (AASHTO, NCHRP, FHWA, and state DOTs) was critical.
7. The special time-constrained nature of the program avoided competition with, or duplication of, ongoing research programs.
8. The research framework as a whole was free of undue political influence.

Act. The latter act required the U.S. DOT to develop, via the National Automated Highway System Research Program (NAHSRP), an automated highway and vehicle prototype as a step toward fully automated intelligent vehicle-highway systems. The goal was to have the first fully automated roadway or an automated test track in operation by 1997.

To implement this mandate, a public-private research consortium called the National Automated Highway System Consortium was formed in 1994, under the leadership of General Motors, with the aim of pooling financial resources, technical expertise, and marketplace experience

(TRB 1998). The consortium's nine core members were drawn from academia and the motor vehicle, highway, electronics, and communications industries. Program costs were budgeted at about \$20 million per year (\$31 million in 2012 dollars) for seven years, with members expected to pay at least 20 percent and the U.S. DOT providing the remainder. The consortium's goal went beyond the ISTEA mandate by including the selection and testing of a preferred concept that would be the basis of future automated highway systems.

In August 1997, the consortium successfully demonstrated automated-vehicle highway operation on a sequestered section of freeway in San Diego, California. But as a result of changing priorities and a shortfall of research funds, the U.S. DOT subsequently withdrew its support of the consortium and discontinued the NAHSRP. These actions were endorsed by an expert committee tasked with reviewing the NAHSRP, which concluded that

- The task of developing, evaluating, and selecting a specification for a preferred fully automated highway system in less than seven years was unrealistic because of daunting technological, social, and institutional issues;
- The consortium had a built-in conflict of interest, given its dual responsibilities to promote a shared vision of automated highways while also having to evaluate the prospects of implementing that vision; and
- The required consensus-based management and decision-making structure of the National Automated Highway System Consortium made it very difficult to respond to changing funding and program priorities (TRB 1998).

Although the National Automated Highway System Consortium failed to meet its goal of specifying a preferred automated highway system, it did create new technologies that have been important in subsequent developments by the ITS Program (see the discussion on the ITS Program later in this section).

### ***21st Century Truck Partnership***

Growing U.S. dependence on imported oil and increasing environmental concern about global climate change have led recent administrations



to support research programs aimed at improving the fuel efficiency of new vehicles. Recognizing that the heavy-duty truck and bus fleet of the United States consumes 20 to 25 percent of total surface transportation fuel, federal officials formed the 21CTP in 2000 as a cooperative research and development initiative comprising four federal agencies (DOE, U.S. DOT, DOD, and EPA) and 15 industrial partners.

21CTP was initially led by DOD's U.S. Army Tank Automotive Research and Development Command, but in 2002 leadership was transferred to DOE's Office of FreedomCAR and Vehicle Technologies (now the Office of Vehicle Technologies). The impetus behind the partnership was the hope that it would dramatically advance the technologies used in heavy-duty trucks and buses, thereby yielding a cleaner, safer, and more fuel-efficient generation of vehicles.

The management of individual projects under the program rests with the individual agencies funding a given project, and these agencies continue to receive their appropriations from their relevant congressional committees. Thus there is no central overall control over budgets and accountability, a weakness highlighted in reviews of the partnership's activities (NRC 2008, 2012). But while managing its own projects, lead agency DOE also organizes meetings, maintains the information-sharing infrastructure (e.g., websites and e-mail lists), and oversees the preparation of technical white papers. The agencies use the information-sharing infrastructure to coordinate efforts and ensure that valuable research results are communicated, thereby reducing any overlap of activities among the agencies' programs.

NRC committees reviewed the partnership's activities in 2007 and again in 2011 (NRC 2008, 2012). The more recent review found a key benefit of the partnership to be the "coordination of research programs directed toward the goal of reducing fuel usage and emissions while increasing the safety of heavy-duty vehicles. Federal involvement is bringing stakeholders to the table and accelerating the pace of technological development. . . . Thus the 21CTP is providing access to the extraordinary expertise and equipment [of] the federal laboratories, in addition to seed funding that draws financial commitment from the companies to push forward in new technology areas" (NRC 2012, 2). This review also found that the partnership "provides the United States with a forum in which member

agencies, in combination with industry, academia, and federal laboratories, can better coordinate their programs” (NRC 2012, 2). Both reports urged continuation of the partnership, while at the same time setting forth recommendations for improvement.

The committee views the 21CTP as a useful model for engaging multiple federal agencies and multiple industry partners in collaborative research activities within the constraints imposed by current institutional arrangements.

## **Research Programs Funded on a Continuing Basis**

### ***State Planning and Research Program***

The Federal Aid Highway Act and the Highway Revenue Act of 1956, which created the Highway Trust Fund and ushered in the Interstate highway era, gave new momentum to highway development and associated research. In particular, the dedicated trust fund gave stability and continuity not only to construction and maintenance, but also to research defined and directed by the states. Included in this research is the SP&R program, which has been a line-item authorization in all surface transportation acts since ISTEA in 1991. A minimum of 25 percent of federal SP&R funds allocated to a state for a fiscal year must be used for research purposes (planning, research and development, and technology transfer). Under the most recent surface transportation act, the 2012 Moving Ahead for Progress in the 21st Century Act (MAP-21), this minimum research funding is estimated to be approximately \$183 million a year for both FY 2013 and FY 2014 ([http://www.fhwa.dot.gov/map21/docs/28aug\\_research\\_technology.pdf](http://www.fhwa.dot.gov/map21/docs/28aug_research_technology.pdf)).

In addition to supporting each state's research program, SP&R funds are used by states to support collaborative research efforts. A portion (5.5 percent) of each state's SP&R allocation is used to support the NCHRP, a collaborative research initiative created in 1962 that targets acute problem areas affecting highway planning, design, construction, operation, and maintenance nationwide (<http://www.trb.org/NCHRP/NCHRPOverview.aspx>). Funds can be spent only for research problems approved by at least two-thirds of the states. State DOTs also use their SP&R funds to support collaborative research efforts through the Transportation Pooled

Fund Program (<http://www.pooledfund.org/Home/About>), which provides a mechanism for state DOTs, commercial entities, and FHWA program offices to combine their resources in pursuit of common goals. Pooled-fund studies may be initiated by federal, state, regional, or local transportation agencies and may involve private companies, foundations, and universities as research partners.

The SP&R program has evolved over the years, with the early focus on highway construction gradually giving way to a multimodal and multidisciplinary scope. Thus eligible activities under MAP-21 include not only research activities relating to the construction and maintenance of highway, public transportation, and intermodal transportation systems but also studies of the economy, safety, convenience, regulation, and taxation of surface transportation systems (<http://www.fhwa.dot.gov/map21/spr.cfm>). The program focuses on applied research, but it has also brought advances in areas of basic science (e.g., materials, communications, human factors, mathematical modeling, and social and behavioral science) to bear in developing solutions to transportation problems faced by the states.

The committee is not aware of any comprehensive retrospective analyses of the benefits of the SP&R program to the states and the nation.<sup>1</sup> However, the continuous improvements in surface transportation safety, infrastructure quality, construction efficiency, and operational methods testify, at least in part, to the effectiveness of this long-term research investment. Selected projects are showcased in the *NCHRP Impacts on Practice* one-page case studies (<http://www.trb.org/NCHRP/NCHRPImpactsonPractice.aspx>).

### ***Transit Cooperative Research Program***

The Transit Cooperative Research Program (TCRP) was initiated in 1992 following the recommendation of an expert committee (TRB 1987). The program was established as part of the ISTEA implementation process by three cooperating organizations: FTA, which funds the program; the Transit Development Corporation, a nonprofit educational and research

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<sup>1</sup> AASHTO's Research Advisory Committee supports work aimed at establishing a performance-measurement tool box and reporting system for research programs and projects (Krugler et al. 2006).

organization, which provides governance through the TCRP Oversight and Project Selection committee; and the National Academies, acting through TRB, which serves as program manager. The program has been funded by FTA since its inception, typically at around \$10 million annually, although funding levels in FY 2012 and FY 2013 dropped significantly.

The goal of TCRP is to help the transit industry develop near-term solutions to operating problems and adopt new technologies and approaches aimed at meeting the demands placed on the nation's public transit systems. Each year a broad solicitation of research problem statements is issued. Projects are selected for funding by the TCRP Oversight and Project Selection committee, which comprises representatives of the transit industry, government, academia, and other interested sectors. In other words, TCRP uses a bottom-up process to develop its research agenda. For each research topic selected, an expert committee is formed and then tasked with preparing the research problem statement, evaluating the proposals, and selecting the organization to conduct the research. Research topics are applied in nature; TCRP does not address longer-term basic and advanced research, including strategic research on future transit systems.

TCRP has followed a similar model for program administration throughout its 20-year history, suggesting that stakeholders view this model as effective for short-term applied research.

### ***Intelligent Transportation Systems Program***

The ITS concept explores opportunities to develop safer, more efficient, more integrated, and more environmentally friendly transportation systems by drawing on developments in communications, computation, sensing, and control. The ongoing ITS program had its origins in a national workshop on intelligent vehicle–highway systems (IVHS). Convened in March 1990 by a core group of representatives from government, academia, and industry, the workshop established broad support for, and agreement on the vision and goals of, a national IVHS program (TTI 1990). Following the workshop, the nonprofit corporation IVHS America was formed, and TRB subsequently issued a report addressing the overall objectives of a national IVHS initiative and methods for effectively managing such a program (TRB 1991).

With input from IVHS America, ISTEA included the Intelligent Vehicle–Highway Systems Act of 1991 (Title VI, Part B), which required the U.S. DOT to develop an IVHS strategic plan within one year. In May 1992, IVHS America (later renamed ITS America) published the congressionally mandated strategic plan, which was developed through a consensus-building process involving the entire IVHS community of stakeholders. P.L. 105-178, the 1998 Transportation Equity Act for the 21st Century, required the U.S. DOT to maintain and update the national ITS Program plan developed by ITS America and the U.S. DOT; subsequent reauthorizations of surface transportation legislation have specified similar actions. The ITS program continues to receive approximately \$100 million annually in federal funding.

ITS research today includes partnerships between government and industry to develop platforms for connecting vehicles and to establish applications for crash avoidance, mobility, and eco-driving. Industry consortia such as the Crash Avoidance Metrics Partnership and the Vehicle Infrastructure Integration Consortium develop precompetitive technologies and related policies, and individual companies address driver interfaces and interventions in the driving process.

Box 3-5 lists some of the more important characteristics of the ITS Program that, in the committee's judgment, have contributed to the success of the initiative.

### ***Association of American Railroads Research Program***

For over 100 years, the American railroad industry has conducted research and testing in its search for better mechanical designs, materials, and operating methods. The benefits of consolidating much of this research into a central program of laboratories and proving grounds have long been recognized by the individual railroads. The Association of American Railroads (AAR), an industry trade group founded in 1934 that represents the major North American railroads, has played (and continues to play) a critical role in organizing committees responsible for much of the industry's research. In addition, several AAR-sponsored university affiliates perform research, and vendors play an important role in developing new products. Individual railroads also conduct some of their own research.

BOX 3-5

## **Characteristics Contributing to ITS Program Success**

1. The leadership of visionary professionals who, seeing a transformational opportunity, convened a planning workshop that included a broad range of public and private stakeholders and produced a vision, goals, and funding estimates for a national program clearly linked to national transportation goals;
2. The establishment of an independent stakeholder advisory and advocacy group for intelligent vehicle–highway systems (IVHS America, subsequently ITS America);
3. Through (1) and (2) above, engaging Congress and securing a stable source of funding and mandated federal leadership;
4. A continuing stakeholder-planned research effort that provides funding for demonstration programs and requires evaluation of outcomes;
5. Flexibility to modify plans and directions based on technological advances and research outcomes;
6. Strong federal leadership;
7. Emphasis on communication of benefits to Congress and the general public;
8. Stability and continuity of federal funding over more than 20 years;
9. Promise of a major market opportunity for the private sector (especially the vehicle and communications industries), thus spurring investment; and
10. Continuing investment in human capital to educate the future professional and technical workforce.

Most acceptance testing for the U.S. railroad industry is centralized at the Transportation Technology Center, Inc. (TTCI), in Pueblo, Colorado. A subsidiary of AAR, TTCI is a transportation research and testing organization that operates the U.S. DOT–owned Transportation Technology Center; the center possesses specialized facilities for testing rolling stock, vehicle and track components, and safety devices.

Examples of efforts involving AAR and TTCI include cooperative testing, research, and standards development by industry and government to improve railroad tank car safety through improved design (Barkan et al. 2013) and advances in track support and management systems to enhance the safety and efficiency of rail infrastructure (Sussman et al. 2013). In the latter case, balancing the potentially competing goals of safety and efficiency is an important driver for the railroad industry.

Railroad industry research priorities are derived from a technology “roadmap” that is revisited annually at a research review conducted by TTCI. Input is provided by the Federal Railroad Administration, railroad company officials, and TTCI staff. In addition to addressing specific research topics, the roadmap outlines research strategies. For example, the 2012 roadmap identified the role of technology implementation and technology-driven productivity improvements in meeting demand for increased railroad capacity. It also noted that coordinated and collaborative research by stakeholders will be required to realize the objectives defined in the roadmap.

### ***University Transportation Centers Program***

The UTC program was established under P.L. 100-17, the Surface Transportation and Uniform Relocation Assistance Act of 1987, which authorized the competitive award of a center in each of 10 federal regions. Each center was funded at \$1 million annually (approximately \$2 million in 2012 dollars) with a requirement for a 100 percent funding match from nonfederal sources; with few exceptions, this match was provided by state DOT funds. In subsequent surface transportation authorizations, additional centers were established by congressional earmarking (i.e., without competition or merit review). In 2005, the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU) authorized up to \$76.7 million a year for four years for

as many as 60 UTCs; 20 were competitively selected in 2006, and 40 were congressionally mandated in the act without competition. The 100 percent nonfederal-match requirement was realized in most cases, and state DOTs continued to be important providers of these matching funds.

In 2011, the U.S. DOT responded to concerns about earmarking by conducting a new competition for UTCs, which culminated in funding awards for 22 centers in January 2012. MAP-21 continues the UTC program, but the legislation requires a more rigorous and transparent recompetition for centers. MAP-21 calls for up to 35 UTCs of various types and funding levels, with each center tied to one of the U.S. DOT strategic goals. The objectives of the centers are to conduct basic and applied research that peers or experts agree should advance transportation knowledge, provide multidisciplinary education programs, and establish technology-transfer programs that lead to implementation.

In general, transportation-related research at universities, such as the work supported by the UTC program, provides two broad benefits. First, the research directly produces new knowledge to help solve transportation problems; see, for example, RITA (2009). Second, it aids faculty in educating the next generation of transportation leaders and other professionals. Since the inception of the UTC program, more than 100 U.S. universities have become involved in research and education in transportation. Many of these universities have used their UTC as a mechanism for building their transportation research and education capacity, while others (with strong established programs) have used the UTC funding for new initiatives aimed at broadening the scope and interdisciplinary nature of their activities.

Overall, the UTCs have had an important impact on transportation education. During the first four years of SAFETEA-LU, over 750 master's and doctoral programs were offered by UTC universities, and almost 9,000 master's and 1,000 doctoral degrees were awarded (RITA 2011).

Over the years, various groups have expressed concern that the UTC program fails to take advantage of universities' expertise in basic and advanced research; see, for example, TRB (1993). In 2011, RITA, which administers the UTC program, conducted a preliminary survey of UTC performance indicators for the first four years of SAFETEA-LU. Although not final, the 2011 data suggest that the UTC program in general is biased



toward applied research (RITA 2011); a similar bias had previously been noted in highway-related projects supported by the UTC program (TRB 2008a). Many observers have attributed this bias, at least in part, to the funding match provided by applications-oriented DOTs. Others have suggested that the large number of universities involved can dilute the funding to the point that multidisciplinary, basic or advanced research programs of critical size cannot be supported. As a result, the focus is on small programs of applied research, typically involving one professor and one or two graduate students who target incremental solutions to narrowly defined problems.

### ***Exploratory Advanced Research Program***

FHWA's Exploratory Advanced Research (EAR) program was established by SAFETEA-LU in 2005 with funding designated for "longer-term, higher-risk, breakthrough research with the potential for dramatic long-term improvements to transportation systems" (<http://www.fhwa.dot.gov/advancedresearch/>). The program bridges basic research (similar to research funded by NSF) and applied research (similar to studies funded by state DOTs).

FHWA has issued broad agency announcements for the EAR program soliciting research proposals in selected focus areas based on the authorizing legislation, stakeholder input, initial-stage research, and FHWA's strategic needs. The six solicitations issued between 2007 and 2012 resulted in the awarding of 50 research projects on 37 topics. Research partnerships are encouraged to stimulate new approaches to problem solving, and awards may be either contracts or cooperative agreements (in which case a nonfederal cost share of a least 20 percent is required). The projects awarded through 2012 total \$42 million in FHWA funds, with \$17 million in matching funds. The research involves multidisciplinary teams at 33 academic institutions, 16 private companies, 10 state and local agencies, and seven federal laboratories (<http://www.fhwa.dot.gov/advancedresearch/>).

The EAR program is an open competition that offers proposers the opportunity to develop their own ideas, subject to the constraints imposed by the focus areas. Writing shortly after the EAR program was established, an expert committee on highway safety research called the

program “a potentially important first step toward a more balanced FHWA research portfolio encompassing both short-term applied and longer-term advanced/exploratory research” (TRB 2008b, 45).

## **STRENGTHS AND WEAKNESSES OF CURRENT RESEARCH FRAMEWORK**

The committee drew on the preceding examples of research activities and on the personal experience of its members to consider the strengths and weaknesses of the current U.S. research framework for surface transportation, as discussed in the following sections.

### **Strengths**

Two major strengths of the current framework are the robust portfolio of applied research and the role played by research in educating future transportation professionals.

#### ***Robust Portfolio of Applied Research***

Over the years, a diverse array of applied research activities has led to important improvements in the nation's surface transportation system. Incremental improvements, particularly when compounded over time, have resulted in safer and more fuel-efficient automobiles, safer road designs, more effective and customer-friendly public transportation services, and improved freight rail operations; see, for example, TRB (1996). Applied research has been, and continues to be, supported both by the public and private sectors, and it engages a variety of research providers. Some applied research activities are continuing in nature, while others are designed to be of limited duration. Many of the initiatives adopt models emphasizing the importance of stakeholder engagement throughout the research process, from initial identification of needs to attainment of new knowledge to the ultimate deployment of new or improved technologies.

The longevity of continuing initiatives, such as the SP&R program, the cooperative research programs, and the ITS program, reflects their value to stakeholders and funding organizations. However, efforts to measure program benefits in terms of return on investment or other metrics tend

to be narrowly focused, as documented in the “Research Pays Off” feature published periodically in TRB’s *TR News*. Examples of more comprehensive program assessments, such as the recent examination of SHRP’s Superpave® initiative (McDaniel et al. 2011), are relatively rare.

The highway sector’s research program has some effective attributes and forms a sound basis for structuring a modally focused transportation research initiative, although the program is limited in scope (no basic research) and lacks the cohesion resulting from an overall research agenda. Nonetheless, the various research efforts address infrastructure, vehicles, fuels, users, and the interactions among them, and these efforts receive important levels of research investment not only by federal and state governments, but also by the automotive and construction industries. Activities include focused advanced research, notably through FHWA’s EAR program, as well as applied research and development. Research partnerships, such as 21CTP, engage different groups with diverse skills and experience. Efforts such as FHWA’s Every Day Counts initiative (<http://www.fhwa.dot.gov/everydaycounts/>) and the Local Technical Assistance Program (<http://www.ltap.org/>) facilitate knowledge transfer and encourage the implementation of research results. At the federal level, a chief scientist within FHWA advises the agency on its research activities, and external advice is provided by the Research and Technology Coordinating Committee of the National Academies (<http://www8.nationalacademies.org/cp/projectview.aspx?key=48799>).

### ***Educating Future Transportation Professionals***

The U.S. DOT has recognized the importance of educating future transportation professionals, and through its UTC program the department has expanded resources devoted to transportation education over the past 25 years. As a result, the number of universities offering training in surface transportation has increased substantially, as has the number of graduates from these programs. In the committee’s view, there is considerable value in continuing to recognize the links between university research and education in surface transportation, even as the U.S. DOT seeks to improve the cost-effectiveness of the UTC program. As noted in a report on recruiting, training, and retaining qualified workers for transportation and transit agencies, “new workforce skills [are needed] to

keep pace with new methods and advanced technologies” as the “changing mission and broader responsibilities of [today’s state DOTs] require a workforce capable of addressing many issues other than engineering” (TRB 2003, 3). The opportunity to participate in research is an excellent way for students to acquire such skills.

## Weaknesses

The committee identified four major areas for improvement in the U.S. transportation research framework:

- Recognizing the importance of basic and advanced research,
- Building value through research partnerships and enhanced coordination,
- Linking to national goals, and
- Quantifying the impacts of research activities and the associated return on investment.

### *Recognizing the Importance of Basic and Advanced Research*

The robust portfolio of applied research outlined above contrasts sharply with the paucity of basic and advanced research activities devoted to surface transportation. Applied research projects have led to important improvements over the years but, in the committee’s judgment, such efforts will not by themselves produce the transformations in transportation needed to meet emerging long-term global challenges, such as climate change and sustainability.

What is generally considered more appropriate for the nation’s portfolio of surface transportation research is a balance of activities with different time frames and different levels of risk. Skinner, for example, suggests including both “research aimed at incremental gains in current technologies and higher-risk research aimed at breakthrough technologies,” although he notes that “no one knows what the ideal mix should be” (Skinner 1997, 5). Other authors have made specific suggestions, however, based on expert judgment. For example, the Research and Technology Coordinating Committee recommended that “at least one-quarter of FHWA’s research expenditure should be invested in [fundamental long-term] research” (TRB 2001a, 6).

The federal role in supporting basic and advanced research is generally acknowledged, given its high-risk and long-term nature. In addition, significant improvements in the understanding of how the components of transportation systems work or the adoption of new technologies have often relied on basic research, albeit in other fields. Examples include traffic flow theory, which draws on basic research in game theory and fluid flow theory (e.g., Bell 2000, Greenberg 1959); behavioral or consumer choice modeling, which draws on basic research in economics (e.g., Simon 1955); electronic tolling, which draws on developments in military technology (Rieback et al. 2006) and research in economics (Vickrey 1963); and ITS, which draws on research into sensors and control (e.g., Varaiya 1993).

Committee members point out, however, that stability and continuity of funding are needed to take full advantage of the potential benefits offered by basic and advanced research in surface transportation. The U.S. DOT has failed to provide sustained support for such research, however, at least until recently. The department's first attempt at an advanced research activity was the Transportation Advanced Research Program, launched in 1973 by the Office of the Secretary. But it was discontinued after several years, following a change in U.S. DOT leadership. Since 2005, FHWA's EAR program has provided dedicated funding for advanced research, but its scope is limited to highways, rather than surface transportation more broadly, and funding is limited (about \$14 million a year). The UTC program, meanwhile, focuses on applied research, as noted earlier, despite universities' expertise in basic and advanced research.

Research investments by federal agencies outside of the U.S. DOT—notably DOE, DOD, EPA, and NSF—may offer opportunities to leverage ongoing basic and advanced research relevant to surface transportation. However, the committee found little evidence that the U.S. DOT has tried to apply these federally funded activities in support of its own mission, much less sought to influence the research agendas of these other agencies.

### ***Building Value Through Research Partnerships and Enhanced Coordination***

Research partnerships stimulate creative thinking by allowing researchers with different perspectives and areas of expertise to work together.

Such partnerships also enable organizations with similar objectives to leverage scarce resources (e.g., by gaining access to specialized research and testing facilities).

Various examples illustrate the benefits of research partnerships that target surface transportation. Both NCHRP and the Transportation Pooled Fund Program permit state DOTs (and others) to combine their resources in pursuit of solutions to highway-related problems of common interest. 21CTP, which engages partners from federal agencies and private industry, has accelerated the pace of technological development for heavy-duty vehicles (NRC 2012). Within the private sector, the U.S. Council for Automotive Research, a partnership formed in 1992 by Ford Motor Company, General Motors, and Chrysler Group LLC, has supported precompetitive research on topics of broad interest to the U.S. auto industry, such as advanced batteries and vehicle recycling.<sup>2</sup>

Despite its partnerships with state DOTs on highway-related research, the U.S. DOT currently plays only a marginal role in partnerships within the federal research community. For example, the U.S. DOT did not engage in *The Science of Science Policy: A Federal Research Roadmap*, an initiative conducted under the auspices of the White House Office of Science and Technology Policy. A collaborative effort among multiple federal agencies,<sup>3</sup> this initiative explored the potential for a more rigorous and quantitative science and technology policy (Koizumi 2011).

In recent years, there have been no sustained and comprehensive efforts to coordinate national surface transportation research, although some coordination of government-funded research activities does occur. For example, the U.S. DOT's Human Factors Coordinating Committee

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<sup>2</sup> Private-sector involvement in precompetitive research partnerships such as 21CTP and the U.S. Council for Automotive Research has grown over the past 25 years in response to changes in antitrust laws.

<sup>3</sup> The Roadmap initiative drew participants from DOE, NSF, the Centers for Disease Control and Prevention, the Central Intelligence Agency, the Department of Commerce, DOD, EPA, the National Aeronautics and Space Administration, the National Institutes of Health, the National Institute for Standards and Technology, the National Oceanic and Atmospheric Administration, the Office of Management and Budget, the Office of Science and Technology Policy, the U.S. Department of Agriculture, the U.S. Geological Survey, and the U.S. Department of Veterans' Affairs ([http://scienceofsciencepolicy.net/sites/all/themes/sosp\\_theme3/userfiles/SoSP\\_Roadmap.pdf](http://scienceofsciencepolicy.net/sites/all/themes/sosp_theme3/userfiles/SoSP_Roadmap.pdf)).

(<http://hfcc.dot.gov/about/index.html>) brings together representatives from the various U.S. DOT administrations and from other federal departments to address crosscutting human factors issues in transportation. RITA is responsible for research coordination across the U.S. DOT, but funding for this effort is modest.

Although research partnerships in general offer the advantage of bringing more resources to bear on a problem, there can be trade-offs. In the case of the UTC program, for example, the nonfederal match is frequently provided by state DOTs or industry to help develop solutions to narrowly focused problems that require immediate solutions. As a result of this type of partnership, the UTC program tends to favor applied research, thereby failing to draw on universities' unique strengths in basic and advanced research.

### ***Linking to National Goals***

As discussed above in "Selected Research Programs," the United States lacks a cohesive national research framework for surface transportation that is clearly linked to overall societal goals. Rather, the current framework is ad hoc in nature and comprises a diverse assortment of research efforts, often modally focused, many of which are responsive to the specific needs of different groups but do not address the transportation system as a whole.

The bottom-up processes used to establish research agendas for programs that address particular stakeholder needs (e.g., the TCRP and the AAR Research Program) do not mesh naturally with a top-down agenda-setting process that targets societal goals. Hence the links between bottom-up research agendas and broad national goals are often tenuous at best. Several major research programs of limited duration, such as SHRP, have a far more strategic perspective; they often define their research agendas in the context of a clear vision of national needs. Nonetheless, many of these programs have a strong modal focus and, as a result, address a narrowly defined set of solutions focused on a single mode. For example, the U.S. Partnership for a New Generation of Vehicles program in the 1990s targeted national goals for energy conservation through improved automobile fuel efficiency, but it did not explore alternative, multimodal, systems-level approaches to reducing energy usage for personal transportation.

Some transportation-related research is widely recognized as key to achieving certain societal goals, such as research on the lightweight materials and powertrains needed to meet new corporate average fuel economy standards, which target reductions in greenhouse gas emissions and oil imports. By contrast, research relating to transportation infrastructure and its use, including programs focused on acquiring a better understanding of travel-related behavior, receives far less attention. Attention to this type of research is notably lacking from high-level policy makers, such as those at the White House Office of Science and Technology Policy, despite potentially significant systemwide benefits. This situation is partially the result of the U.S. DOT's limited engagement with the broad federal research community.

### ***Quantifying the Impacts of Research Activities and the Associated Return on Investment***

As discussed in Chapter 2, realizing tangible value from research investments is a critical attribute of a national transportation research framework. In practice, however, efforts by the U.S. surface transportation community to quantify the impact and return on investment of research have been limited in scope, as illustrated by research programs described in this chapter. Although stakeholders appear to view a number of these programs as effective, robust and quantitative assessments of effectiveness are frequently lacking. AASHTO's Standing Committee on Research is supporting efforts to establish a performance-measurement tool box (Krugler et al. 2006), but in the committee's view, more such efforts are needed. Measuring return on investment is unquestionably a challenging task. In the absence of such quantitative information, however, policy makers, research sponsors, and others cannot take full advantage of the lessons learned from experience about what types of research programs are of greatest value to the nation.

## **OPPORTUNITIES FOR IMPROVEMENT**

Surface transportation research is undertaken and funded by many groups, each with somewhat different perspectives. The initiation, continuity, and longevity of research programs are influenced by funding



constraints and societal and technological changes. Against this backdrop, the committee's examination of the strengths and weaknesses of the current ad hoc framework for surface transportation research in the United States has led it to identify four areas of insufficiency in which major improvements are needed:

- Insufficient and erratic support for basic and advanced research aimed at conceiving innovative solutions to transportation problems;
- Insufficient emphasis on research coordination and partnerships, particularly across the federal research community;
- Insufficient attention to multimodal systems-level and policy research in support of national and societal goals; and
- Insufficient effort to quantify research impact and return on investment.

The next chapter explores transportation research in other nations, with an emphasis on areas in which the current U.S. framework is lacking.

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### *Abbreviations*

FHWA	Federal Highway Administration
NRC	National Research Council
NSB	National Science Board
RITA	Research and Innovative Technology Administration
TRB	Transportation Research Board
TTI	Texas A&M Transportation Institute

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## 4

## Transportation Research Frameworks in Other Countries

As part of its charge, the committee was asked to identify and assess promising features of other nations' transportation research frameworks. To carry out this task, it examined eight transportation research organizations in Europe and Asia (see Table 4-1). Several of these organizations hosted the 2008 scan tour on transportation research program administration in Europe and Asia that was a precursor to the present study (Elston et al. 2009).

This chapter outlines the committee's information-gathering strategy and provides overviews of the research organizations listed in Table 4-1. It then presents certain of their research frameworks' key features that, if adopted in the United States, could potentially enhance the productivity of investments in U.S. surface transportation research. Attention is given in particular to those areas identified in Chapter 3 that could especially benefit from such enhancement: establishing a robust national program of basic and advanced research, exploring additional opportunities for cooperation and coordination, strengthening policy and systems-level analyses in support of societal goals, and quantifying research impacts and associated return on investment. The chapter concludes with a categorization and brief discussion of the lessons learned from other countries. Throughout its analysis, the committee was mindful of the factors identified in Chapter 1 as potentially contributing to the failure of policy transfer efforts.

### COMMITTEE'S STRATEGY FOR GATHERING INFORMATION

The committee focused its information-gathering efforts on countries with mature transportation systems (rather than on developing nations) and on organizations with established transportation-related research

**TABLE 4-1** Transportation Research Organizations in Countries That Provided Information on Their Research Frameworks

Country	Organization	2008 Scan Tour Host
European Union	Transport Directorate, Directorate-General for Research and Innovation, European Commission	Yes
France	Institute of Science and Technology for Transport, Development, and Networks (IFSTTAR)	Yes <sup>a</sup>
	National Research Agency (ANR)	No
Netherlands	Rijkswaterstaat (RWS) Center for Transport and Navigation	Yes
	SWOV Institute for Road Safety Research	Yes
United Kingdom	Rail Safety and Standards Board (RSSB)	No
Japan	Ministry of Land, Infrastructure, Transport, and Tourism (MLIT)	Yes
South Korea	Korea Transport Institute (KOTI)	Yes

<sup>a</sup>IFSTTAR's precursor organizations, the French Central Laboratory of Roads and Bridges and the French National Institute for Transport Safety and Research, hosted the 2008 scan team.

programs. This strategy made the best use of available time and resources, allowing the committee to target foreign research practices most likely to benefit surface transportation research in the United States.

The countries visited on the 2008 scan tour provided useful pointers as policy makers considered enhancing the U.S. surface transportation research framework (Elston et al. 2009). Hence, in the present study, the committee devoted considerable effort to obtaining more detailed information about these countries' research frameworks, including any changes since the scan.

The committee also expanded its information gathering to include countries not visited on the 2008 scan tour. Committee members' individual knowledge informed this activity, as did the desk scan (Harder 2007) conducted before the tour. The Harder report reviewed transportation research programs in countries [including Canada, Mexico, Brazil, European Union (EU) member nations, South Africa, India, South Korea, Japan, China, Australia, and New Zealand] with substantial experience in related administrative activities.

Two organizations not included on the 2008 scan tour—the United Kingdom's Rail Safety and Standards Board (RSSB) and France's National

Research Agency (ANR)—were judged to be of particular interest in the context of the committee's work. Because RSSB is a private-sector research organization, its inclusion brought a perspective largely absent from the scan tour, which focused almost exclusively on public-sector research entities. ANR was of interest because of its support both of fundamental and industrial research and its emphasis on research quality.

## TRANSPORTATION RESEARCH ORGANIZATIONS

### **Transport Directorate, Directorate–General for Research and Innovation, European Commission**

The EU is an economic and political coalition of 27 member states operating through a series of supranational institutions. The European Commission, the executive body of the EU, sets objectives and priorities for action, proposes legislation to the European Parliament, and manages and implements the EU's policies and budget. All the EU's research-related initiatives are grouped under the Framework Program (FP), a common framework designed to respond to the community's growth, competitiveness, and employment goals.

The ongoing Seventh Framework Program for Research and Technological Development (FP7) is the EU's main instrument for funding research. The Transport Directorate, contained within the European Commission's Directorate–General for Research and Innovation, is responsible for the FP7's transportation research.<sup>1</sup> The total budget for the seven-year (2007 to 2013) FP7 program is approximately €50 billion (\$65 billion), of which €4.16 billion (\$5.4 billion) is devoted explicitly to transportation.<sup>2, 3</sup> This transportation funding

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<sup>1</sup> Information on the FPs was obtained from Rogge (2011), from discussions with Rogge and others at the committee's July 2011 workshop, from Damiani (2012), and from the FP7 website ([http://ec.europa.eu/research/fp7/index\\_en.cfm](http://ec.europa.eu/research/fp7/index_en.cfm)). Additional references to specific aspects of FP programs are provided in the text.

<sup>2</sup> The budget data provided in this section on transportation research organizations are given in the currency units of the original source materials, including presentations at the committee's workshops; approximate conversions to US\$ are provided as needed.

<sup>3</sup> [http://cordis.europa.eu/fp7/understand\\_en.html](http://cordis.europa.eu/fp7/understand_en.html).

is divided among four subthemes, one of which is sustainable surface transportation.<sup>4</sup>

In general the FP aims to complement, not replace, national innovation programs. Hence it seeks to create “European added value” in the innovation process. Such added value may include expanding the funds available to national researchers to address common European issues, growing knowledge more rapidly through pooling of the competencies of researchers in different nations, and supporting larger projects and research portfolios than could be funded by individual nations (Arnold 2005). The focus is on precompetitive research, with the development of marketable products left largely to individual companies. In recent years, however, European industry has sought more market-oriented research within the FP, and special funding mechanisms have been established that are aimed at engaging industrial partners. These mechanisms include research public–private partnerships (PPPs), such as the European Green Cars Initiative, as well as a dedicated funding instrument for small- and medium-sized enterprises.

### **Institute of Science and Technology for Transport, Development, and Networks, France**

The Institute of Science and Technology for Transport, Development and Networks (IFSTTAR) is a national transportation research institute funded by the French government.<sup>5</sup> It was established on January 1, 2011, through a merger of the French Central Laboratory of Roads and Bridges and the French National Institute for Transport Safety and Research. Overseen by two government departments (the Ministry of Ecology, Sustainable Development, Transport, and Housing and the Ministry of Higher Education and Research), IFSTTAR conducts applied research in the fields of transportation, infrastructure, natural hazards, and urban issues. The aim of the institute, whose budget for 2011 was €120 million

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<sup>4</sup> The other subthemes are aeronautics and air transportation; horizontal activities (for the implementation of the transportation program); and Galileo (support for the European Global Satellite Navigation System).

<sup>5</sup> Information about IFSTTAR was obtained from Jacob (2011), from discussions with Jacob at the committee's July 2011 workshop, and from the institute's website ([www.ifsttar.fr](http://www.ifsttar.fr)).



(\$156 million), is to improve the living conditions of French residents and promote society's sustainable development.<sup>6</sup>

### **National Research Agency, France**

ANR is a public research-funding organization established by the French government in 2005 to fund research projects on a competitive basis, thereby bringing more flexibility to the country's research system.<sup>7</sup> The agency supports both fundamental and industrial research in virtually all scientific fields. Funds are available for public research organizations, including universities, and for private companies, the latter through PPPs. ANR's total turnover for 2011 was €770 million (\$1 billion). Programs are organized under six thematic areas; programs addressing sustainable transportation and mobility are included within the sustainable-energy area.

### **Rijkswaterstaat Center for Transport and Navigation, the Netherlands**

Rijkswaterstaat (RWS), the executive arm of the Dutch Ministry of Infrastructure and the Environment, is responsible for developing and managing the Netherlands' main highway and waterway networks.<sup>8</sup> Its goals are to ensure "dry feet, sufficient clean water, smooth and safe traffic flows on the nation's roads and waterways, and reliable and useful information" (RWS 2010, 9). The total RWS budget for 2010 was €5 billion (\$6.5 billion), of which €40 to €60 million (\$50 to \$80 million) was devoted to research. The Center for Transport and Navigation, located in Delft, is one of RWS's five national centers of excellence.

In recent years, RWS has transitioned from being an organization that conducted some research to being almost exclusively a client for research

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<sup>6</sup> IFSTTAR also conducts expert appraisals, offers consulting services, promotes innovation transfers, and participates in certification and standardization activities.

<sup>7</sup> Information about ANR was obtained from Jacob (2011), from discussions with Jacob at the committee's July 2011 workshop, and from the agency's website (<http://www.agence-nationale-recherche.fr/>).

<sup>8</sup> Information about RWS was obtained from a conference call with Roger Demkes (Head of Knowledge Management at the Center for Transport and Navigation) on December 1, 2011; from discussions with Joris Al, Max Klok, and Jan van der Waard in 2011 at the 90th Annual Meeting of the Transportation Research Board (TRB); and from the RWS 2010 annual report (RWS 2010).

conducted by others. Staff members now act much like consultants, providing information on the availability of knowledge and on solutions to specific problems. The focus is on improving the day-to-day operations of the country's transportation systems, including their asset management and life-cycle analyses.

### **SWOV Institute for Road Safety Research, the Netherlands**

SWOV, founded in 1962, is the major Dutch road-safety organization devoted to scientific research.<sup>9</sup> The institute's average annual turnover is €5 to €6 million (\$7 to \$8 million), 75 to 80 percent of which comes from grants from the Dutch Ministry of Infrastructure and the Environment; the remainder is provided by remunerations from domestic and international assignments.

### **Rail Safety and Standards Board, United Kingdom**

Established in 2003, RSSB is a not-for-profit private company owned and funded by major stakeholders in the United Kingdom's railroad industry, including the infrastructure manager (Network Rail), passenger operating companies, freight operating companies, rolling-stock leasing companies, infrastructure contractors, and suppliers.<sup>10</sup> The government (Department for Transport) and regulator (Office of Rail Regulation) are involved as observers. The Department for Transport also provides approximately \$15 to \$20 million a year to support the two industrywide R&D programs managed by RSSB.

### **Ministry of Land, Infrastructure, Transport, and Tourism, Japan**

Three Japanese government ministries have R&D budgets for transportation: the Ministry of Land, Infrastructure, Transport, and Tourism

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<sup>9</sup> Information about SWOV was obtained from Wegman (2011), from discussions with Wegman at the committee's July 2011 workshop and at the 90th TRB Annual Meeting in 2011, and from the institute's website ([http://www.swov.nl/UK/Profiel/Inhoud/about\\_swov.htm](http://www.swov.nl/UK/Profiel/Inhoud/about_swov.htm)).

<sup>10</sup> Information about RSSB was obtained from Jack (2011), from discussions with Jack at the committee's July 2011 workshop, and from the board's website ([http://www.rssb.co.uk/AboutUs/Pages/a\\_guide.aspx](http://www.rssb.co.uk/AboutUs/Pages/a_guide.aspx)).

(MLIT); the Ministry of Economy, Trade, and Industry; and the Ministry of Education, Culture, Sports, Science, and Technology. MLIT is the most technologically oriented of these ministries.<sup>11</sup> It is responsible for using, developing, and conserving land in Japan in an integrated and systematic way; for creating the infrastructure needed to attain these goals; and for implementing transportation policies.<sup>12</sup> MLIT comprises a number of bureaus, including those for policy; water and disaster management; roads; railroads; civil aviation; and ports and harbors. In 2011, MLIT received 1.4 percent [¥51 billion (\$600 million)] of the Japanese government's total R&D budget of ¥3.64 trillion (\$43 billion).

### **Korea Transport Institute**

The Korea Transport Institute (KOTI), established in 1985, is an official research agency of the South Korean government.<sup>13</sup> Its mission is to provide recommendations for the nation's transportation policy and to create an optimal transportation system through specialized research and technological innovation. KOTI's activities cover many aspects of transportation, including green growth, comprehensive transportation, individual modes (road, rail, and aviation), safety, surveys, economics, and logistics.

Three funding sources each contribute in approximately equal measure to the institute's annual budget of about \$35 million: (a) funds from the Prime Minister's research councils; (b) funds from commissioned projects for the Ministry of Land, Transport, and Maritime Affairs; and (c) funds from a variety of other sources, including local governments, the Korea Railroad Construction Corporation, the Korea Aviation Corporation, the Korea Highway Corporation, and, most importantly, the Korea Institute of Construction and Transportation Technology Evaluation

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<sup>11</sup> Information about MLIT was obtained from Morichi (2011), from discussions with Morichi at the committee's October 2011 workshop, and from the ministry's website (<http://www.mlit.go.jp/en/index.html>).

<sup>12</sup> See MLIT brochure (<http://www.mlit.go.jp/common/000047294.pdf>).

<sup>13</sup> Information about KOTI was obtained from Oh (2011), from discussions with Oh at the committee's October 2011 workshop and at the 90th and 91st TRB Annual Meetings (2011 and 2012, respectively), and from the institute's website (<http://english.koti.re.kr/>).

and Planning (KICTEP).<sup>14</sup> KOTI competes with research institutes, universities, and the private sector for funding from the second and third listed sources.

## APPROACHES TO RESEARCH FUNCTIONS

This section highlights successful foreign research practices that could potentially benefit surface transportation research in the United States. The discussion is organized according to the research functions identified in Chapter 2, with one additional function added at the section's end.

### Identification of the Role of Research in Achieving Societal Goals

Several of the organizations listed above employ research-planning processes that establish clear links between transportation research activities and societal goals. For example, the Lisbon Strategy adopted in 2000 included an objective that the EU should become the most dynamic and competitive knowledge-based economy in the world by 2010. A wide-ranging set of pertinent goals relating to employment, innovation, enterprise, and the environment were translated into targets to be achieved in support of the overall objective. The European Commission's Transport Directorate used these goals and targets to guide transportation research in FP7; for example, the directorate aimed to decarbonize and "green" the transportation system, encourage modal shift, decongest transportation corridors, and ensure sustainable urban mobility. Similarly, Japan's Innovation 25, a long-term strategy guideline adopted at a Cabinet meeting on June 1, 2007, established a series of societal goals for the nation. MLIT then identified a role for transportation research in contributing to the achievement of four of these goals. The goal of a safe and secure society, for example, has implications for various aspects of transportation, such as traffic accidents and the risks associated with a rapidly aging infrastructure, and MLIT developed its research priorities accordingly.

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<sup>14</sup> KICTEP's budget for transportation and construction R&D increased from \$228 million in 2006 to \$409 million in 2010. In the transportation area, most of this funding (87 percent) is devoted to product-oriented developmental research; applied research receives about 10 percent of the funding, and the remaining 3 percent goes to fundamental research (Oh 2011).

In South Korea, policy goals and strategies established under the 2008 National Strategy on Green Growth have led KOTI and other research organizations to undertake transportation research activities related to green growth.

## Research Agenda Setting

### *Top-Down and Bottom-Up Approaches*

Most of the organizations the committee considered adopt a combination of top-down and bottom-up processes in setting their research agendas, although the balance between the two approaches differs from one organization to another. KOTI's annual research action planning, for example, is primarily a top-down activity, as it is closely tied to the South Korean government's five-year midterm research planning. In contrast, preparation of the EU's initial FP proposal has an important bottom-up component. Extensive consultations with stakeholder groups, including technical advisory groups from member nations, technology platforms (e.g., the European Road Transport Research Advisory Council and the European Intermodal Research Advisory Council), and the general public, are particularly important in setting research priorities. At the national level, SWOV also emphasizes the importance of giving all stakeholders the opportunity to influence the institute's agenda-setting process. In Japan, expert opinion is highly valued in research agenda setting. Although the Japanese government plays a major role in this process, experts are active participants in related discussions; the 14-member Council for Science and Technology Policy, for example, includes technical experts as well as the Prime Minister, the Minister of Science and Technology, and four other ministers.

In the above examples, research agenda setting blends top-down and bottom-up processes into one composite procedure; in contrast, France's ANR clearly distinguishes the two approaches and pursues them simultaneously. In 2010, half of ANR's grants went to thematic programs defined by a top-down process in response to economic, environmental, and societal demands, as well as to scientific or technological priorities; the other half went to nonthematic researcher-initiated programs identified through a bottom-up process.

### ***Administrative Burden***

Despite the advantages of engaging an inclusive set of stakeholders in research agenda setting, the process can become cumbersome and time consuming, particularly if numerous approvals of the proposed agenda are required. Preparing, negotiating, and adopting a new EU FP, for example, is an iterative process that takes about four years to complete: two years to prepare the initial proposal and another two years for the legislative process leading to legal adoption. As a result, the FP is not sufficiently nimble to respond in a timely manner to new and urgent problems facing individual member nations; it tends instead to focus on precompetitive research.

FP administration has generally been perceived by program participants as more burdensome than in national programs, possibly because of the greater scale and complexity of trans-European projects and also because of the greater need for transparency in these highly visible undertakings (Arnold 2005). Thus extensive efforts are underway to reduce the level of bureaucracy associated with the FP and to limit the costs of administering the program (Damiani 2012).

### ***Agenda Balance and Scope***

The EU emphasizes the need for an agenda that balances the many demands on transportation research, such as modal versus system issues, or technical versus policy issues. Hence the agenda-setting process for the FP seeks equilibrium between a holistic approach and modal specificities, between technological and socioeconomic aspects, and between policy goals, industry goals, and user needs.

Some organizations aim to balance short- and long-term issues in their research agendas. For example, RSSB's core program, which supports many aspects of railroad operations, focuses on relatively short-term research, but its Rail Technical Strategy, which includes a vision of the railroads in 30 years' time, aims to help the industry achieve challenging long-term goals associated with the four C's—customers, carbon, capacity, and cost. Not all organizations take such an approach, however. SWOV focuses on so-called “there-and-then” research that addresses mid and long-term applications. Although the Dutch government understands the benefits of this longer-term research culture, at least in principle, policy makers

are increasingly pressuring the setters of the research agenda to emphasize short-term problems at the expense of long-term research.

Both RSSB and IFSTTAR stress the importance of a multidisciplinary research agenda. RSSB's core program draws on expertise in engineering, operations, risk, workforce development, occupational health, sustainable development, and social sciences. IFSTTAR promotes a similarly wide range of experts in its research activities, which address a broad set of issues.

### ***Strategic Approach***

RWS takes a highly strategic and structured approach to identifying its research needs and to setting an agenda. The organization makes its four-year plans by using a "knowledge tree" that identifies the fields of knowledge needed for performing specific tasks, such as traffic management or facilities maintenance. For each field of knowledge (e.g., asset management, construction technology, security, environment), a strategy plan identifies the knowledge that will be needed in four years' time; options for producing, buying, or sharing this knowledge; and the risks associated with *not* having the knowledge. This strategy plan is used to guide the research tasks that RWS supports at universities and other research organizations.

### **Distribution of Funding for Specific Research Activities**

Different countries take different approaches to funding the various categories of research, such as basic, advanced, and applied. Basic research in particular is often funded separately. Toward that end, the European Research Council (ERC) was established, as a component of the EU's FP7, with the specific objective of allowing researchers to identify new directions and opportunities in "frontier" research.<sup>15</sup> Hence the ERC complements the EU's other (nonfrontier) research-funding activities. In France, ANR plays a similar role, funding investigator-initiated fundamental research while separately funding applied research.

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<sup>15</sup> The ERC notes that the distinction between basic and applied research is blurred. It uses the term "frontier research" to designate activities directed toward fundamental advances at and beyond the frontiers of knowledge (<http://erc.europa.eu/about-erc/mission>).

In Japan, by contrast, MLIT regards basic research as an integral part of the overall innovation process. Hence it does not separate basic research from other research activities in the funding process. Clear definition of technological targets (e.g., for intelligent transportation systems or Maglev) allows the various levels of research to be identified and funded, as needed, as part of the target's overall research objective.

Both the ERC and ANR use open competition to select research projects for funding, consistent with scientific communities' tradition for ensuring research quality. ANR employs a rigorous three-step process of program planning, selection, and follow-up and implementation. Each step has received ISO 9001 certification for quality-management systems by the International Organization for Standardization; thus the project-selection process is based on peer review in accordance with highest international standards. In addition, ANR consults with members of the scientific community both at home and abroad during its program-planning process as a means of enhancing the French research system's competitiveness.

## **Conduct of Research**

All the national organizations listed in Table 4-1 emphasized to the committee that participation in research partnerships and networks, both national and international, is an essential component of their research activities. The advantages cited by these organizations are summarized in the following paragraphs.

### ***Different Perspectives on Research Problem Solving***

Engaging participants from different sectors and countries brings diverse perspectives to bear. One of MLIT's goals in its research is to achieve well-coordinated cooperation among research partners so that the characteristic strengths of academia, government, and industry are effectively used. For example, research at universities contributes advanced knowledge and relatively unrestrained thinking, and academia also helps develop human capital for future research. The central government is best positioned to communicate the goals of cooperative research efforts, develop technology roadmaps, and support research on technologies destined primarily for public-sector applications. Industry partners play a major role in research, notably in transforming new knowledge into practical applications. For



example, 23 companies participated in joint public–private research for the Smartway project to develop cooperative vehicle–highway systems. Similarly, private-sector organizations are encouraged to participate in ANR-funded activities, either through PPPs, which require at least one partner from each sector (public and private); or through the open programs, which are available both to PPPs and academic research organizations.

The United Kingdom's RSSB engages with domestic and international researchers, both through formal partnerships and through informal collaborations with organizations such as the Rail Research UK Association, Japan's Railway Technical Research Institute, Australia's Rail Industry Safety and Standards Board, the U.S. Department of Transportation's Federal Railroad Administration, and the Association of American Railroads' Transportation Technology Center.

### ***More Effective Participation in the Research Community***

Combining activities and resources allows research organizations to participate more productively in the overall research community, particularly at the international level. For example, France's IFSTTAR is involved in several Research and Academic Clusters (PRES), which are regional public bodies that allow universities, specialized schools, and other research organizations to participate in international scientific projects.<sup>16</sup>

### ***Greater Coordination***

Research partnerships also facilitate coordination among research activities supported by different funding organizations. Thus IFSTTAR participates in the Program for Research and Innovation in Land Transport (PREDIT), which was initiated in 1990 to coordinate the objectives of French ministries in charge of research, transportation, environment, and industry.<sup>17</sup> Within the EU, coordination is achieved not only through the FP but also through various research networks and technology platforms, such as the European Conference of Transport Research Institutes, the Forum of European National Highway Research Laboratories,

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<sup>16</sup> <http://www.campusfrance.org/en/page/universities-and-higher-education-and-research-clusters>.

<sup>17</sup> <http://www.predit.prd.fr/predit4/homePage.fo>.

the European Rail Research Network of Excellence, and the European Construction Technology Platform.

### ***New Opportunities***

Participation in research networks and other cooperative efforts allows organizations to explore different disciplines and areas of interest and, as a result, to broaden the scope of their research. For example, SWOV promotes a multidisciplinary research agenda through its participation in (a) different research networks (e.g., road safety, health) and (b) cooperative international efforts under the auspices of bodies such as the EU, the United Nations, the World Bank, the World Health Organization, and the Organization for Economic Cooperation and Development (OECD). Such collaboration provides research opportunities that may not be otherwise available in a small country such as the Netherlands.

### ***Enhanced Research Quality***

Engagement with other research organizations at home and abroad allows transportation research bodies to enhance both the quality of their research and their standing within the transportation research community. For example, part of KOTI's mission is to position itself as one of the world's leading transportation research institutes, and for this purpose it participates in researcher-exchange programs with foreign entities such as the World Bank and OECD. Similarly, SWOV cooperates with other Dutch and foreign research and educational organizations to support its ongoing quest for higher research quality.

### **Research Evaluation**

All the transportation research organizations considered by the committee view research evaluation as an essential tool for determining which programs work better than others and for what reasons. The focus of each organization's research evaluations varies with its mission and objectives.

Some organizations are particularly proactive in ensuring that their research investments yield practical payoffs; hence, they emphasize retrospective evaluations that track economic benefits and commercialization. This approach is especially important in Japan and South Korea,

where the cultures see research as a tool for societal good (Elston et al. 2009), and in industry organizations such as the United Kingdom's RSSB.

In the case of the EU's FP, mandatory assessments are conducted every five years to monitor progress, evaluate results, and create a feedback loop for consequent policy making and planning (Arnold 2005). The latter aspect is particularly important for assimilating and applying lessons learned from past experience. The duration of programs from FP7 onward has in fact been extended to allow for more meaningful incorporation of feedback from earlier efforts (Andrée 2009). For the next FP program, called Horizon 2020, the preparatory phase will include ex post evaluations of FP5 and FP6 and an interim evaluation of FP7, as well as an ex ante impact assessment of Horizon 2020.<sup>18</sup>

Quantitative metrics such as reductions in fatalities and benefit-cost ratios can be particularly valuable in assessing research outcomes. For example, SWOV's Sustainable Safety strategy is estimated to have reduced fatalities from 1998 to 2007 to less than half the average annual rate of the preceding 10-year period. Benefits to society resulting from investments in infrastructure and enforcement from 1998 to 2007 are estimated to have exceeded the costs by a factor of four.

In addition to assessing the practical outcomes of its research, SWOV attempts to assess the quality of its research. Recognizing that quality is far more difficult to measure than quantity, the institute bases its assessment on indirect evidence, such as invitations to participate in regional, national, and international projects, expert groups, congresses, and reviews. These invitations, which come both from the scientific community and organizations interested in the practical implementation of research results,<sup>19</sup> provide opportunities for the increased exposure of SWOV's staff and the dissemination of their knowledge.

## Dissemination of Results

Several organizations highlighted the importance of disseminating the results of their research. SWOV, for example, takes a proactive approach

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<sup>18</sup> The reader is referred to Arnold (2005) for a more detailed discussion of FP evaluation.

<sup>19</sup> See the SWOV 2010 Annual Report ([http://www.swov.nl/rapport/Jaarverslag/UK/Annual\\_Report\\_2010.pdf](http://www.swov.nl/rapport/Jaarverslag/UK/Annual_Report_2010.pdf)).

so that new knowledge is quickly available to contribute to increasing road safety. Research results are always published, often in scientific journals, and SWOV staff participates in activities focused on practical implementation of those results. RSSB provides a wide range of information about its research activities in its publications and on its website. Brief case study reports include descriptions of the problem, the solutions resulting from the research, the value of their benefits, reactions from stakeholder groups, and links to related documents and briefings.

### **Implementation of New Knowledge**

Several organizations conducting applied research highlighted the strategies they use to facilitate the practical implementation of new knowledge. RSSB's 10-point plan to enhance innovation in transportation builds on existing best practices and lessons from cross-industry projects. In addition, engagement with the industry both at the inception and completion of such research projects helps ensure that the fruits of the research can be put into practice and add value. A cost-benefit analysis is conducted at the research proposal stage, and a postimplementation review focuses on the value of the research outcomes' benefits (including costs avoided).

In Japan, MLIT stresses the importance of giving back to society through discernible research results. Technology road-mapping and the promotion of joint academia-government-industry research partnerships help establish implementation plans; funding incentives encourage private-sector research; and the use and dissemination of new technologies are encouraged through the promotion of international standardization and the provision of subsidies for the technologies' introduction.

### **Research and Human Capital**

During the committee's discussions, representatives from several organizations noted the important role of research in attracting and training future transportation professionals. In France, IFSTTAR actively engages in training activities through its research. The institute's 1,250 employees include 250 PhD students, and 77 doctoral theses were defended in

2010 by employees of IFSTTAR's precursor organizations. Similarly, in the Netherlands, SWOV recognizes the importance of investing in human capital. The institute has a PhD program for staff, and researchers at various universities have the option of conducting their doctoral research within the institute's research program. In addition, collaborative projects conducted under the auspices of the EU's FP can bring in new researchers by offering attractive opportunities to work with organizations in other European countries, such as Mercedes-Benz in Germany.

## LESSONS LEARNED

This section analyzes information that the committee gathered on the transportation research frameworks of the EU, France, the Netherlands, the United Kingdom, Japan, and South Korea. These analyses are presented within six categories:

- Governance structure,
- Cohesive research frameworks,
- Links to societal goals,
- Importance of basic and advanced research,
- Value of research partnerships, and
- Research evaluation.

To help identify opportunities and challenges for effective U.S. adoption of certain features of the surface transportation research frameworks of the above five countries and one coalition (i.e., the EU, henceforth referred to as a country for simplicity of exposition), important differences and similarities are noted between those frameworks and that of the United States.

### Governance Structure

From an institutional perspective, the countries considered by the committee differ from the United States in important ways. In particular, their surface transportation systems and services are far more centralized than in the United States, and their corresponding decision-making systems are more unified, being guided in large part by national govern-

ments. By contrast, surface transportation activities in the United States are highly decentralized, with government responsibilities and decision-making authority distributed among federal, state, and local jurisdictions (see Chapter 3).

As in the United States, the research frameworks of the European and Asian nations engage academia, government, and industry in the national transportation research endeavor. In all cases, industry plays a key role in linking knowledge creation to knowledge implementation in the form of new or improved products and services. Recent funding initiatives in Europe, such as research PPPs established by the EU and ANR, encourage greater participation by industry in the research process. In Japan and South Korea, the relationship between research outcomes and the creation of economic value is widely assumed (Elston et al. 2009), as is the associated role of industry. The Japanese government takes special measures to engage industry in the research process, providing financial incentives for research by private industry and for the use and dissemination of new technologies. In South Korea, the assessment of research outcomes from projects funded by the Korea Institute of Construction and Transportation Technology Evaluation and Planning emphasizes economic benefits, such as the fees generated from commercialization. As these examples illustrate, the important role of central government in the national transportation research endeavor in European and Asian nations does not preclude strategic, goal-driven, and commercializable research.

Unlike the United States, other nations make extensive use of research institutes in establishing partnerships and collaboration. The 2008 scan team observed that all the countries visited, without exception, used some form of research institute “to either fund and financially manage or foster, house, and accomplish collaborative research efforts” (Elston et al. 2009, 3). The structure of these institutes was observed to vary among countries, but in each case the institute brought together government, government-funded independent organizations, foundations, academia, and industry in a way that enabled these various partners to respond to the national strategic framework more effectively in collaboration than each organization could on its own. The scan team noted that the United States does not have comparable entities to facilitate

collaborative research on the same level, although “some U.S. structures can accomplish portions of the roles of these institutes” (Elston et al. 2009, 5). For example, universities and large consulting organizations often take on a collaborative role, working directly with organizations that implement research results in the form of new products and processes. The U.S. Department of Transportation also undertakes efforts aimed at promoting innovation, such as the Federal Highway Administration’s (FHWA’s) Every Day Counts initiative.<sup>20</sup> However, the European and Asian integration of responsibility for bridging the gap between knowledge creation and knowledge application in one institutional structure (a research institute) stands in stark contrast to the U.S. public-sector model (Elston et al. 2009).

### **Cohesive Research Frameworks**

Because the surface transportation networks and systems in many European and Asian countries are centralized, their transportation research frameworks are correspondingly cohesive. Thus both Japan and South Korea have structured transportation research frameworks linked to national goals for economic growth and quality of life. Government ministries play a major role in developing strategic research plans and research agendas and in implementing these agendas in a coordinated fashion across the research enterprise. For example, the strategies and policy goals established under South Korea’s 2008 National Strategy on Green Growth have led to a series of green growth–related transportation research activities by KOTI and other organizations. In contrast, because the surface transportation enterprise in the United States is highly decentralized, the nation’s transportation research framework is fragmented and ad hoc (see Chapter 3).

An important objective of the EU’s FP is to overcome the fragmentation of Europe’s research activities and resources. Initial attempts to achieve greater integration of the various countries’ programs focused on establishing collaborative projects. In FP6 and FP7, for example,

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<sup>20</sup> [www.fhwa.dot.gov/everydaycounts/](http://www.fhwa.dot.gov/everydaycounts/).

additional “integrating instruments,” such as Joint Technology Initiatives (i.e., PPPs) and the ERC, were introduced (Andrée 2009). These Europe-wide community-building efforts have established linkages between national surface transportation research activities and broader pan-European programs; representatives of several European transportation research organizations commented to the committee on their involvement in such efforts. The opportunity to benefit from intangible assets (e.g., improved capabilities, tools, and techniques gleaned through interactions with other researchers) was shown to be a strong motive for participation in FP6 networks within the information technologies area (Wagner et al. 2005; Ruegg and Jordan 2007).

### **Links to Societal Goals**

The 2008 international scan team observed a perspective on transportation research that “differed greatly from the U.S. public sector model”; in all the countries visited, transportation research was seen as “an integral piece of . . . efforts to maintain or create a more robust national economy” (Elston et al. 2009, 2). This observation was confirmed by the committee’s examination of the national research organizations listed in Table 4-1. Each organization establishes clear linkages between its transportation research and national (or supranational) goals in areas such as economic development, quality of life, and protection of the environment. These linkages are largely the result of the countries’ use of top-down processes to develop research agendas. Most of these top-down processes, however, have an important bottom-up component in that they seek input from a variety of stakeholders, including technical experts and organizations potentially interested in implementing research results. Hence a judicious combination of top-down and bottom-up approaches is used to develop robust research agendas with a high-level strategic focus.

In the United States, by contrast, many initiatives for transportation research programming and funding are organized according to a bottom-up approach that focuses on solving problems identified by particular sponsors, such as state departments of transportation or transit



agencies. As a result, U.S. surface transportation research often, though not always, lacks the clear linkages to national goals that characterize research frameworks in other nations. American exceptions include research partnerships between the federal government and industry that target technologies for more fuel-efficient vehicles; for example, the 21st Century Truck Partnership addresses national goals for reducing the nation's dependence on imported oil and cutting greenhouse gas emissions (see Chapter 3).

### **Importance of Basic and Advanced Research**

In Europe, as in the United States, budgetary constraints tend to favor applied research with a relatively short-term payoff over basic and advanced research offering potential benefits in the future. Nonetheless, European nations continue to value and fund basic research. In particular, both France and the EU have established organizations (ANR and ERC, respectively) for the specific purpose of supporting basic and advanced research.

In Japan, basic research is regarded as an integral part of the overall innovation process and is not artificially separated from other research activities in the funding process. However, basic research needed to achieve specific technological targets is funded as part of a project-oriented research initiative, such as for development of intelligent transportation or Maglev rail systems.

The United States adopts both of the above strategies for funding basic and advanced research, although the nation's overall basic and advanced research effort targeting surface transportation is relatively modest, as noted in Chapter 3. Funding for FHWA's Exploratory Advanced Research Program specifically aims at longer-term, higher-risk breakthrough research. The Asphalt Research Program (Superpave®), which originated in the Strategic Highway Research Program (see Chapter 3), was essentially an applied research program; however, early work included considerable amounts of basic research, such as studies of the influence of asphalt chemistry, that were needed to achieve the desired pavement performance (McDaniel et al. 2011).

## Value of Research Partnerships

Domestic and international research partnerships provide several major benefits. Access to the complementary skills and experience of partners from the public, private, and academic sectors strengthens the entire research and innovation process. For example, MLIT's research programs engage academia, government, and industry; and ANR's PPPs involve public research organizations and private industry. Research partnerships allow institutions to pool resources, thus enabling the pursuit of research that is too broad in scope or too costly to be undertaken by a single organization (or country). EU research under FP7, for example, addresses common European issues. Research partnerships also provide opportunities to improve research quality, increase the likelihood of successful outcomes, enhance the status of the research organization, and develop human capital through engagement in the wider, particularly international, research community. Examples include RSSB's formal and informal research collaborations with organizations in Japan, Australia, and the United States, and KOTI's researcher-exchange programs with the World Bank and OECD.

## Research Evaluation

The European and Asian transportation research organizations considered by the committee, in common with their U.S. counterparts, emphasize the value of knowledge-based decision making in helping them make the best use of available resources. In that spirit, research evaluation provides important information for those who fund or conduct research. These organizations use a variety of research-evaluation methods to monitor ongoing research and assess research outcomes in various forms, such as new understanding of basic phenomena, new transportation policies, and new or improved commercial technologies. Research evaluation also uses lessons learned from past experience to inform future research planning.

## HIGHLIGHTS

Highlights of the committee's analysis of information on transportation research frameworks in other countries are listed in Box 4-1.

BOX 4-1

## **Highlights: Transportation Research Frameworks in Other Countries**

- Through community-building efforts that leverage national research activities in support of broad pan-European goals, the EU's Framework Program has added value to member nations' surface transportation research.
- Central governance in a national research endeavor can lead to strategic, goal-driven, and commercializable transportation research.
- Research partnerships, whether domestic or international, strengthen the research process by drawing on the complementary skills and experience of the partners. Such partnerships may also facilitate the pooling of resources in support of research that is too broad in scope or too costly to be undertaken by a single organization or country.
- Research partnerships, both formal and informal, can be established through a variety of mechanisms, including research institutes, transnational cooperative initiatives, research public-private partnerships, research networks, and technology platforms.
- Balancing top-down and bottom-up approaches to setting a country's research agenda makes it more likely to be technically robust and reflective of national and societal goals.
- Basic research and advanced research, though less obviously linked to new or improved transportation systems than applied research and technology transfer, are recognized as a valuable component of a national or supranational transportation research portfolio.
- Information gained from a variety of research evaluation methods helps transportation research organizations, including those that provide funding, to develop research plans and make informed decisions about resource allocations for the future.

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RWS            Rijkswaterstaat Center for Transport and Navigation

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## 5

## Research Frameworks in Domestic Nontransportation Sectors

Part of the committee's mandate was to identify and assess examples of U.S. national strategic research planning in sectors other than transportation. The committee assembled information on the research frameworks of organizations within six other sectors: agriculture, astrophysics and astronomy, construction, energy, health, and science research (see Table 5-1). The research frameworks considered were not all directly comparable, as they represented disparate programs, organizations, and scales and scopes of activity. For example, the National Institutes of Health (NIH) annual budget is on the order of \$30 billion, whereas the decadal survey in astrophysics and astronomy is conducted largely by volunteers.<sup>1</sup> In addition, because the U.S. framework for surface transportation research extends beyond the federal agencies, the committee's intent was not simply to select organizations directly comparable to the U.S. Department of Transportation (U.S. DOT), but rather to explore a wider range of organizations. By focusing on the research functions described in Chapter 2, the committee was able to explore a diversity of approaches across the domestic research spectrum.

This chapter first summarizes the committee's information-gathering strategy and provides background information on the research organizations listed in Table 5-1. It then discusses some of their salient features, particularly those that could potentially benefit surface transportation research in the United States. The chapter concludes with a categorization and brief discussions of the lessons learned from these nontransportation sectors.

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<sup>1</sup> The budget data provided in this chapter are intended to provide order of magnitude indications of research investment rather than to permit detailed analyses of federal (and other) research budgets.

**TABLE 5-1** Nontransportation Organizations That Provided Information on Their Research Frameworks

<b>Sector</b>	<b>Organization or Program</b>
Agriculture	Agricultural Research Service (ARS)
Astrophysics and astronomy	Decadal Survey
Construction	FIATECH
Energy	National Renewable Energy Laboratory (NREL)
Health	National Institutes of Health (NIH)
Science research	National Science Foundation (NSF)

## COMMITTEE'S STRATEGY FOR GATHERING INFORMATION

The committee's information-gathering activities focused on sectors and organizations whose research frameworks were judged to be of particular value to the study charge. In some cases, there were similarities with transportation; for example, the U.S. Department of Agriculture (USDA) is a mission-oriented federal agency not unlike the U.S. DOT. In other cases, it was the dissimilarities that appealed to the committee; for example, the National Science Foundation (NSF) supports basic and advanced research, whereas U.S. surface transportation research is currently lacking in these areas. The choice of organizations also reflected the committee's desire to gather information from the public, private, and academic sectors, each of which plays a key role in the nation's transportation research enterprise.

The information presented in this chapter was obtained through the committee's workshops (see Appendices A and B) and supplemented by web-based searches and follow-up phone conversations with workshop guests and other sources, as needed. Some of the research-related activities described in this chapter have been the subject of extensive studies by expert groups; see, for example, NRC (2007), Fuglie and Heisey (2007), and reports from NSF's Committee of Visitors.<sup>2</sup> However, because of resource constraints and especially the committee's mandate, its reviews of these studies were limited to areas most pertinent to surface transportation research.

<sup>2</sup> <http://www.nsf.gov/od/iaa/activities/cov/>.

## RESEARCH ORGANIZATIONS

### **Agriculture: Agricultural Research Service**

The Agricultural Research Service (ARS) is the intramural science research arm of USDA, and one of four agencies in the department's research, education, and economics mission area.<sup>3</sup> The ARS budget for FY 2012 was approximately \$1.1 billion.<sup>4</sup> The agency currently supports over 1,000 projects involving some 2,500 scientists and postdoctoral researchers in more than 100 laboratories. Research may be conducted in partnership with other agencies, universities, and industries, as well as through international collaborations.

ARS's research covers a wide variety of areas, ranging in scope from the farm to the table (St. John 2011). To address issues of national importance, such as food safety, plant diseases, and aquaculture, this research is organized into national programs, of which there are currently 18. Developed around a five-year cycle, each of these programs is made up of projects contributing to five-year objectives. ARS engages federal administrators and other key stakeholders in setting its research priorities, and the agency uses peer review to help ensure the scientific merit of the research that it funds. Considerable emphasis is placed on the implementation of research results, and the findings of retrospective peer assessments of program outcomes and impacts are used to inform the ongoing program cycle, as well as future projects.

### **Astronomy and Astrophysics: Decadal Survey**

National Research Council (NRC) decadal science-strategy surveys, which are conducted by committees of experts, have been used for more than 50 years (*a*) to provide prospective and retrospective assessments of the status and outlook of research fields and (*b*) to recommend highest-priority research activities (NRC 2007). Priorities are established through a process that involves a significant cross section of the research community and leads to a broad consensus.

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<sup>3</sup> The other agencies are the National Institute of Food and Agriculture, the Economic Research Service, and the National Agricultural Statistics Service.

<sup>4</sup> <http://www.ars.usda.gov/AboutUs/AboutUs.htm>.



The decadal survey of astronomy and astrophysics is a multiyear effort that engages the fields' investigators in setting a research agenda for the next 10 years. The astronomy and astrophysics community conducted its first such survey in 1964, and it has since done five more at approximately 10-year intervals (Haynes 2011). The surveys are widely seen as a way of maintaining coherence on priorities among astronomers and astrophysicists, who engage in the survey process through preparation of white papers, town hall meetings, and membership on committees and working groups. This relatively small research community, funded by several federal agencies<sup>5</sup> and by limited state and private support, focuses on science rather than on payoff to industry or society.

### **Construction: FIATECH**

FIATECH is an industry-led, collaborative, not-for-profit, research consortium of approximately 50 owners, contractors, suppliers, and research organizations. Its mission is to accelerate the deployment of integration and automation technology. Membership is open to all interested parties, and activities are funded through annual membership dues. Formed in 2000 by the Construction Industry Institute and the U.S. National Institute for Standards and Technology, the consortium seeks breakthrough opportunities by focusing on collaborative research and by emphasizing the implementation of research results.

FIATECH has developed, and continues to maintain, a Capital Projects Technology Roadmap<sup>6</sup> that is intended to provide an industrywide research agenda and to guide investments in that research. The roadmap facilitates gap analyses and the identification of research projects with potentially high payoff, some of which may receive FIATECH funding. The consortium has completed 30 projects to date (Jackson 2011).

### **Energy: National Renewable Energy Laboratory**

The National Renewable Energy Laboratory (NREL), contained within the Office of Energy Efficiency and Renewable Energy of the U.S.

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<sup>5</sup> NSF, the National Aeronautics and Space Administration, the Department of Energy, and the Department of Commerce's National Oceanic and Atmospheric Administration.

<sup>6</sup> <http://www.fiatech.org/tech-roadmap>.

Department of Energy (DOE), is operated by the Alliance for Sustainable Energy, LLC, a partnership between Battelle and MRIGlobal. NREL's mission is to develop "renewable-energy and energy-efficiency technologies and practices, [to advance] related science and engineering, and [to transfer] knowledge and innovations to address the nation's energy and environmental goals."<sup>7</sup> The laboratory's annual budget for FY 2011 was approximately \$387 million.

A staff of approximately 1,700, together with 800 visiting researchers, interns, and contractors, conducts research on fuel production, transportation, the built environment, electricity generation and delivery, and the relationships between these systems. Research ranges from basic science to the validation of new products for commercial markets, and it may be conducted in partnership with private industry, academia, or other parts of government.

NREL's research agenda, which responds primarily to the needs of the Office of Energy Efficiency and Renewable Energy, supports national goals for reduced oil imports and greenhouse gas emissions through efforts to improve vehicle fuel economy. NREL considers a range of research topics, including vehicle systems analysis and testing, advanced propulsion and vehicle efficiency improvements, energy-storage technologies, advanced power electronics, advanced combustion engines, and alternative fuels (Christensen 2011). The laboratory also conducts research for DOE's Office of Science and Office of Electricity Delivery and Energy Reliability.

### **Health: National Institutes of Health**

NIH, part of the U.S. Department of Health and Human Services, is the primary federal agency for supporting and conducting medical research.<sup>8</sup> It comprises 27 disease- or program-focused institutes and centers. The NIH budget for FY 2011 was \$30.9 billion.

About 10 percent of the budget supports intramural research involving some 6,000 scientists, and almost 45,000 extramural research grants engage more than 325,000 researchers at 3,000 universities, medical

<sup>7</sup> <http://www.nrel.gov/about/overview.html>.

<sup>8</sup> <http://www.nih.gov/about/>.

schools, and other research institutions both at home and abroad. Most of the research that NIH supports is either basic or applied: these categories receive approximately 52 percent and 45 percent of the budget, respectively. NIH uses more than 200 mechanisms to fund research (Anderson 2011).

NIH's mission is to seek fundamental knowledge about the nature and behavior of living systems and to apply that knowledge to enhance health, lengthen life, and reduce the burdens of illness and disability. Its goals are to

- Foster fundamental discoveries, innovative research strategies, and their applications as a basis for ultimately protecting and improving health;
- Develop, maintain, and renew scientific human and physical resources so as to ensure the nation's capability to prevent disease;
- Expand the knowledge base in medical and associated sciences in order to enhance the nation's economic well-being and enjoy a continued high return on the public investment in research; and
- Exemplify and promote the highest levels of scientific integrity, public accountability, and social responsibility in the conduct of science (Anderson 2011).

NIH identifies a broad range of constituents, including the American people, scientists, health care providers (who apply researchers' results), advocacy groups (for specific diseases, conditions, or populations), Congress, the media, and in general the research enterprise in virtually all its manifestations. Hence NIH's programs tend to address a wide range of, and a great many, individuals.

### **Science Research: National Science Foundation**

NSF is an independent federal agency created by Congress in 1950 "to promote the progress of science; to advance the national health, prosperity, and welfare; [and] to secure the national defense."<sup>9</sup> NSF fulfills this mission largely by issuing limited-term grants to support specific research proposals that are selected on the basis of a rigorous and objective merit review. Grants are typically for three years, and about 11,000 new grants are awarded each year. NSF's annual budget, which was some

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<sup>9</sup> <http://nsf.gov/about/>.

\$7.0 billion in FY 2012, supports approximately one-fifth of all federally funded basic research conducted by U.S. colleges and universities. The organization's director oversees a staff of about 1,400 career employees, 200 scientists from research institutions on temporary duty at NSF, and 450 contract workers responsible for research management.

NSF supports basic science through a variety of models, including

- Unsolicited research funded through existing research programs (e.g., Infrastructure Management and Extreme Events Program);
- People-focused award programs (e.g., graduate research fellowships and postdoctoral awards);
- Specialized centers (e.g., Engineering Research Centers, Centers of Research Excellence in Science and Technology);
- Partnerships with industry (e.g., Industry and University Cooperative Research Program, Grant Opportunities for Academic Liaison with Industry); and
- Workshops and special initiatives.<sup>10</sup>

The focus throughout is on risky but potentially transformative projects, which over the past two decades have become larger, more complex, and of longer duration. NSF has explicitly decided to limit its investment in transportation research, but funding transportation research projects is not excluded. Each year a modest investment is made in such projects, and from 2001 to 2003 a partnership with the U.S. DOT conducted exploratory research on information and communications systems for surface transportation (Nelson 2011).

## APPROACHES TO RESEARCH FUNCTIONS

This section highlights practices in domestic nontransportation sectors that could potentially benefit the country's surface transportation research. The discussion is organized according to the research functions identified in Chapter 2.

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<sup>10</sup> Examples of recent special initiatives are the Integrated NSF Support Promoting Interdisciplinary Research and Education (<http://www.nsf.gov/pubs/2013/nsf13518/nsf13518.htm>); Emerging Frontiers in Research and Innovation (<http://www.nsf.gov/pubs/2012/nsf12583/nsf12583.htm>); and Science, Engineering, and Education for Sustainability ([http://www.nsf.gov/funding/pgm\\_summ.jsp?pims\\_id=504707](http://www.nsf.gov/funding/pgm_summ.jsp?pims_id=504707)).

## Identification of the Role of Research in Achieving Societal Goals

Nontransportation sectors' connection of research to societal goals often occurs as part of a program's agenda-setting or budget-allocation process, but a research program can be built, right from the start, around societal goals. For example, ARS conducts research to address "agricultural and food problems and opportunities of high national priority" (St. John 2011). The program development cycle begins by questioning its relevance and consistency with societal goals; in that way ARS addresses not only, say, improvements in agricultural productivity, but also the need for access to healthful food.

NREL's projects address national energy goals defined in policy documents (Christensen 2011). Examples of these goals are as follows:

- By 2025, reduce oil imports by one-third from current levels (Koonin 2011);
- By 2022, 36 billion gallons of renewable fuels per year are available in the transportation fuel infrastructure (Renewable Fuel Standard, Energy Independence, and Security Act of 2007); and
- By 2015, the nation supports battery-manufacturing capacity for 500,000 plug-in hybrid electric vehicles a year (DOE Strategic Goal 2011).

NIH inherently links research to health-related societal goals, but it also explicitly makes connections between research and health in a variety of ways. For example, NIH universally employs the tag line "Turning Discovery into Health"; it broadly defines its constituencies to include the American people and advocacy groups; and it funds a full spectrum of research activities, from basic research through clinical research.

## Research Agenda Setting

ARS produces and updates National Program Action Plans on a five-year cycle.<sup>11</sup> These plans are informed by prior program assessments, ARS's mission, the USDA's strategic plan, presidential and USDA priorities, customers' and other stakeholders' inputs, advisory boards, the

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<sup>11</sup> <http://www.ars.usda.gov/aboutus/docs.htm?docid=2&page=2>.

ARS leaders' goals, and, of course, scientists' inputs. This planning process is collaborative and inclusive, and it reflects current work, research (including basic research) needs, and implementation strategies.

The decadal survey of astronomy and astrophysics, managed by the NRC through a committee, is a well-established, well-defined, and inclusive research agenda setting process. The committee responsible for the (most recent) 2010 decadal survey was tasked with surveying “the field of space- and ground-based astronomy and astrophysics and recommending priorities for the most important scientific and technical activities of the decade 2010–2020. The principal goals of the study are to carry out an assessment of activities in astronomy and astrophysics, including both new and previously identified concepts . . .” (Haynes 2011). The decadal survey committee fulfilled its assignment while covering not only activities but also infrastructure, such as telescopes (NRC 2010).

The decadal survey committee's process reflected the desirable attributes of research agenda setting identified in Chapter 2; it was

- Inclusive and collaborative, engaging stakeholders through several mechanisms;
- Both bottom up and top down because of stakeholder engagement and the roles of the committee and funding agencies;
- Comprehensive and balanced; and
- Based on an assessment of the current state of the field.

Given the nature of the field, however, the agenda-setting process did not address implementation.

The FIATECH collaborative develops a Capital Projects Technology Roadmap that sets an industrywide agenda based on major challenges facing the construction industry. The roadmap, which is developed and maintained to guide investments in research, includes an assessment of needs, a database on what is being done, a gap analysis, and a process for forming initiatives (based on a national consensus) to prioritize and address the gaps. The FIATECH roadmap focuses on getting products to industry, with intellectual property and other implementation issues explicitly addressed. Ownership of specific intellectual property is determined by the project participants, but all FIATECH members have some access to the products.

NIH's research agenda setting is informed by criteria (both general and specific), constituencies, and process (Anderson 2011), which can briefly be characterized as

- Engaging a very broad range of stakeholders, including advisory groups and program staff;
- Providing opportunities for bottom-up input; and
- Developed around systematic and transparent processes that include strategic planning, workshops, and requests for information.

Specific criteria for project funding include

- Public health needs based on the incidence, severity, and cost of specific disorders;
- Scientific quality of the research;
- Potential for scientific progress;
- Portfolio diversification along the broad and expanding frontiers of research; and
- Support of infrastructure, including human capital, equipment, instrumentation, and facilities.

Given that collaboration is an important attribute of effective agenda setting, many of NSF's initiatives involve partnerships with other agencies, as shown in Table 5-2. The only recent NSF partnership with the U.S. DOT, however, was the Partnership for Exploratory Research on Information Communication Systems for Surface Transportation, which ran from 2001 to 2003 and was supported by \$500,000 from each of the two agencies (Nelson 2011).

Divisions and programs within NSF often facilitate input from the academic research community, whether in a specific discipline or cross-cutting area, by convening events to engage members of that community. Such efforts may also include other agencies and industry. Workshops, principal-investigator meetings, reports, and white papers are used to describe new areas of research; potential sources of funding; and the expected size, scope, duration, and outcomes of awards.

Partnerships with NSF have the advantages that they build on its credibility with the academic community, connect to other relevant areas, include rigorous peer review of projects, and may avoid some of the challenges imposed by the political process.

**TABLE 5-2** Examples of NSF Partnerships with Other Federal Agencies

<b>Agency</b>	<b>NSF Program</b>
National Institutes of Health (NIH)	Computational Neural Science Ecology of Infectious Diseases Joint Initiative to Support Research at the Interface of the Biological and Mathematical Sciences
National Oceanic and Atmospheric Administration	Comparative Analysis of Marine Ecosystems
U.S. Department of Energy (DOE)	Partnerships in Basic Plasma Science and Engineering Pan-American Advanced Studies Institute
U.S. Department of Agriculture (USDA)	Water Sustainability and Climate
USDA and DOE	Decadal and Regional Climate Prediction Using Earth System Models
National Endowment for the Humanities	Documenting Endangered Languages
Department of Homeland Security	Academic Research Initiative
National Air and Space Administration (NASA)	Global Learning and Observations to Benefit the Environment Management and Operation of the Virtual Astronomical Observatory
NASA, USDA, and NIH	National Robotics Initiative
National Institute of Standards and Technology	Interaction in Basic and Applied Scientific Research
National Science and Technology Council, USDA, NIH, DOE, and U.S. Agency for International Development	National Plant Genome Initiative—Plan Genome Research Program
U.S. Census Bureau	NSF Census Research Network
Food and Drug Administration (FDA)	NSF–FDA Scholar in Residence Program at FDA

SOURCE: Nelson (2011).

## Distribution of Funding for Specific Research Activities

The process by which funding is distributed to specific research activities is intended to produce a high-quality research portfolio that recognizes the mission of the particular agency or sector. Some of the agencies or programs the committee explored focused on specific goals, and others aimed to develop a balanced portfolio. For example, FIATECH favors research that will be implemented by the construction industry. In contrast, NIH



has a spectrum of programs that ranges from basic research to clinical trials to implementation.

ARS allocates funding based on the expected quality and performance of the project, its relevance and impact, and situational criteria such as customer support (Kenna and Berche 2012). Toward these ends, new projects go through a peer-review process that employs panels with membership external to ARS but with ARS oversight.

FIATECH uses its roadmap to guide an annual process in which proposals are submitted by members, reviewed by their topics' champions within the organization, revised, submitted for final review, and (potentially) approved by the board of directors. The success of this process is of course dependent on the quality of the roadmap and the integrity of the internal reviewers.

The NIH research investment process is more elaborate, recognizing not only that the quest for innovation is serendipitous and that impact can be long term, but also that balance must be achieved through shorter-term deliverables and realistic constraints on human capital and resources. For NIH, the decision about who to fund is based on a two-tiered review process that is referred to by many in the research community as the international "gold standard" of scientific review. This process includes

- Peer-review panels comprising external experts who evaluate the scientific merit of grant applications, and
- Institute advisory councils that evaluate how well the expected applications address their particular Institute's mission and programmatic priorities.

Currently, NIH funds about one application in five. Scored criteria include significance, investigators, approach, environment, and potential innovation. Attributes considered but not scored relate to how well the proposed research complements other projects being funded, for example, or whether policy issues such as protection of human subjects; inclusion of women, minorities, and children; humane treatment of vertebrate animals; and prevention of possible biohazards are adequately addressed in the proposal.

NSF also conducts rigorous peer evaluations for project selection. Key criteria are intellectual merit and the likelihood of broader impacts.

## Conduct of Research

As described in Chapter 2, the actual research is not conducted in isolation but in concert with a diverse portfolio of other research projects directed at innovation; this diversity is intended to ensure that activities at any given time are occurring at all stages of the research pipeline. However, the totality of these projects requires coordination and cooperation among numerous participants. The following examples illustrate the range of strategies that the studied organizations use to ensure a full pipeline:

- To balance its portfolio, ARS explicitly includes program coordination in its national program cycle, which addresses a program's ensemble of individual projects, especially their performance and potential implementation of their results;
- To move research into practice more rapidly, FIATECH negotiates intellectual property issues with project participants right from the beginning;
- To facilitate a diversity of research efforts, NIH has numerous funding mechanisms, including
  - Research projects to support a discrete and circumscribed objective and to be performed by the named investigators in an area representing specific interests and competencies;
  - Small Business Innovation Research Phase I grants to support projects, limited in time and amount, to establish the technical merit and feasibility of research and development ideas that may ultimately lead to commercial products or services;<sup>12</sup>
  - Undergraduate Institutional Grants to enable minority institutions, at their discretion, to make training awards to individual students or staff;
  - Centers, contracts, collaborative agreements, or consortia, among other models; and
- To make stronger connections to practice, the NSF partners with other, more mission-oriented organizations, as described in the previous subsection on research agenda setting.

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<sup>12</sup> All federal agencies with extramural programs above a certain amount are required to have a Small Business Innovation Research program.

## Research Evaluation

Because research evaluation promotes quality research, enhances coordination and cooperation, and engages stakeholders, most agencies engage in some form of it, whether for selection of projects, assessment of progress, or as a feedback mechanism for setting new directions.

The use of peer review by NIH and NSF for prospective evaluation is well accepted by researchers. However, performance assessment based on long-term impacts, especially in the case of basic and advanced research, is not so well accepted because of the lack of consensus about the construction and use of reliable and valid measures. As a practical matter, NSF uses representative metrics, such as numbers of papers published in peer-reviewed journals or numbers of students graduated.

ARS reviews programs and gathers data on outcomes. The Farm Bill of 1998 (P.L. 105-185) requires that all ARS research be reviewed every five years; consequently, 20 percent of the agency's programs undergo a retrospective evaluation each year. These evaluations involve peer assessment, with a focus on scientific merit. Oversight is provided by the National Agricultural Research, Extension, Education, and Economics Advisory Board. Data on outcomes are gathered during project implementation and are used to improve project coordination.

## Dissemination of Results

Most federal agencies expect researchers to integrate strategies for the dissemination of research results into their research projects. For example, NSF requires researchers to include a dissemination plan in their proposals.

Several agencies also do some of the dissemination themselves. For example, ARS uses several mechanisms so that information and technology reach researchers and practitioners. These mechanisms include

- The National Agricultural Library, a departmental resource for agricultural and related information;
- The Office of Technology Transfer, which oversees Cooperative Research and Development Agreements, patents, and licensing with industry and other partners;

- Public affairs staff, who produce *Agricultural Research* magazine, news releases, exhibits, and a website;
- Other scientific publications, as well as conferences, workshops, and field days; and
- Releases of germplasm<sup>13</sup> for use by the public.

Similarly, NIH supports the National Library of Medicine.

## Implementation of New Knowledge

Agencies and other organizations that involve stakeholders throughout the research process appear to be more successful at implementing research results than those who do not engage stakeholders. For example, FIATECH, which focuses on helping to deploy innovations, engages stakeholders' support of implementation by addressing issues of intellectual property early on, by involving end users in the research process, and by identifying key deliverables. Similarly, NIH links basic research to clinical applications; NSF asks grantees to constantly keep the broader impacts of their research in mind; and NREL identifies each project's barriers to implementation.

## LESSONS LEARNED

Although none of the domestic nontransportation research frameworks examined (those of ARS, the astronomy and astrophysics decadal survey, FIATECH, NREL, NIH, and NSF) was directly transferable in its entirety to the U.S. surface transportation research enterprise, the committee gained valuable insights from its consideration of these entities' different approaches. This section discusses the lessons learned, grouped under five major themes:

- Nature of the research enterprise,
- Agenda setting,
- Distributing funds,
- Growing opportunities for basic research, and
- The innovation process.

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<sup>13</sup> Germplasm is the collection of genetic resources for an organism.

## Nature of the Research Enterprise

Guest speakers' presentations to the committee highlighted the fundamental differences between mission-oriented and scientific agencies. By definition, mission-oriented agencies focus on applied research relevant to their mission, with specific targets and an emphasis on implementation. As in the case of ARS, much of this research is conducted internally with limited external peer review. Similarly, research led or sponsored by industry is generally short term and applied, with successful implementation a high priority, as in the case of FIATECH.

Scientific agencies such as NSF engage in the basic research and discovery part of the innovation process. These agencies have broad goals and often operate with a flexible bottom-up research agenda. Much of the research is conducted externally, thereby engaging a large science community. Peer review is emphasized as an important mechanism for research evaluation, and exploratory research is recognized as being relatively high risk, but also as offering the potential for major discovery.

DOE conducts basic research and also engages in applied research, development, and implementation activities in support of its mission, and so it combines the features of mission-oriented and scientific agencies. In addition, the culture of an organization and the nature of its research enterprise are closely related. In the case of DOE and NIH, both of which have strong research efforts, a research culture permeates the organization. Evidence of this culture includes actions such as listing basic research needs (<http://science.energy.gov/bes/efrc/research/basic-research-needs/>) and the widespread use of a peer-review process.

## Agenda Setting

Agenda setting is most successful when there is a clearly defined research community and it is well represented in the process. That is, effective agenda setting is inclusive, engaging stakeholders in the establishment of priorities and identification of projects. As a result, these communities have leverage in influencing funding allocations. For example, the decadal survey engages the relatively small astronomy and astrophysics community, and the resulting research priorities, although often controversial, nonetheless reflect a community consensus. Similarly, FIATECH and NIH engage stakeholders in setting the agenda.

Connecting agenda items to well-articulated national policies, strategic plans, and initiatives is not only politically prudent but also can drive an agenda. For example, NREL builds its agenda based on administration policy and DOE's initiatives and priorities; this agenda then influences NREL's diverse research activities. FIATECH takes a similar approach, albeit at a far more modest scale, basing its research agenda on a strategy defined by its parent organizations in response to clearly articulated problems.

### **Distributing Funds**

When rigorous peer review is used to select projects, the research community is more tolerant of the process and the quality of the results appears to improve. The peer-review processes used by NSF and NIH, for example, are well accepted and, although they entail considerable time, effort, and in-kind contributions of the research communities, they provide an assessment of individual projects that is as objective as possible.

### **Growing Opportunities for Basic Research**

NSF's mission and its broad-based experience in helping to seed and nurture basic research efforts offer potentially valuable lessons for initiating a basic research initiative in surface transportation. The agency's experience in partnering with other agencies could also be valuable in fostering such an initiative, even though NSF and the U.S. DOT do not have a strong tradition of working together, at least to date.

### **Innovation Process**

A well-designed stakeholder-engagement process can help identify and overcome barriers to the implementation of research outputs. Several models show how. For example, FIATECH directly addresses intellectual property issues, which can present a strong barrier to implementation; ARS uses a variety of outreach mechanisms to disseminate its research results to practitioners with the intent of stimulating technology transfer; and NIH has many different types of research programs as part of its effort to involve diverse constituencies both in the conduct of research and the application of its results.

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DOE	U.S. Department of Energy
NRC	National Research Council

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## 6

## Recommendations

Innovations in surface transportation are needed to support the economic growth of the United States, strengthen its global competitiveness, and enhance its inhabitants' quality of life. Successful innovation in the transportation sector largely depends on a potent research<sup>1</sup> endeavor, one that is productive in building knowledge and devising ways to meet new transportation demands, as well as in operating current systems more efficiently and cost-effectively. This research endeavor needs to address the individual components of the systems, notably infrastructure, vehicles, fuels, and users, and the interactions among them. It also needs to provide key players in the nation's surface transportation enterprise (policy makers, public officials, equipment manufacturers, service providers, planners, engineers, and others) with a robust knowledge base for identifying improvement opportunities and for informing decisions.

### VALUE OF A NATIONAL RESEARCH FRAMEWORK

Nations with which the United States competes place a high priority on improving the performance of their transportation systems in support of social, economic, and environmental goals. These nations also have effective research frameworks in place for this purpose: the scanning study of transportation research program administration in Europe and Asia found strategic and policy-driven frameworks for transportation research to be standard in the countries visited (Elston et al. 2009). The

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<sup>1</sup> As noted in Chapter 1, the term "research" is used throughout this report as shorthand for research, development, and deployment (RD&D).



committee's review of transportation research organizations in Europe and Asia allowed it to identify important features of these frameworks (see Box 4-1).

As discussed in Chapter 2, a transportation research framework encompasses a series of functions, from initial identification of research's role in achieving desired goals through the implementation of new knowledge in various forms. The execution of these functions is influenced by the research context, which depends on organizational structures, funding mechanisms, and a variety of policies and procedures. For example, even if overall funding levels are adequate for initiating a research project, scientific and technological progress may be thwarted if the subsequent flow of funding is sporadic. An effective national research framework with the critical attributes identified in Chapter 2, however, can help ensure that the country's transportation research enterprise supports overall societal goals. The framework can also guide investment throughout the research process.

In contrast to its competitors, the United States lacks a cohesive national framework linking surface transportation research activities to societal goals.<sup>2</sup> It relies instead on a fragmented and ad hoc array of diverse and largely uncoordinated research initiatives, often with no clear linkage to overall social, economic, and environmental goals. In other words, the United States lacks the centralized transportation policy making that characterizes many of its competitors (see Chapter 4), and national interests and individual well-being suffer in some respects from this omission. An effective U.S. national research framework for surface transportation, one that engaged multiple levels of government; bridged the public and private sectors; and drew on the nation's research capacity in academia, industry, and elsewhere, would contribute to the country's economic, societal, and environmental health.

Lacking such a framework, current U.S. surface transportation research tends to be organized by mode, funding source, federal government

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<sup>2</sup> The committee envisions that a national transportation research framework for the United States would ultimately encompass all modes of transportation. To avoid going beyond its charge, however, the committee addressed only surface transportation in this report. It also excluded pipelines, inland waterways, and coastal shipping from its discussions to render its task more tractable with available resources.

department, and other arbitrary groupings, as the examples in Chapter 3 illustrate. This mixed private–public enterprise has served America well for decades, but it has resulted in some missed opportunities, such as the improvement of transportation services through systems-level approaches; the leveraging of different research competencies in support of broad and crosscutting initiatives; and the pooling of funds for research that is of common interest to many organizations but that is too costly to be undertaken by any single organization. A more cohesive framework would place greater emphasis on “the big picture,” identifying research areas of high national priority, possible synergies among research activities, and research gaps.

In the judgment of the committee, addressing surface transportation research in a more holistic way could help overcome current deficiencies, notably

- A lack of policy making and systems-level analysis needed to support national goals,
- Too much attention to incremental improvements and scant attention to the search for new knowledge that might enable wider-ranging and more innovative solutions, and
- Insufficient emphasis on coordination of research activities.

Through its broad perspective on providing the transportation systems needed to meet national goals, a new framework could better address the diversity and breadth of transportation research. It could also help establish greater networking across the research community, engaging not only those traditionally involved in transportation research but also new players with new ideas. Hence the committee concludes that the United States needs a modern, cohesive, national research framework for surface transportation and should deploy, without delay, the mechanisms for building, implementing, and sustaining such a framework. This framework would retain the effective features of current U.S. surface transportation research identified in Chapter 3, namely, the robust portfolio of applied research and the role played by research in educating future transportation professionals.

In the remainder of this chapter, the committee presents its recommendations for creating the proposed new national research framework for surface transportation. In particular, because the federal government, as

a major sponsor of surface transportation research, will have a key role in supporting the new framework, the committee recommends ways of structuring a more productive federal research enterprise in the context of that framework. Given the ubiquitous nature of transportation, the committee also offers recommendations for raising awareness of surface transportation research beyond the confines of the transportation research community per se to include decision makers at the national policy level.

The committee's recommendations are intended not only to help the research community move toward a new and more cohesive national framework for surface transportation research, but also to encourage organizations and individuals to think more broadly about opportunities for solving transportation problems. Specific suggestions are made for achieving the desired goals, but recognizing that other opportunities may present themselves, the committee encourages the research community to explore alternative approaches.

## **BUILD AND IMPLEMENT A NEW NATIONAL RESEARCH FRAMEWORK**

In the committee's judgment, there is no silver bullet that could rapidly transform the current fragmented and ad hoc national research framework for surface transportation into a more cohesive alternative. Rather, a series of steps over a period of years will be needed, both to fully engage a broad spectrum of interested groups and to implement strategies for making more effective use of the nation's extensive research capabilities. Taking the initial steps without delay is essential, given the growing and changing demands on the nation's transportation systems, the ever-increasing pressure on research budgets, the need to use research funds wisely, and the emphasis placed on transportation research by many U.S. competitors.

The steps in the process that the committee envisions are described in the following subsections on leadership, national summit, lead organization, and funding, in the context of the first two of the committee's nine major recommendations. The sequence of activities is illustrated schematically in Figure 6-1. The connections between the process steps are accomplished through the leadership and organizational structure.



**FIGURE 6-1** Steps leading to a new national research framework.

**Recommendation 1: An initiative to establish a new framework for U.S. surface transportation research should be launched without delay.** The Standing Committee on Research (SCOR) of the American Association of State Highway and Transportation Officials (AASHTO) should instigate this activity and engage other influential organizations from the public, private, academic, and nonprofit sectors. The resulting leadership group should

- Secure funding to support the initiative;
- Promote the advantages of a more cohesive research framework to the public, private, academic, and nonprofit sectors; and
- Appoint a convener for a national summit, which would use the framework concept to explore effective strategies for addressing major challenges in surface transportation research.

## Leadership

The committee recognizes that an initiative aimed at building and implementing a new national framework for surface transportation research faces many obstacles, particularly in the current budget-constrained

environment. For example, at present no single organization or research group could effectively serve the multimodal leadership, stewardship, and funding roles that the framework calls for in the future. The committee also is well aware that earlier efforts to establish a more cohesive approach to transportation research have had mixed results. The first Strategic Highway Research Program (SHRP) proved successful in approaching highway research “from the vantage point of a unified industry” rather than from the individual perspectives of “every state, city, county, and toll highway authority, and thousands of contractors and suppliers” (TRB 1984, v). The Intelligent Transportation Systems (ITS) program has from its earliest days engaged representatives from government, academia, and industry (see Chapter 3). However, an attempt by the Federal Transportation Advisory Group<sup>3</sup> to establish a cohesive approach to transportation research across the federal government did not lead to greater integration of research activities (FTAG 2001).

An important lesson learned from the SHRP and ITS experiences (see Chapter 3) is that the likelihood of success is greatly enhanced when respected leaders from within transportation organizations and the research community commit to and champion an initiative. This lesson is not unique to the United States. The 2008 scanning study of transportation research program administration in Europe and Asia observed that, in a number of host countries, “senior-level individuals frequently emerge as visionaries or champions and play an instrumental role in national program focus and support” (Elston et al. 2009, 2).

For the proposed new framework initiative for the United States, the committee recommends an approach similar to that used to launch the ITS program, while recognizing that building a surface transportation research framework in its entirety will be a more challenging endeavor than addressing ITS alone. The first steps toward establishing what was to become ITS America were taken by a core group of volunteer partici-

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<sup>3</sup> The Federal Transportation Advisory Group was established by the National Science and Technology Council under the auspices of the Federal Aviation Administration's Research, Engineering, and Development Advisory Committee and the National Aeronautics and Space Administration's Aerospace Technology Advisory Committee. Its 24 members represented aerospace, water, land, and multimodal interests and were drawn from the public, private, and academic sectors (FTAG 2001).

pants (i.e., champions), known as Mobility 2000. This group, which represented the public, private, academic, and nonprofit sectors, included, among others, the Federal Highway Administration (FHWA), the Texas State Department of Highways and Public Transportation, the General Motors Corporation, the University of Michigan, the Texas A&M Transportation Institute, and the Massachusetts Institute of Technology. The group convened a national planning workshop on intelligent vehicle–highway systems (IVHS) in Dallas, Texas, in March 1990 (TTI 1990). The workshop included a broad range of stakeholders and produced a vision, goals, and funding estimates for a national program that was clearly linked to national transportation goals. The Mobility 2000 group was disbanded after the workshop, and the nonprofit corporation IVHS America (subsequently ITS America) was formed. In 1991, the Transportation Research Board (TRB) issued a special report addressing the overall objectives for a national IVHS initiative and methods for effectively managing such a program (TRB 1991).

The committee envisions a similar group of respected and influential leaders from within the current surface transportation community initiating the effort to build a new research framework for surface transportation. Like the Mobility 2000 group that championed the national IVHS initiative, this cadre of volunteer leaders (“the leadership group”) would represent the public, private, academic, and nonprofit sectors. It would market the potential advantages of a cohesive research framework to these sectors and raise funds for a national surface transportation summit analogous to the 1990 IVHS workshop. And like the Mobility 2000 group, this leadership group would disband once its work was done.

The leadership group itself will need an institutional leader. The committee recommends AASHTO’s SCOR for this role, for three main reasons:

- SCOR has a strong interest in alternative frameworks and institutional models with the potential to enhance surface transportation in the United States, as reflected in its decision to commission and fund the current study;
- SCOR’s role as AASHTO’s “driving force for high-quality transportation research and innovation to improve the nation’s mobility of

people and goods”<sup>4</sup> aligns with the broad objectives of the new research framework; and

- SCOR’s experience in working with federal, industrial, academic, and nonprofit partners, notably through the National Cooperative Highway Research Program (NCHRP), demonstrates that the organization is well positioned to engage a broad spectrum of interest groups in the new framework initiative. Moreover, because it represents departments of transportation (DOTs) in all 50 states, SCOR’s influence extends nationwide.

The committee considered the possibility of the U.S. Department of Transportation (U.S. DOT) leading the core group of framework champions, but decided against recommending this option for two reasons: the U.S. DOT’s lack of a strong, departmentwide research culture (see Chapter 3) and the department’s role in setting national policy. In the committee’s judgment, the leader of the core group needs to have not only a strong commitment to research but also the ability to provide a neutral forum for discussion independent of administration policy.

## **National Summit**

The committee recommends holding a national summit on transportation research to launch efforts to build and implement a new national research framework. The summit’s starting point would be to review the major research challenges that need to be addressed if surface transportation is to continue supporting progress toward societal goals for economic development, sustainability, and quality of life. The summit’s overarching objective would be to foster the blend of diverse interests, the informal working relationships, and the commitment to common objectives that characterized the launch of the IVHS initiative (TTI 1990). Toward this end, the summit would engage a broad range of interested parties, including representatives from entities outside the traditional transportation research community, such as the information technology and communications industries.

Preparatory work in advance of the summit would synthesize lessons learned from earlier efforts to identify major challenges facing surface

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<sup>4</sup> <http://research.transportation.org/Pages/AboutSCORandRAC.aspx>.

transportation research. For example, the *Vision 2050* report, although over 10 years old, provides useful suggestions for research areas that could dramatically transform transportation in the future (FTAG 2001). TRB's *Critical Issues in Transportation* (2013a) could also be potentially helpful in identifying areas in which innovations are needed and research thus has a key role to play.

Summit participants would explore strategies for addressing these challenges effectively under the new framework concept. In the case of disaster reduction, for example, the summit could survey opportunities to leverage and build on the disparate set of ongoing activities in support of a cohesive value-added research initiative targeting national goals (see Box 6-1). In a similar way, the Framework Program of the European Union (EU) leverages and builds on research activities of member nations to create pan-European value-added research.

The committee anticipates that the national summit, perhaps with a modified scope, would be repeated as the framework evolves. The research challenges, for example, would need to be updated over time in response to environmental, technological, and social changes. The required frequency of follow-up summits is likely to become clearer as the framework develops.

Resources would be needed to plan and conduct the summit and prepare a follow-up report (see Recommendation 2). The committee envisions that interested organizations—notably, those that might use the challenges to guide their research activities and investments—could well make contributions, at the urging of the leadership group, to support the summit. Interested organizations could include federal and state government agencies, private companies, industry associations, universities, and foundations. If a sufficiently large number of organizations were persuaded to contribute, the amount needed from each one would be relatively modest.

The leadership group, spearheaded by SCOR, would appoint an organization to act as summit convener. This convener would assemble an organizing committee tasked with developing the summit agenda, recruiting speakers, and encouraging a broad range of organizations to participate. The organizing committee would be representative of organizations potentially interested in contributing knowledge and resources to the new framework initiative.



BOX 6-1

## **Disaster Reduction: Illustrating a Cohesive Value-Added Transportation Research Initiative**

The National Science and Technology Council's Subcommittee on Disaster Reduction, a federal interagency body tasked with formulating science- and technology-based guidance for policy makers, identified six grand challenges for disaster reduction (Subcommittee on Disaster Reduction 2005):

1. Provide hazard and disaster information where and when it is needed,
2. Understand the natural processes that produce hazards,
3. Develop hazard-mitigation strategies and technologies,
4. Recognize and reduce vulnerability of interdependent critical infrastructure,
5. Assess disaster resilience using standard methods, and
6. Promote risk-wise behavior.

Although these challenges do not mention transportation explicitly, addressing them will require research into issues of transportation infrastructure, operations, and planning. Such research can, for example, suggest ways of reducing the vulnerability of critical infrastructure and inform the development of improved evacuation plans.

Funding for transportation research related to disaster reduction comes from a variety of sources, including the National Science Foundation, the Department of Homeland Security, individual states through their departments of transportation and emergency management agencies, and the University Transportation Centers program. By sharing ideas and lessons learned, working together to identify research areas of common interest, and looking for potential synergies, these (and other) organizations could bring new perspectives to their individual research activities and add value to the overall research endeavor targeting disaster reduction.

To ensure impartiality and independence from particular interest groups, the summit should be convened under the auspices of an organization that is widely perceived as being unbiased and reasonably isolated from the immediate political environment. This convening organization would also need to have stature and credibility in the eyes of stakeholders. To help ensure the desired openness to new ideas and opportunities, the convening organization should have experience in bringing people together from different sectors and disciplines to further national research objectives. In other words, it should be able to reach out to the traditional surface transportation research community and beyond to engage summit participants with a broad range of expertise and experience.

The committee briefly considered the pros and cons of several candidate convener organizations, as discussed in the following paragraphs. It anticipates, however, that the leadership group would want to undertake a more thorough examination of these and other candidates before selecting a summit convener.

As discussed in Chapter 3, the U.S. DOT's Research and Innovative Technology Administration (RITA) is responsible for coordinating and facilitating the department's research programs across all modes; its five-year research, development, and technology strategic plan takes a systems-level view of the nation's multimodal transportation system. RITA is also engaged in a broad range of subject areas and activities through its programs, including transportation data and analysis through the Bureau of Transportation Statistics; research and innovation through the University Transportation Centers (UTC) program and the Volpe Center; and education and training through the Transportation Safety Institute (<http://www.rita.dot.gov/>). Thus RITA possesses the necessary crossmodal and multimodal perspectives appropriate for a summit convener, although its strong federal focus and limited experience in engaging stakeholders across different sectors raises questions about its ability to engage the desired degree of diversity of summit participants.

The Institute of Transportation Engineers (ITE), an international educational and scientific association of transportation professionals with nearly 17,000 members in more than 90 countries, is also a possible summit convener (<http://www.ite.org/aboutite/index.asp>). ITE addresses

mobility and safety needs for all modes of ground transportation. It seeks to stimulate research; develop public awareness programs; support and encourage education; and encourage the exchange of professional information through its meetings, seminars, publications, and membership in its special-interest councils. Thus, ITE has many of the desired attributes for a summit convener, although its strong focus on transportation engineering raises questions about its ability to attract summit participants from outside the traditional transportation community.

Private foundations, such as the Eno Transportation Foundation, may be suitable candidates. Eno is a nonpartisan think tank that supports professional development programs, policy forums, and publications in its efforts to increase the transportation system's mobility, safety, and sustainability across all modes (<http://www.enotrans.org/about-us>). It often works in partnership with government agencies, professional organizations, and other private organizations. The National Academies is also a potentially promising candidate, given the institution's independent status and the relevant experience of bodies operating under its auspices. For example, TRB has experience both in convening expert committees tasked with exploring opportunities for multidisciplinary research in the national interest (e.g., TRB 2009) and in attracting a broad spectrum of the transportation community to its annual meeting and other activities.

**Recommendation 2: The summit convener should issue a report to the leadership group on the outcomes of the summit.** This report would explore ways of implementing a new national surface transportation research framework, discuss means of funding the framework initiative, and consider opportunities to leverage existing research.

Two important questions need to be answered if the proposed new national research framework is to become a reality:

- Which group or organization should take the lead in furthering the framework initiative *after* the summit?
- Where is the initiative's funding to come from?

The committee recommends that the convener organization address these two questions in its postsummit report. In much the same way as

the Mobility 2000 report (TTI 1990) formed a steppingstone toward a national IVHS initiative, the convener's report on the national summit would form a base from which to develop technical and management plans for a framework initiative and build stakeholder support.

## Lead Organization

At this preliminary stage, the committee considers it prudent to leave options open for the organizational structure of the entity tasked with developing and implementing the new transportation research framework. This would allow the research community itself to determine the most suitable option commensurate with its needs and available funding. However, two general points merit consideration.

First, initiatives for transportation research programming and funding in the United States are generally organized according to a bottom-up approach, in contrast to the more top-down procedures used in some countries (see Chapter 4). The committee agreed, therefore, that the lead organization would likely be based on a distributed (i.e., bottom-up) model as described in Chapter 2. Its structure would reflect the diverse transportation community and its stakeholders, and it would probably be a cooperative venture. Past experience suggests that effective organizational structures could include a new nonprofit organization (as in the case of ITS America) or a special unit within an existing nonprofit (as in the case of SHRP, which was housed in the National Academies).

Second, efforts to develop a more cohesive research framework would need to recognize that individual public-sector organizations (e.g., state DOTs, which own and operate major portions of the nation's transportation infrastructure) need the freedom to pursue mission-specific research needs independent of and in addition to any national strategy or agenda. In addition, private-sector organizations would be free to pursue their competitive advantage in company-specific research activities. Thus the lead organization would have to endorse the concept of a framework that provides guidance in the form of high-level priorities but allows individual organizations to identify for themselves the areas and means they will pursue. Such a "plug and play" concept (analogous to computer hardware to which a device can be connected and functions immediately) would provide opportunities for these organizations

to maximize the value of their research activities by integrating them within a broader national vision for surface transportation. The concept would not, however, compromise the ability of individual public-sector organizations to simultaneously pursue other research objectives, nor the ability of private-sector organizations to freely pursue their commercial objectives.

## **Funding**

Development of a new national research framework and the subsequent activities associated with its implementation will require sustained funding over a period of years. Obtaining such funding clearly presents a challenge in the current economic environment: requests for new research funding are highly unlikely to be met, and suggestions for major reallocations of existing research funds are likely to face strong opposition. The Highway Trust Fund, for example, is already insufficient to meet the demands placed on it. Assigning a larger proportion of the fund for research-related activities, such as the development and implementation of a new national research framework, would leave even less for operations; this shortfall could exacerbate the existing problems in maintaining the nation's aging transportation infrastructure and in building new infrastructure where needed. However, if the surface transportation research community is to compete effectively for scarce public and private funds, it needs to demonstrate its ability to address transportation challenges in a more holistic manner, as reflected in the proposed new national research framework.

In the committee's view, greater leveraging of current research activities could be a favorable approach for supporting the proposed framework initiative. The Federal Transportation Advisory Group, for example, has suggested that the large federal research investments made by the Department of Defense (DOD), the Department of Energy (DOE), and the National Aeronautics and Space Administration in a variety of scientific and technological areas could be leveraged by the U.S. DOT for the benefit of the transportation system as a whole (FTAG 2001). For example, experience gained in developing high-performance materials for military and space applications might be applied in the design and manufacture of high strength-to-weight materials for auto-

motive applications. Such leveraging of existing research investments could offer opportunities to start building the proposed new research framework. In the future, the U.S. DOT and DOE, for example, might work together to identify research areas of common interest, look for potential synergies, and explore possible cofunding. Hence the committee suggests that the summit convener explore these approaches, together with other creative funding options, in its report to the leadership group.

Suggestions for funding the framework initiative should also take into account some of the lessons learned from the EU Framework Program. Although this program has clearly been successful in fostering partnerships among European research organizations in support of pan-European goals and in bringing European value added to the innovation process, the associated administrative burden is considerable (see Chapter 4). Thus the convener's report will need to explore opportunities for building a cohesive research framework that does not depend on overly burdensome and costly administrative procedures.

## **BUILD A MORE PRODUCTIVE FEDERAL RESEARCH ENTERPRISE**

The steps described above for building and implementing a new national research framework would involve interested parties from all levels of government, the private sector, academia, and nonprofit organizations. To supplement these steps and further support the transition to a new research framework, the committee identified actions that could be taken within the federal government to help build a more cohesive and productive transportation research enterprise. The federal government, after all, is a major sponsor of surface transportation research, as noted in Chapter 3, and federal research programs have “a unique and critical role to play in overcoming the challenges that face [the] nation's transportation system” (RITA 2012, 7). In particular, federal involvement supports long-term national interests and societal goals through research targeting a more effective and efficient transportation system.

**Recommendation 3: The White House Office of Science and Technology Policy (OSTP) should convene a task force to explore potential synergies and other gains from greater coordination and cohesion among federal agencies engaged in research relevant to surface transportation.**

Federal responsibility for transportation-related research is distributed across numerous government departments and agencies, but the extent of coordination among these activities is limited (see Chapter 3). The U.S. DOT is the federal entity explicitly tasked with supporting the nation's transportation system. This responsibility has not, however, translated into a strong coordinating role, and as a result both the research and resources involving transportation are largely fragmented. Further, some estimates suggest that other federal agencies together invest more than the U.S. DOT does in transportation-related research (Brach 2005), with DOD and DOE in particular making considerable investments in support of their individual missions.

In the committee's judgment, establishing stronger working relationships among federal departments that conduct research related to surface transportation could lead to a more coordinated and cohesive research endeavor, consistent with the proposed new research framework. Such an approach could also result in more effective use of resources. A review of RITA's most recent five-year strategic plan makes a similar point, noting that "many of the issues U.S. DOT faces are also being faced by other agencies, research institutions, and regulatory bodies" and recommending that the U.S. DOT "deepen its relationships with other federal agencies . . . to include research" (TRB 2013b, 12).

OSTP, through its National Science and Technology Council (NSTC), has the lead responsibility within the executive branch for coordinating science and technology policy across the diverse entities that make up the federal research enterprise. Hence OSTP would appear to be the natural leader of an initiative aimed at establishing greater coordination and cohesion among surface transportation-related research efforts in different federal departments. In fact, the NSTC Transportation R&D Committee<sup>5</sup> established the first-ever governmentwide strategic plan-

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<sup>5</sup> For administrative reasons, this committee was subsumed under the NSTC Committee on Technology after one year.

ning process for transportation research in the late 1990s, but the effort foundered after a change of administration. In the committee's view, the time has come to consider reestablishing such an initiative.

**Recommendation 4: The Secretary of Transportation should consider ways to strengthen the coordination of transportation research within the U.S. DOT and across other federal agencies.** One promising option for doing so would be to establish within the Office of the Secretary the position of chief scientist, who could serve as a science and technology advisor to the Secretary and be the U.S. DOT's champion for research.

The committee considered various options for strengthening the coordination of transportation research within the U.S. DOT and across other federal agencies, as follows:

- Maintain the status quo, whereby the RITA Associate Administrator for Research, Development, and Technology (RD&T) is responsible for coordinating the U.S. DOT's research programs;
- Task the RITA Administrator with coordinating transportation research both within the U.S. DOT and across other federal agencies;
- Move RITA's current responsibilities for coordinating the U.S. DOT's research programs into the Office of the Secretary; and
- Appoint a chief scientist within the Office of the Secretary; this individual would be a distinguished transportation professional external to the U.S. DOT who would serve for a limited term (two or three years).

Each of these options has strengths and weaknesses, as discussed in the following paragraphs.

Currently, the RITA Associate Administrator for RD&T is responsible for coordinating research within the U.S. DOT. A major focal point for this coordination is the development of a departmental strategic plan for RD&T, with the latest version of the plan mandated by the Moving Ahead for Progress in the 21st Century Act (MAP-21). As noted in a recent review of RITA's draft U.S. DOT RD&T strategic plan (TRB 2013b), such coordination is challenging, particularly given the many institutional and financial constraints the department faces. The authors of the review commended RITA's attempt to overcome modal constraints in developing the



strategic plan. However, they also found research coordination within the U.S. DOT to be less than optimal and, in addition, urged the department to strengthen its relationships with other federal agencies in support of its research endeavor. In this context, it is natural to ask whether an associate administrator within RITA has the necessary organizational status to improve research coordination among the modal administrations and to liaise effectively with other federal agencies.

Possible options for elevating the status of the U.S. DOT's research leader, or champion, could be to charge the RITA administrator, rather than an associate administrator, with the role of strengthening research coordination, or to move RITA's responsibilities to the Office of the Secretary under a senior executive position. Both these options would confer greater status on the U.S. DOT's research leader, but both also have significant disadvantages.

The RITA administrator has not always been a scientist, and it is far from clear that an individual lacking accomplishments and recognition in the research field would command the respect of the federal research community in general and of senior research managers within the U.S. DOT in particular. In addition, the RITA administrator has many administrative duties that would limit his or her ability to focus on coordination issues. A senior executive position within the Office of the Secretary could have both the necessary status and time to address the issue of greater research coordination; however, a disadvantage would be the lack of funds to support such a position. The Office of the Secretary's budget for surface transportation research is very modest, as indicated in Table 3-1, and has frequently been a target for cost and staff reductions during past appropriations. A further complication with establishing a new senior executive position within the Office of the Secretary is that such positions are subject to a cap set by the Office of Personnel Management. Thus, any new position could require the U.S. DOT to relinquish another such position to avoid exceeding headcount limitations. Furthermore, moving RITA's responsibilities to the Office of the Secretary would require some level of authorization by Congress.

The position of chief scientist is widely used in mission-oriented enterprises of government and the private sector, both in the United States and abroad. The roles and responsibilities of chief scientists vary

widely across these enterprises, ranging from a narrow scientific supervisory and decision-making role (e.g., in an expedition on a deep-ocean research vessel) to a broad research advisory or leadership role in a federal mission agency or a major corporation. In the former case, the chief scientist is typically responsible for the specific scientific mission, coordinating the work of the various scientists involved, and having ultimate decision-making authority about the mission's scientific aspects. In the latter case, at the other end of the spectrum, the chief scientist may be responsible for ensuring the quality, relevance, impact, and future vision of the entire agency's or corporation's research program. In some cases, the chief scientist may also have line and budget authority over all or part of the research program.

The establishment of a chief scientist position, or a role with similar stature, within the U.S. DOT could be a valuable step toward enhancing the department's research culture and capacity, thereby strengthening its ability to take an active role in furthering the proposed new research framework.<sup>6</sup> The appointment of a distinguished transportation professional to a position within the Office of the Secretary could help ensure that the chief scientist had the stature and background needed to communicate effectively with counterparts in other government agencies, with the President's science advisor, with the scientific and professional communities, with academia, and with the private sector. One advantage of a limited-term appointment would be the reduced likelihood of the chief scientist being assigned numerous day-to-day responsibilities that would detract from his or her ability to address big-picture issues. There would, however, be a concomitant disadvantage in that any new chief scientist would have a limited time (two or three years) in which to become familiar with the issues and establish the effective working relationships needed to have an impact on the U.S. DOT's research enterprise. And, as noted earlier, the Office of the Secretary has a very limited budget for research activities.

Many of the research, development, and technology entities within the federal government, including the U.S. Department of Agriculture; the U.S. Air Force, Army, and Navy; the National Aeronautics and Space

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<sup>6</sup> In the context of the chief scientist position, "science" is interpreted broadly to include physical and social sciences, as well as other fields of knowledge relevant to transportation.

Administration; the U.S. Food and Drug Administration; and DOE, have one or more chief scientists. The value of such positions appears to have been confirmed over time, especially since the 1950s, as most have been sustained and more have been added. At the secretarial level within the U.S. DOT, however, the chief scientist position has had a somewhat uneven history because of organizational and political changes.<sup>7</sup> Thus, the Secretary would need to consider the lessons learned from past experience when assessing the pros and cons of reestablishing the chief scientist position.

The chief scientist could, of course, be called on to pursue critical issues across all modes, and not just in the area of surface transportation. The Secretary would need to consider the potential implications for all modes when assessing the merits of establishing the chief scientist position.

**Recommendation 5: The U.S. DOT should engage more fully with the research community, with a view to leveraging investments in technical and policy areas by other federal departments, as well as by states, industry, and academia.**

If the U.S. DOT is to play a major role in furthering the new research framework, it needs to strengthen its own research capacity. Historically, the department's science interests have been modest and narrow in scope compared with those of some other federal departments. Hence the U.S. DOT as a whole lacks the strong research culture developed by departments such as DOE and DOD to support their missions, despite efforts in recent years by individual modal administrations to strengthen their research efforts. For example, a TRB review committee recently observed a "strong institutional commitment to continuous improvement in the management of

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<sup>7</sup> The position of chief scientist at U.S. DOT was first established in 1970, when it was located within the Office of the Assistant Secretary for Research and Systems Development. The position initially had no associated line or day-to-day responsibilities, but later became a career position before eventually being eliminated in the early 1980s. In the late 1990s, the Associate Administrator for Innovation, Research, and Education performed a number of "chief scientist" functions for the Deputy Secretary, including chairing the committee responsible for departmentwide R&D strategic planning, representing U.S. DOT at OSTP, and serving as executive director of the NSTC Transportation R&D committee. However, these chief scientist functions were not pursued after the 2001 change in administration.

the FRA [Federal Railroad Administration] R&D program” (TRB 2012a). Institutional commitment to other U.S. DOT research programs, however, has attracted less favorable comment.<sup>8</sup> Overall, the framework committee was struck by the inconsistencies and unevenness in research management across the U.S. DOT and by the need for a more coherent departmentwide approach that builds on best practices developed by the department’s individual administrations.

The U.S. DOT is essentially a mission-oriented agency with a very small research component, as illustrated by an analysis of FY 2013 data for various federal budget functions (Hourihan 2012). This analysis estimated the ratio of R&D funding to total funding to be an order of magnitude less for transportation than for several other areas, including energy, health, and agriculture.<sup>9</sup> By engaging with other federal departments, the U.S. DOT could leverage these departments’ research investments in a variety of areas, such as human performance and behavior; information and communication systems; advanced materials and structural technologies; sensing and measurement technologies; and social, economic, and institutional policy issues for the benefit of the nation’s surface transportation system (FTAG 2001). Such engagements would not only benefit the U.S. DOT, but would also allow other federal departments to explore transportation-related research opportunities and apply their research results to help solve a wider range of problems.

Other initiatives by the federal research community, such as those that assess the impacts of research investments, should be of potential interest to the U.S. DOT as it seeks to enhance its research capacity. For example, OSTP’s Science of Science Policy Roadmap initiative<sup>10</sup> was an inter-agency collaboration that explored the potential for a more rigorous and

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<sup>8</sup> See, for example, a recent report by TRB’s Long-Term Pavement Performance (LTPP) Committee (TRB 2012b), which expressed concern about the adverse effects of periodic reorganizations, reassignments, and budget revisions regarding the development and delivery of LTPP products.

<sup>9</sup> This analysis is based on provisional budget data, but Hourihan notes that the ratio of R&D spending to general spending changed very little between FY 2003 and FY 2012, and in some cases it is identical to what it was 10 years ago.

<sup>10</sup> The goal of research on the science of science policy is to “provide a scientifically rigorous, quantitative basis from which policy makers and researchers can assess the impacts of the nation’s scientific and engineering enterprise, improve their understanding of its dynamics, and assess the likely outcomes” (NSTC 2008, 1).

quantitative basis for science and technology policy through improved data, tools, and methods (NSTC 2008). Similarly, the Science and Technology for America's Reinvestment: Measuring the Effect of Research on Innovation, Competitiveness, and Science (STAR METRICS) initiative is a multiagency venture led by the National Institutes of Health (NIH), the National Science Foundation (NSF), and OSTP.<sup>11</sup> The aim of STAR METRICS is to help the federal government document the value of its R&D investments by measuring their impacts on employment, knowledge generation, and health outcomes. In 2010, NIH and NSF together committed \$1 million to STAR METRICS for its first year.

The U.S. DOT was a regular participant in meetings of the NSTC's Committee on Technology during the late 1990s, but its engagement in activities of the federal research community appears to have waned. For example, it did not participate in the Science of Science Policy Roadmap initiative, nor is it involved in the STAR METRICS initiative. As a result, the U.S. DOT is missing opportunities to strengthen and broaden its research capabilities by leveraging the expertise and experience of other federal departments and agencies.

In contrast to its limited engagement in activities of the federal research community, the U.S. DOT has strong research partnerships with state DOTs, particularly in highway research. Federal–state initiatives, such as NCHRP and the Transportation Pooled Fund Program, support collaborative research involving FHWA, state DOTs, and others. The committee encourages the U.S. DOT to build on these collaborative efforts and to follow the example of transportation research organizations in other nations by reaching out to a broad spectrum of research partners in the public, private, and academic sectors. As noted in Chapter 4, such engagement with other research organizations helps improve research quality and build overall research capacity.

**Recommendation 6: A broad and robust program of basic and advanced research that encompasses the many disciplines relevant to surface transportation should be established.** To help ensure its longevity, the program needs to be embedded in a culture that values research.

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<sup>11</sup> <http://www.nih.gov/news/health/jun2010/od-01.htm>.

In the committee's judgment, incremental improvements in U.S. surface transportation will not by themselves produce the transformations required to meet the long-term challenges associated with increased global competition, the growth and aging of the U.S. population, demands for energy, and ever-tighter constraints on environmental impacts. Other advisory committees have made similar observations, and suggested more ambitious agendas, over the years. The Federal Transportation Advisory Group, for example, noted that "the solution lies in new technology and concepts" (FTAG 2001). A 2001 report from the Research and Technology Coordinating Committee (RTCC), which advises FHWA on its research activities, gave examples of basic long-term research that would go beyond solving problems incrementally; the report observed that such research "has the potential for high payoffs, even though it tends to be risky and typically requires longer to complete [than applied research]" (TRB 2001). The RTCC went on to highlight the importance of federal investments in research aimed at innovative solutions to problems, noting that state and private-sector research programs are unlikely to undertake this type of research.

Despite widespread recognition of the federal role in supporting basic and advanced research, the U.S. DOT has historically faced difficulties in providing continued support for such research. The first department-wide attempt of this type, the Transportation Advanced Research Program, was launched in 1973 by the Office of the Secretary. The program was designed exclusively for universities, used nationwide competition, and was funded at an initial level of \$3 million per year (\$14.5 million per year in 2010 dollars). After several years of operation, however, changes in U.S. DOT leadership resulted in the program's discontinuation.

Subsequent efforts sought to build on the strength of universities in knowledge creation through basic and advanced research; in particular, the UTC program was established in 1987 with the aim of promoting research, education, and technology transfer. Over the years the UTC program has grown considerably (see Chapter 3), but this growth has not led to an increase in support for basic research, and several expert committees have expressed concern about the program's applied research bias. In 1993, for example, a committee tasked with helping the U.S. DOT review the UTC program noted that "typically, local sponsors are interested

in applied research and not the high-risk, cutting-edge research envisaged by the program's founders" (TRB 1993, 2). More recently, the RTCC analyzed UTC projects on highways included in the Research in Progress database and concluded that 20 percent at most could be categorized as advanced research, with the remaining 80 percent being highly applied. The RTCC expressed concern that this applied research bias "diverts the program . . . from the strength of universities" (TRB 2008a, 76).

In 2005, FHWA's Exploratory Advanced Research (EAR) program (see Chapter 3) was established by the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU), with funding designated for "longer-term, higher-risk, breakthrough research with the potential for dramatic long-term improvements to transportation systems" (FHWA 2011, 1). As an open, competitive program, EAR provides opportunities for investigator-initiated research, a feature often deemed particularly valuable for basic research (e.g., TRB 2008b). In the committee's view, the EAR program promises (provided funding continues to be available) to increase the proportion of quality, potentially breakthrough research in FHWA's portfolio. As required by congressional authorization, however, the program is focused on highway-related research, and thus it does not address basic and advanced research across the broad spectrum of U.S. DOT activities. Nevertheless, it is a valuable model for a departmentwide initiative.

The committee has identified a need for such an initiative: a wide-ranging and sustained program of research, exploring potentially high-payoff opportunities, to enhance U.S. surface transportation in support of societal goals. Such a program of basic and advanced research would fill one of the critical gaps in current U.S. surface transportation research (see Chapter 3). The committee recommends that the program link to and coordinate with research conducted by other federal agencies (including NSF, DOE, and DOD) in areas offering opportunities to revolutionize transportation performance. Many innovations used in transportation were originally developed in other fields (see Chapter 3) and applied successfully to a component or specific element, rather than to the system or the service provided. Basic research focused on transportation systems and services is needed to address complex problems related to interde-

dependencies in the system, interactions between different components, and the impact of institutional policies (public or private) and individual decisions, which may be affected by regulatory restrictions and promotional subsidies.

The committee also recommends that the program be overseen by a panel of distinguished subject experts, along the lines of NSF practices, and that the program be proactive in engaging university researchers. This latter feature would not only take advantage of universities' expertise and experience in basic research, but would also support the education of the next generation of transportation leaders. The committee acknowledges, however, the significant challenges in establishing and sustaining this kind of program, such as finding adequate funding.

Also, in the committee's view, there is no clear institutional home for a comprehensive, multidisciplinary, basic and advanced research program pertaining to surface transportation. The U.S. DOT's failure to sustain basic research programs in the past and its lack of a strong, department-wide research culture raise concerns about the long-term viability of any new basic research program within the department. Nonetheless, three options identified by the committee as worthy of further examination would all place the proposed program within the U.S. DOT.

One option would be to expand FHWA's EAR program to all modes of surface transportation and to greatly increase its funding level. A second option would be to expand and restructure the UTC program to incentivize basic and advanced research. A third option would be to create an Advanced Research Projects Agency–Transportation (ARPA-T) within the U.S. DOT. Such an agency would be somewhat analogous to DOE's Advanced Research Projects Agency–Energy (ARPA-E), which in turn was modeled on DOD's Defense Advanced Research Projects Agency (DARPA). DARPA supports high-risk, long-term research, at universities and elsewhere, which has the potential of producing revolutionary results. The goals of ARPA-E are to promote and fund R&D appropriate to advanced energy technologies. The committee envisions an ARPA-T initiative having a broader perspective than ARPA-E, which has a strong technology focus. Nonetheless, the overall ARPA-E framework may be



worth considering as a way for the U.S. DOT to aggressively pursue advanced transportation research.

In the committee's view, efforts by the U.S. DOT to strengthen its research culture could help sustain the proposed new program of basic and advanced research. For example, the U.S. DOT could explore opportunities to build the research capacity of its professional staff through initiatives such as the Intergovernmental Personnel Act's Mobility Program, which provides for the temporary assignment of federal government personnel to other federal agencies, state and local governments, universities, federally funded R&D centers, and other eligible organizations. Assignments that facilitate interactions between staff at the U.S. DOT and those at research universities or NSF could be particularly helpful in building the U.S. DOT's research capacity and culture. Further in-service education of current and future R&D leaders would be a valuable step.

The committee acknowledges that federal funding of basic and advanced research, given present budgetary constraints, will be difficult. Nevertheless, it sees the future costs of *not* funding basic and advanced research as huge, and this view appears to be substantiated by actions taken elsewhere—notably in Europe, where both the EU and France have set aside funding explicitly for basic research. Thus the European Research Council was established within the EU's Seventh Framework Program with the specific objective of allowing researchers to identify new opportunities and directions in basic research. The French National Research Agency (ANR) funds research projects on a competitive basis, with some of this funding devoted to basic research. In neither case, however, is the research tied in particular to surface transportation, although ANR's sustainable energy area includes programs that address transportation and mobility.

**Recommendation 7: The U.S. DOT should continue its activities that promote knowledge transfer and disseminate research results.**

The U.S. DOT actively supports knowledge transfer and dissemination of research results through a variety of mechanisms, which include

- Requiring research proposals to address implementation;
- Providing resources directly for technology transfer and training;
- Supporting databases to enhance access to knowledge;

- Supporting courses, conferences, workshops, and peer exchanges to facilitate the acquisition of new knowledge;
- Making data available to researchers; and
- Supporting workforce development by training students engaged in research, notably through the UTC program.

For example, the UTC program requires centers to enter their projects into the Research in Progress (RiP) database,<sup>12</sup> which serves as a clearinghouse for UTC projects and also allows other researchers and practitioners to search for related information. In addition, centers are required to include their research products in the Transportation Research International Documentation (TRID) database, which provides access to more than one million records on transportation research worldwide.<sup>13</sup> Many UTCs also require their researchers to develop implementation and dissemination plans.

Other programs target specific audiences or aspects of transportation. Since 1982, the FHWA-supported Local Technical Assistance Program and Tribal Technical Assistance Program have assisted jurisdictions in improving their roads and bridges. A network of centers provides an information clearinghouse, introduces new technology and methods to local and tribal governments, and provides training and personalized technical assistance (Saunders and Shea 2008). In this context, the committee notes that sharing best practices and innovations from abroad, as well as from research supported by the U.S. DOT, could prove helpful for state and local jurisdictions. FHWA's Every Day Counts initiative<sup>14</sup> focuses directly on implementation; it is designed to identify and deploy innovations aimed at reducing the time it takes to deliver highway projects, enhancing safety, and protecting the environment.

National Highway Institute courses, conferences, workshops, and peer exchanges are also important ways of disseminating research results. In many instances, the U.S. DOT partners with other organizations to facilitate knowledge transfer and dissemination. For example, the *Transportation Asset Management Guide* (AASHTO 2011a) was

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<sup>12</sup> <http://rip.trb.org>.

<sup>13</sup> <http://trid.trb.org>.

<sup>14</sup> <http://www.fhwa.dot.gov/everydaycounts/>.

developed under an NCHRP project, with additional funding from FHWA. Once the guide was completed, FHWA funded the development of a National Highway Institute course on asset management.<sup>15</sup> FHWA has also actively supported the National Asset Management Conferences, which include peer exchanges focused on specific asset management topics.

The U.S. DOT plays an important role in making data and models available to researchers. The Long-Term Pavement Performance (LTPP) Program<sup>16</sup> and the Highway Performance Monitoring System<sup>17</sup> are rich sources of data that have proved valuable to researchers. The LTPP database, for example, includes data on over 2,500 pavement sections collected since 1988. To encourage university students, professors, and highway department engineers from around the world to use the LTPP database, a paper-writing contest, cosponsored by the American Society of Civil Engineers, is held each year.

The Highway Performance Monitoring System database includes data on the condition, performance, and use of the nation's highways. Other U.S. DOT databases of potential value to researchers include the National Bridge Inventory,<sup>18</sup> the Freight Analysis Framework,<sup>19</sup> and the National Transit Database.<sup>20</sup>

## **RAISE AWARENESS OF SURFACE TRANSPORTATION RESEARCH**

Transportation's role as a driver of economic growth and a key determinant of quality of life is widely acknowledged both by the United States and its competitors. However, the role of research in improving transportation frequently goes unrecognized in the United States outside of the confines of the transportation research community itself. High-

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<sup>15</sup> [http://www.nhi.fhwa.dot.gov/training/course\\_detail.aspx?num=FHWA-NHI-131106&cat=&key=Transportation+Asset+Management&num=&loc=&sta=%25&tit=&typ=&lev=&ava=&str=&end=&drl](http://www.nhi.fhwa.dot.gov/training/course_detail.aspx?num=FHWA-NHI-131106&cat=&key=Transportation+Asset+Management&num=&loc=&sta=%25&tit=&typ=&lev=&ava=&str=&end=&drl).

<sup>16</sup> <http://www.fhwa.dot.gov/research/tfhrc/programs/infrastructure/pavements/ltppl/>.

<sup>17</sup> <http://www.fhwa.dot.gov/policyinformation/hpms.cfm>.

<sup>18</sup> <http://nationalbridges.com/nbi>.

<sup>19</sup> [http://www.ops.fhwa.dot.gov/freight/freight\\_analysis/faf/faf3/netwkdbflow/](http://www.ops.fhwa.dot.gov/freight/freight_analysis/faf/faf3/netwkdbflow/).

<sup>20</sup> <http://www.ntdprogram.gov/ntdprogram/ntd.htm>.

profile national policy initiatives, such as the ambitious fuel-efficiency standards for cars and light trucks issued in August 2012,<sup>21</sup> have highlighted the importance of transportation research aimed at reducing vehicle fuel consumption and greenhouse gas emissions. In general, however, the value of transportation research, particularly research on infrastructure, is frequently overlooked until some element of the transportation system fails, and alternative technologies and methods are unavailable to solve the problem. For example, the 2011 and 2012 “Carmaggedon” weekend shutdowns of Freeway 405 in Los Angeles for major repairs highlighted the need for ways of replacing or repairing assets more quickly to avoid major disruptions. Such research on rapid construction under SHRP 2 aims to reduce both inconvenience to travelers and the costs of infrastructure repair and replacement.

**Recommendation 8: The U.S. DOT should establish a relationship with OSTP to elevate the visibility of transportation research and its importance on the national science and technology agenda.**

Although Americans often care deeply about many of the benefits that transportation research can provide, they may not see research as a means of achieving these benefits. In Asia and Europe, on the other hand, transportation research is often given greater prominence as a means of achieving societal goals. As noted during the 2008 scan tour, the prevalent belief in every country visited was that “if you aren’t doing transportation R&D, then you won’t be globally competitive” (Elston et al. 2009, 2).

As discussed in Chapter 5, domestic sectors outside of transportation take a variety of approaches to communicating the value of their research to different audiences. In the medical field, NIH is well served by an advocacy community that includes groups that advocate for specific diseases or conditions; groups that advocate for certain populations; outspoken and influential industries; extramural research scientists; health care providers who apply research results; and the American people themselves (Anderson 2011). Other federal agencies, however, “cannot always rely on a similar groundswell of public support to sustain their budget”

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<sup>21</sup> <http://www.nhtsa.gov/About+NHTSA/Press+Releases/2012/Obama+Administration+Finalizes+Historic+54.5+mpg+Fuel+Efficiency+Standards>.

(Eliasson 2009, 26). The DOE's National Renewable Energy Laboratory seeks to influence policy through its scientific achievements; testifying before congressional committees provides an opportunity to tell policy makers what the laboratory has accomplished through research (Christensen 2011). The committee that conducted the most recent decadal survey in astronomy and astrophysics sought to capture the public imagination through the release of photos and simple but compelling language to the media (NRC 2010), thereby helping to make a case for research in astronomy, most of which is usually neither seen nor understood by the public.

The committee concludes that a concerted and sustained effort by the U.S. DOT and OSTP in particular is needed to raise public awareness of the value of surface transportation research in the United States. The U.S. DOT is the primary federal entity for shaping policies and programs to protect the safety, adequacy, and efficiency of the transportation system. Regarding science and technology in general (which includes but is not limited to transportation), OSTP leads federal policy making and provides advice to the President and other White House officials. Consistent with the responsibilities of the U.S. DOT and OSTP, therefore, the committee considers it incumbent on the two organizations to work together to increase the visibility of surface transportation research and its priority on the national agenda. A chief scientist within the Office of the Secretary of Transportation (see Recommendation 4) could play a major role in this activity.

**Recommendation 9:** The many and diverse organizations that make up the surface transportation research community should, both individually and in cooperation with each other, take a proactive approach to sharing the successes of transportation research with a wide range of audiences, including elected officials, other high-level decision makers, and the general public. To this end, the surface transportation research community should

- Continue to build the skills and culture needed to communicate effectively with diverse audiences, following the example set by AASHTO;
- Seek to quantify the impacts of research activities and the associated returns on investment;

- Highlight successes relating to transportation infrastructure, which is often taken for granted by users; and
- Commission a retrospective evaluation of selected transportation research activities over a period of years, with a view to demonstrating their value in the pursuit of national policy goals.

AASHTO's Research Advisory Committee has been actively exploring opportunities among diverse audiences, including transportation executives and other decision makers, to increase their appreciation for the role of research.<sup>22</sup> The committee's annual publication *Research Makes the Difference* highlights outcomes that exemplify the high returns on transportation research investments by state DOTs.<sup>23</sup> AASHTO also has studied different communications processes for sharing information about research with various kinds of recipients (e.g., Zmud et al. 2009).

Although AASHTO's initiatives are of considerable value, they do not provide a comprehensive perspective on how surface transportation research in general, including multimodal and crossmodal efforts, has benefited the nation over periods of 10 years or more. For example, the committee is not aware of any assessments of surface transportation research analogous to the report *Energy Research at DOE: Was It Worth It?*, which was prepared in response to a request from the U.S. House Appropriations Subcommittee on the Interior (NRC 2001). This report took a comprehensive look at the outcomes of DOE's research in energy efficiency and fossil energy over two decades, and it found that significant economic-, environmental-, and national security-related benefits had resulted.

In the committee's judgment, a similar (and collaborative) effort by members of the surface transportation research community could help draw attention to the role its research has played over time in furthering the nation's economic and societal goals. This effort would supplement ongoing communications initiatives by individual organizations, and it would take advantage of lessons learned about how to communicate effectively with different audiences.

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<sup>22</sup> See, for example, AASHTO (2011b).

<sup>23</sup> <http://research.transportation.org/Pages/ResearchMakestheDifference.aspx>.

The need to quantify research impacts and associated returns on investment merits special attention in the context of the communications initiative articulated in Recommendation 9. As discussed in Chapter 4, transportation research organizations in other countries emphasize research evaluation as an essential part of their research frameworks, and they regard quantitative metrics as particularly valuable in assessing research outcomes. In the United States, efforts to measure the impacts of research activities and associated returns on investment have been limited in scope, as noted in Chapter 3. Given the value of quantitative metrics in informing decisions about future research investments, a greater focus on quantitative assessments of research activities offers the potential to make the new research framework a more useful and robust tool.

## CONCLUDING OBSERVATIONS

Much is at stake as the United States seeks to ensure that its surface transportation systems meet the challenges of the 21st century. Changing trade patterns, a growing and aging population, and the need to reduce greenhouse gas emissions are among the factors placing new demands on surface transportation. Research has a critical role to play in exploring creative options and developing cost-effective solutions that support the nation's economic growth, position it to be globally competitive, and enhance its inhabitants' quality of life.

One of the challenges facing policy makers is deciding how best to invest the limited research resources of the present so that transportation continues to meet the nation's needs in years to come. Toward that end, a new research framework would offer opportunities to leverage the research conducted by individual organizations and add value to the overall national research endeavor. By encouraging transportation research organizations and the broader research community to work together in support of societal goals, the framework has the potential to make surface transportation research more productive, to address problems that have been neglected because of the current fragmented approach, and to explore crosscutting systems-level solutions to a variety of problems.

Building and fully implementing a new and cohesive research framework to replace the current fragmented and ad hoc approach is likely

to take years. In the meantime, much can be done to make U.S. surface transportation research more productive. As the U.S. DOT takes steps to build its research capacity and culture, a variety of public, private, academic, and nonprofit organizations should be cooperatively engaged in starting to create that new framework.

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### *Abbreviations*

AASHTO	American Association of State Highway and Transportation Officials
FTAG	Federal Transportation Advisory Group
FHWA	Federal Highway Administration
NRC	National Research Council
NSTC	National Science and Technology Council
RITA	Research and Innovative Technology Administration
TRB	Transportation Research Board
TTI	Texas A&M Transportation Institute

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## APPENDIX A

# Committee Meetings and Other Activities

### **FIRST COMMITTEE MEETING**

**November 30–December 1, 2010, Washington, D.C.**

Invited speakers and individual committee members made the following presentations to the committee:

**Lessons/Highlights from 2008 International Scan on Transportation Research Program Administration**

David Huft, *Committee Member*

**The Research and Innovative Technology Administration's (RITA's) Efforts to Develop a Comprehensive R&D Strategic Plan for the U.S. Department of Transportation**

Jan Brecht-Clark, *Associate Administrator of RD&T, RITA*

**The Federal Highway Administration's (FHWA's) Efforts to Develop a Highway R&D Strategic Plan**

Debra Elston, *Director of the Office of Corporate Research, Technology, and Innovation Management, FHWA*

### **ACTIVITIES IN CONJUNCTION WITH THE 90th ANNUAL MEETING OF THE TRANSPORTATION RESEARCH BOARD**

**January 23–27, 2011, Washington, D.C.**

Small groups of committee members met with some of the hosts from the 2008 scanning tour of Europe and Asia, which surveyed transportation

research program administration.<sup>1</sup> The purpose of these informal meetings was to discuss changes that have occurred in the two to three years since the scanning tour and to make the tour hosts aware of the study committee's work.

Meetings were held with the following individuals and groups:

- Steve Phillips, Secretary General of the Forum of European National Highway Research Laboratories, Brussels, Belgium;
- Jaehak Oh, Director of the Global Research Office for Green Growth and Convergence, Korea Transport Institute, Goyang-Si, South Korea;
- Fred Wegman, Managing Director of the Institute for Road Safety Research (SWOV), Duindoorn, Netherlands; and
- Joris Al (General Director) and Max Klok (Senior Advisor) of the Rijkswaterstaat Center for Transport and Navigation, Delft, Netherlands; and Jan van der Waard, Program Manager of the Netherlands Institute for Transport Policy Analysis, The Hague, Netherlands.

## **SECOND COMMITTEE MEETING**

**March 31–April 1, 2011, Washington, D.C.**

Committee planning for workshops and other information-gathering activities were conducted.

## **THIRD COMMITTEE MEETING AND FIRST WORKSHOP**

**July 19–20, 2011, Washington, D.C.**

The committee hosted its first workshop to explore strategic research frameworks used in the transportation sector internationally and in nontransportation sectors in the United States. During the course of this workshop, invited speakers made the following presentations to the committee:

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<sup>1</sup> Elston, D., D. Huft, B. T. Harder, J. Curtis, M. R. Evans, C. W. Jenks, L. McGinnis, H. R. Paul, G. Roberts, E. Wingfield, and J. B. Wlaschin. 2009. *Transportation Research Program Administration in Europe and Asia*. Report FHWA-PL-09-015. <http://www.international.fhwa.dot.gov/pubs/pl09015/pl09015.pdf>.

**A Perspective from the Netherlands**

Fred Wegman, *Managing Director of the SWOV Institute for Road Safety Research, Duindoorn, Netherlands*

**A Perspective from the European Commission**

Ludger Rogge, *Research Program Officer of the Directorate-General for Research, European Commission, Brussels, Belgium*

**A Perspective from the United Kingdom**

Anson Jack, *Director of Policy, Research, and Risk and Deputy Chief Executive Officer of the Rail Safety and Standards Board, London, United Kingdom*

**A Perspective from France**

Bernard Jacob, *Deputy Scientific Director for Transport, Infrastructure, and Safety, Institute of Science and Technology for Transport, Development, and Networks (IFSTTAR), Paris, France*

**A Perspective from the White House Office of Science and Technology Policy**

Kei Koizumi, *Assistant Director of the White House Office of Science and Technology Policy, Washington, D.C.*

**A Perspective from the Agricultural Research Service**

Judy St. John, *Associate Administrator for National Programs, Agricultural Research Service, U.S. Department of Agriculture, Beltsville, Maryland*

**A Perspective from the National Institutes of Health**

James Anderson, *Deputy Director of the National Institutes of Health (NIH) and Director of the NIH Division of Program Coordination, Planning, and Strategic Initiatives, Bethesda, Maryland*

**The Decadal Science Strategy Survey Process**

Martha Haynes, *Goldwin Smith Professor of Astronomy, Cornell University, Ithaca, New York*

Following the presentations, workshop participants divided into breakout groups for informal discussions on four themes of particular interest to the committee:

- Agenda setting and processes,
- Models for collaboration,

- Performance assessment, and
- Funding long-term research.

Brief discussion papers on these themes (see Appendix B) were circulated to participants in advance of the workshop.

## **FOURTH COMMITTEE MEETING AND SECOND WORKSHOP**

**October 24–25, 2011, Washington, D.C.**

The committee hosted its second workshop to explore strategic research frameworks used in the transportation sector internationally and in non-transportation sectors in the United States. During the course of this workshop, invited speakers made the following presentations to the committee:

### **A Japanese Perspective**

Shigeru Morichi, *Director of the Policy Research Center, National Graduate Institute for Policy Studies, Tokyo, Japan*

### **A Korean Perspective**

Jaehak Oh, *Senior Research Fellow and Director of the Global Research Office for Green Growth and Convergence, Korea Transport Institute, Goyang-Si, South Korea*

### **A Perspective from the U.S. Department of Energy**

Dana Christensen, *Deputy Laboratory Director for Science and Technology at the U.S. Department of Energy's National Renewable Energy Laboratory, Golden, Colorado*

### **A Perspective from FIATECH, a Not-for-Profit Industry Consortium**

Ric Jackson, *Founding Director of FIATECH, Potomac, Maryland*

### **A Perspective Motivated by National Science Foundation Research Opportunities**

Priscilla Nelson, *Professor, Department of Civil and Environmental Engineering, New Jersey Institute of Technology, Newark*

Following the presentations, workshop participants divided into break-out groups for informal discussions of the same four themes discussed at the third committee meeting and first workshop. As before, the discussion

papers on these themes (see Appendix B) were circulated to participants in advance of the workshop.

## **TELECONFERENCE WITH RIJKSWATERSTAAT, THE NETHERLANDS**

**December 1, 2011**

Committee Chair Sue McNeil and Study Director Jill Wilson held a teleconference with Roger Demkes, Head of Knowledge Management at the Rijkswaterstaat Center for Transport and Navigation (Delft, Netherlands), to discuss his organization's strategic research framework(s).

## **ACTIVITIES IN CONJUNCTION WITH THE 91st ANNUAL MEETING OF THE TRANSPORTATION RESEARCH BOARD January 22–26, 2012, Washington, D.C.**

Committee members hosted a two-part session on national research frameworks, with the objectives of learning more about transportation research frameworks in other countries (Part 1) and engaging meeting participants in discussions on how the current U.S. research framework for surface transportation needs to be improved (Part 2).

Agendas for the session were as follows:

### **Part 1: International Perspectives on Research Agenda Setting (Presentations)**

Presiding Officer: T. John Kim, *University of Illinois, Urbana–Champaign*

**EU Transportation Research: Priority Setting and Funding Schemes**  
Alessandro Damiani, *European Directorate–General for Research and Innovation, Brussels, Belgium*

**Promoting International Transport–Research Cooperation: EU Activities and Future Work of the EUTRAIN Project**  
George Giannopoulos, *Hellenic Institute of Transport, Thessaloniki, Greece*

**Transportation Research Agenda Setting Process in South Korea**  
Jaehak Oh, *Korea Transport Institute, Goyang-Si, South Korea*

**Part 2: Town Hall Meeting (Discussions)**

Presiding Officer: Laurie McGinnis, *University of Minnesota, Minneapolis*

**Key Observations from National Research Frameworks Study**

David Huft, *South Dakota Department of Transportation, Pierre*

Genevieve Giuliano, *University of Southern California, Los Angeles*

Robert Gallamore, *Rehoboth Beach, Delaware*

**Stakeholder Reactions to Key Observations**

Harold Paul, *Louisiana Department of Transportation and Development, Baton Rouge*

Shashi Nambisan, *Iowa State University, Ames*

Lawrence Orcutt, *California Department of Transportation, Sacramento*

**Open Discussion****FIFTH COMMITTEE MEETING**

**February 23–24, 2012, Washington, D.C.**

Closed meeting for committee deliberations.

**SIXTH COMMITTEE MEETING**

**June 18–19, 2012, Chicago, Illinois**

Committee conversation with Mort Downey, former Deputy Secretary of the U.S. Department of Transportation. Closed sessions for committee deliberations.

**SEVENTH COMMITTEE MEETING**

**September 27–28, 2012, Irvine, California**

Closed meeting for committee deliberations.

**EIGHTH COMMITTEE MEETING**

**November 29–30, 2012, Washington, D.C.**

Closed meeting for committee deliberations.



## APPENDIX B

## Workshop Discussion Papers

In preparation for its workshops, the committee developed brief discussion papers on four themes that it deemed of particular importance for strengthening the U.S. surface transportation research enterprise. These themes were

- Agenda setting and processes,
- Models for collaboration,
- Performance assessment, and
- Funding long-term research.

The committee formulated questions relating to each theme and included them in the papers to provide guidance to workshop guests and help stimulate informative discussions.

### **THEME 1: AGENDA SETTING AND PROCESSES**

#### **Context**

Many organizations in the United States fund research, development, and deployment (RD&D) programs aimed at improving the economy and the quality of life through, for example, the implementation of new technologies or the adoption of environmental or safety standards. The purposes of such programs are to generate new knowledge and to explore ways in which this knowledge can be effectively applied. In practice, however, the potential benefits of RD&D programs may not be fully recognized, or may be unduly delayed, because no integrated and cohesive framework exists for addressing the nation's overall economic development and quality of life. The lack of a strategic research framework is particularly apparent in the area of transportation.

Other countries, by contrast, have been successful in building transportation research frameworks that are closely tied to national policy goals. A team of U.S. transportation experts who toured Europe and Asia in April 2008 observed that, in the countries visited, transportation RD&D is directly related to national economic growth and competitiveness, among other goals.<sup>1</sup>

## Questions

- What processes do you use to set the national RD&D agenda and establish multiyear RD&D program plans? Are these processes top down or bottom up? Are there any unintended consequences, such as an overemphasis on short-term objectives?
- What place does transportation RD&D have in economic and environmental planning and evaluation at the different levels of government: supranational (e.g., European Union), national, regional, and local? Are steps taken to document linkages between transportation RD&D and economic development and quality of life?
- What processes do you use to resolve (or accommodate) differences in priorities among the levels of government and among organizations with potentially competing interests (e.g., entities representing different modes of transportation)?

## THEME 2: MODELS FOR COLLABORATION

### Context

The innovation process can be difficult and unpredictable, especially when diverse stakeholders are involved. But collaboration can be a mechanism for bringing together and engaging all the relevant parties (public, private, and academic) in the innovation process.

Models for collaboration recognize that innovation is sometimes driven by government regulation. For example, the introduction of more

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<sup>1</sup> Elston, D., D. Huft, B. T. Harder, J. Curtis, M. R. Evans, C. W. Jenks, L. McGinnis, H. R. Paul, G. Roberts, E. Wingfield, and J. B. Wlaschin. 2009. *Transportation Research Program Administration in Europe and Asia*. FHWA Report PL-09-015. <http://www.international.fhwa.dot.gov/pubs/pl09015/pl09015.pdf>.

stringent standards governing tailpipe emissions drives the adoption of low-emissions vehicles. In other cases, inventions or technological improvements move into practical application through a process of voluntary adoption, often in conjunction with capital investments aimed at expanding capacity or replacing obsolete methods. Examples include the widespread adoption of premium steel and aggressive track-maintenance protocols, which have reduced derailments and doubled the service life of rails; and, in the case of highways, the adoption of protocols for longer-lasting pavements.

The transportation sector is becoming more reliant on public–private–academic partnerships and on leveraging RD&D conducted in all three sectors to their mutual benefit. However, collaborative models for bringing these parties together often fall short of realizing the full potential of new knowledge.

## Questions

- How does your program establish and use partnerships involving government agencies, industry, and academia for transforming research-derived knowledge into application? What models of collaboration are most beneficial for “voluntary adoption” of innovations, and why?
- Does your program use the regulatory model to advance innovation, and if so, how? What benefits and drawbacks do you see with this model?
- What types of organizational structures and funding models are used to enhance application of research results or to stimulate innovation and deployment activities?
- What are the barriers to forming collaborative partnerships? What techniques are used to overcome these barriers?
- How are proprietary issues and intellectual property rights addressed among partners?

## THEME 3: PERFORMANCE ASSESSMENT

### Context

Across the member nations of the Organization for Economic Cooperation and Development, from North and South America to Europe and

the Asia–Pacific region, there has been a general trend toward evidence-based decision making, accompanied by increasingly formalized requirements for strategic planning and quantitative evidence of performance. Nations differ, however, in how they implement these requirements, so the transferability of “good practices” across borders remains an open question. Similarly, little evidence is publicly available on the requirements’ impacts—whether positive, negative, or neutral. Nevertheless, methods and measures are available that can help in prioritizing RD&D activities and assessing their impacts; these tools include, but are not limited to, rate of return on investment, benefit–cost analysis, bibliometrics (e.g., citation analysis, content analysis), and rates of start-up of new businesses.

## Questions

- What methods and measures do you use in setting RD&D priorities? What time frames are involved? Which methods and measures are required by which funding or oversight entities?
- What methods and measures do you use to assess the impacts of RD&D? Which methods and measures are required by which funding or oversight entities? Are the same measures used at supranational (e.g., European Union), national, regional, and local levels of government?
- Do the methods and measures used to set priorities and assess impacts for transportation RD&D differ from the methods and measures used for RD&D in other sectors?
- To what extent does performance assessment of prior investments influence your decisions on future research investments?

## THEME 4: FUNDING LONG-TERM RESEARCH

### Context

In the United States, efforts to develop and sustain long-term research initiatives have often run into difficulties because of politically mandated research agendas that are relatively short term. Research for which a pay-off is years, or even decades, away is less likely to receive funding than research offering more immediate benefits. However, long-term research

in its various forms is an essential component of the innovation process. In the case of transportation, such research enables the possible application of results emerging from the basic sciences, such as nanotechnology for use in preventing metal fatigue in rails or bridges, or molecular chemistry to create self-healing asphalt pavement. Long-term research also creates tools for analyzing and predicting the performance of systems not yet in existence, such as new paradigms for public transportation. Long-term research also investigates policy alternatives related to a future that is complex, diffuse, and uncertain. For example, such research might consider the impacts of climate change on transportation systems or the implications of changing demographics for future travel behavior and demand, thereby providing guidance about whether to invest in costly and long-lived transportation infrastructure.

## Questions

- Does your research portfolio include funding for long-term initiatives as well as for short-term applied research?
- If so, what is the approximate funding split between the two categories of research (long term versus short term), and how has this split varied over time?
- Does your funding for the two types of research come from the same source(s)? In other words, is there competition for funding between long-term and short-term research?
- If so, do you take any measures to ensure that funding for long-term research is not eroded by the prospect of more immediate payoffs from short-term research? Please describe any such measures and comment on their effectiveness.
- How do you justify long-term research in your requests for funding?

## Study Committee Biographical Information

**Sue McNeil**, *Chair*, is Professor of Civil and Environmental Engineering and of Public Policy and Administration at the University of Delaware (UD). She is also Director of UD's University Transportation Center and former Director of its Disaster Research Center. Dr. McNeil was formerly a Professor in the College of Urban Planning and Public Affairs, a Professor of Civil and Materials Engineering, and Director of the Urban Transportation Center at the University of Illinois at Chicago (UIC). Before joining UIC, she was a Professor of Civil and Environmental Engineering and of Engineering and Public Policy at Carnegie Mellon University. Her research and teaching interests include transportation infrastructure management (with emphasis on the application of advanced technologies), economic analysis, analytical methods, and computer applications. Dr. McNeil is a former member of the TRB Executive Committee and the National Research Council (NRC) Board on Infrastructure and the Constructed Environment. She served on the NRC committees on Review of the National Transportation Science and Technology Strategy and on Study of the Regulation of Weights, Lengths, and Widths of Commercial Motor Vehicles, and she chaired the TRB Committee on Transportation Asset Management from 2004 to 2010. She is a founding Associate Editor of the American Society of Civil Engineers' *Journal of Infrastructure Systems*, and currently serves as its Editor-in-Chief. Dr. McNeil earned bachelor's degrees in mathematics and civil engineering from the University of Newcastle, Australia, and an MS and PhD in civil engineering from Carnegie Mellon University.

**William L. Ball** retired from General Motors (GM) in 2009 after 25 years with the company. At the time of his retirement, he was Vice President,

Public Policy, of OnStar LLC, GM's in-vehicle wireless communication service, which includes automatic crash notification and remotely initiated slowdown of stolen vehicles. His responsibilities included leading all aspects of OnStar's public policy at the state and federal levels. Mr. Ball was previously Director, Strategic Planning and Program Management, of the GM Advanced Technology Vehicles Group, working with the group's executive director to create strategic options for investment in advanced alternative-propulsion vehicles. In this position, he assisted in leading the successful negotiation and implementation of the GM–Toyota Collaboration for Advanced Technology Partnership; he also cochaired the Electric Vehicle Association of the Americas, delivering congressional testimony on the trade association's behalf. Mr. Ball has served on two expert panels convened by the U.S. Centers for Disease Control and Prevention, and on the Board of Directors of the COMCARE Emergency Response Alliance. His awards include the Friends of EMS [emergency medical services] Award from the National Association of EMS Physicians in 2010, and Chairman's Honors from GM in 1997 and 2005. Mr. Ball earned a BChemE degree from the University of Minnesota, an MBA from Stanford University, and a JD from the University of Minnesota.

**Irwin Feller** is an Emeritus Professor of Economics at Pennsylvania State University, where he served on the faculty for 39 years, including 24 years as Director of the Institute for Policy Research and Evaluation. Currently he is a Senior Visiting Scientist at the American Association for the Advancement of Science, where his research interests include the economics of science and technology, the evaluation of federal and state technology programs, the university's role in technology-based economic development, and the adoption and impacts of performance measurement systems. Dr. Feller has served on various National Research Council committees, including the Research and Technology Coordinating Committee and the Committee on the Review of the U.S. DOT Strategic Plan for Research, Development, and Technology. He also chaired the Committee on Assessing Behavioral and Social Science Research on Aging and coedited its final report, *A Strategy for Assessing Science: Behavioral and Social Research on Aging* (2007). He is a National Associate of the National Academies. Dr. Feller earned a BBA degree in economics from

the City University of New York and a PhD from the University of Minnesota, also in economics.

**Robert E. Gallamore** is a railroad expert known nationally for his contributions to economic, operational, managerial, and policy studies of the industry. He retired in 2006 from his positions as Director of the Transportation Center and Professor of Managerial Economics and Decision Sciences in the Kellogg School of Management at Northwestern University. Before joining the university in 2001, Dr. Gallamore was on executive loan from Union Pacific Railroad to the Transportation Technology Center, Inc., in Pueblo, Colorado, where he was Assistant Vice President for 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; as Deputy Federal Railroad Administrator in the Carter administration, he led the executive branch's development of recommendations for railroad deregulation and revitalization. Dr. Gallamore chairs the National Research Council (NRC) Committee for Review of the Federal Railroad Administration Research, Development, and Demonstration Programs. He also chaired the Committee for the Study of the Feasibility of a Hazardous Materials Transportation Cooperative Research Program and the Committee on Freight Transportation Information Systems Security. He has been a member of a number of other NRC committees, and is a National Associate of the National Academies. He is currently coauthoring a book on the economic history of and public policy toward the American railroad industry during the 20th century. Dr. Gallamore earned an AB degree from Wesleyan University, and an MA in public administration and a PhD in political economy and government from Harvard University.

**Genevieve Giuliano** is a Professor, Senior Associate Dean for Research and Technology, and Margaret and John Ferraro Chair in Effective Local Government at the University of Southern California's Sol Price School of Public Policy. She is also Director of the METTRANS Transportation Center, a joint partnership of the University of Southern California and California State University, Long Beach. Her research interests include land use and transportation, transportation policy analysis, and information technology applications in transportation. Dr. Giuliano is a



former chair of the TRB Executive Committee. She has served on various National Research Council committees and chaired the Committee for the Study of Funding Options for Freight Transportation Projects of National Significance. She was named a National Associate of the National Academies in 2003; received the 2005 TRB W. N. Carey, Jr., Award for Distinguished Service; was awarded the Deen Lectureship in 2007; and received the Transportation Research Forum's Outstanding Transportation Researcher Award in 2012. She serves on the editorial boards of *Research in Transportation Business and Management* and the *Journal of Transport Policy*. Dr. Giuliano earned a BA degree in history from the University of California, Berkeley, and a PhD in social science from the University of California, Irvine.

**David L. Huft** is a Research Program Manager and Intelligent-Transportation Systems Coordinator in the South Dakota Department of Transportation's Office of Research, which addresses a broad range of research topics in transportation design, construction, operations, maintenance, planning, administration, and market research. Active in national research activities, Mr. Huft is a past Chair of the Research Advisory Committee of the American Association of State Highway and Transportation Officials (AASHTO); he cochaired the 2008 scanning study of Europe and Asia, sponsored by the Federal Highway Administration, AASHTO, and the National Cooperative Highway Research Program (NCHRP), which reviewed transportation research program administration practices; and he is a former member of the AASHTO Standing Committee on Research. Mr. Huft served on the National Research Council Committee for Research on Improved Concrete Pavement for Federal Aid Highways, chaired the TRB Committee on Highway Traffic Monitoring, and was a member of the TRB Steering Committee for the Conference on Remote Sensing and Spatial Information Technologies for Transportation. Currently, he chairs the NCHRP Project Panel on Long-Range Strategic Issues Affecting Preservation, Maintenance, and Renewal of Highway Infrastructure. Mr. Huft is a recipient of the 2009 TRB W. N. Carey, Jr., Award for Distinguished Service and of two AASHTO awards: the President's Award for Research and the Alfred E. Johnson Award for Outstanding Achievement. He is also a member of South Dakota's Transportation Hall of Honor. He earned a BS degree in physics from Michigan State University.

**Dennis C. Judycki** retired from the Federal Highway Administration (FHWA) in 2008. During his career with FHWA, he served in a number of senior executive positions, including Associate Administrator for Safety and System Applications. At the time of his retirement, he was Associate Administrator for Research, Development, and Technology, and Director of the Turner–Fairbank Highway Research Center in McLean, Virginia. In these positions he was responsible for leadership in developing and coordinating national research and technology partnerships; in facilitating corporate coordination for the delivery of technology and innovation; and in directing the formulation, conduct, and evaluation of research and development. Mr. Judycki served as the U.S. Department of Transportation's delegate to the Board of Directors of the ITS World Congress and was the U.S. delegate to the Organization for Economic Cooperation and Development–European Council of Ministers of Transport's Joint Transport Research Committee. He also served as liaison representative to the National Research Council Research and Technology Coordinating Committee. Mr. Judycki's awards include the Presidential Distinguished Senior Executive Rank Award in 1998 and TRB's Roy W. Crum Distinguished Service Award in 2008. Following his retirement from FHWA, he became president and general manager of the Red River Ski Area in New Mexico. Mr. Judycki earned a BS degree in civil engineering from New England College, New Hampshire, and an MSCE, with a specialty in urban transportation planning and traffic operations, from West Virginia University.

**Tschangho John Kim** is Endowed Professor Emeritus of Urban and Regional Systems at the University of Illinois at Urbana–Champaign (UIUC) and a Senior Research Fellow at the Engineering Research Institute of Seoul National University, South Korea. Dr. Kim has also worked in Austria, Germany, Indonesia, Kenya, the People's Republic of China, Saudi Arabia, and Sweden. From 1979 to 1980, he served as Project Director of the National Comprehensive Transportation Study of Korea, sponsored by the World Bank, and from 1990 to 1991 he directed the Optimal Transport Sector Development Project in Indonesia. He was Associate Director for International Programs and Studies and was Director of the Office of Overseas University Collaboration at UIUC from 1984 to 1991; he was also special advisor on international affairs to the Governor

of Illinois from 1985 to 1987. More recently, Dr. Kim led a number of technical committees for geographic information systems and intelligent transportation systems of the International Organization for Standardization, and he served as president of the Western Regional Science Association and as a member of the Boards of Directors of the Korea–USA Science Cooperation Center and the Fulbright Academy of Science and Technology. He is currently a Planning Advisor to the Arriyadh Development Authority of Riyadh, Saudi Arabia. Dr. Kim is a member of the editorial boards of 11 international journals and of the review board of the European Research Council. His publications include eight books, 33 book chapters, and more than a hundred journal or professional articles. He earned a BS degree in engineering from Hanyang University in Seoul, South Korea; an MCP from the Pratt Institute in Brooklyn, New York; and a PhD in urban planning from Princeton University.

**Laurie G. McGinnis** is Director of the University of Minnesota's Center for Transportation Studies (CTS). Her previous positions at CTS include Research Coordinator, Director of Research and Contract Management, Associate Director, and Acting Director. In these roles, Ms. McGinnis has been a key player in the development and growth of CTS over the last 20 years; her activities have included identifying program opportunities, securing funding, directing programs, guiding program delivery, overseeing center operations, and establishing future directions in transportation research, education, and outreach. Before coming to the University of Minnesota, she was a Project Manager at HNTB (an architectural and engineering firm), where she participated in the design of several bridges for state and local agencies. Ms. McGinnis serves as Chair of TRB's Research and Education Section, and she chaired the TRB Committee on Conduct of Research from 2003 to 2009. She participated in the 2008 scanning study of Europe and Asia, sponsored by the Federal Highway Administration, the American Association of State Highway and Transportation Officials, and the National Cooperative Highway Research Program, which reviewed transportation research program administration practices. Ms. McGinnis earned a BS degree in civil and environmental engineering from the University of Wisconsin and master's degrees in public affairs and business administration from the University of Minnesota.

**Herbert H. Richardson** is Director Emeritus of the Texas Transportation Institute (TTI), the largest university-affiliated transportation research entity in the United States. A member of the Texas A&M University System, TTI works with nearly 200 sponsors from all levels of government and from the private sector to address challenges facing virtually all modes of transportation. TTI is also the largest participant in the Texas Department of Transportation's research program. Dr. Richardson served as Director of TTI from 1993 to 2006, during which time he also was Associate Vice Chancellor for Engineering of the Texas A&M University System and Professor Emeritus of Mechanical Engineering at the Massachusetts Institute of Technology (MIT). He has been a consultant to a wide range of organizations, including Caterpillar Tractor Co., Foster-Miller Inc., the International Union of Teamsters, Skychefs Inc., and the U.S. Department of Transportation. Dr. Richardson, whose professional interests include dynamics, control systems, systems engineering, and fluid mechanics, was elected to the National Academy of Engineering (NAE) in 1980 in recognition of his leadership in transportation research and his contributions to systems-dynamics education in mechanical engineering. A former Chair of the TRB Executive Committee, he has also participated in numerous NAE and National Research Council (NRC) activities; he served on the Executive Committee of the NAE Council, on the Governing Board of the NRC, and on a wide variety of NRC study committees. He is a National Associate of the National Academies and received the 2006 TRB Roy W. Crum Award for Distinguished Service. Dr. Richardson earned BS, MS, and ScD degrees in mechanical engineering from MIT.

**Peter F. Sweatman** is Director of the University of Michigan Transportation Research Institute (UMTRI). His areas of expertise include accident investigation and analysis, freight efficiency and productivity, intelligent transportation systems (ITS), performance-based standards, vehicle-infrastructure interaction, and research leadership. He is currently helping to develop new research fields for assisting the transition from today's automotive industry to the transportation industries of the future. In 2013, the University of Michigan launched the Michigan Mobility Transformation Center under Dr. Sweatman's leadership. Before joining UMTRI in 2004, Dr. Sweatman held various positions in

transportation research and development in Australia. He was founder and Managing Director of Roaduser Systems Pty., Ltd.; Chief Scientist at the Australian Road Research Board; and Senior Fellow at the University of Melbourne. Dr. Sweatman served on the Committee on the Review of the U.S. DOT [U.S. Department of Transportation] Strategic Plan for R&D and on the Committee for a Study of Supply and Demand for Highway Safety Professionals in the Public Sector. He served as a member of U.S. DOT's ITS Advisory Committee and as Chair of the ITS America Board of Directors during 2012 and 2013. He was elected in 1997 to the Australian Academy of Technological Sciences and Engineering, and in 2002 he was awarded the Centenary Medal by the Prime Minister of Australia for service to Australian society in transportation engineering. Dr. Sweatman was named Australian Freight-Industry Personality of the Year in 2004. He earned BE and PhD degrees in mechanical engineering from the University of Melbourne.

**Nigel H. M. Wilson** is a Professor of Civil and Environmental Engineering at the Massachusetts Institute of Technology (MIT), a position he has held since 1982. His research and teaching concentrate on urban public transportation, including topics related to the operation, analysis, planning, and management of transit systems. Dr. Wilson directs major long-term research and education programs involving collaborations between MIT and three transport agencies: Transport for London, Diputación Foral de Gipuzkoa in Spain, and the Massachusetts Department of Transportation. From 1994 to 2003 he was the lead faculty member on a collaboration between MIT, the University of Puerto Rico, and the Puerto Rico Highway and Transportation Authority that focused on Tren Urbano, the new urban rail system in San Juan. During sabbatical leaves from MIT he has worked directly in three large transit agencies (the Massachusetts Bay Transportation Authority, London Transport, and Metro Transit in Minnesota), and he has served as a consultant to a number of other North American transit authorities. Dr. Wilson is a former member of the National Research Council's Transit Research Analysis Committee and also served on the Committee for a Study of Contracting Out Transit Services and the Committee for a Strategic Transportation Research Study, Transit. He chaired the TRB Committee on Transit Management and Performance for six years and has

served on various Transit Cooperative Research Program panels. He has been a member of the editorial advisory boards of *Transportation Research Part B: Methodological* and the *UITP Revue*, a journal of the International Association of Public Transport. Dr. Wilson earned a BS degree in civil engineering from Imperial College, University of London; an SM in civil engineering from MIT; and a PhD in transportation systems from MIT.