SPECIAL REPORT 295

The Federal Investment in Highway Research 2006–2009

Strengths and Weaknesses

TRANSPORTATION RESEARCH BOARD
OF THE NATIONAL ACADEMIES

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Research and Technology Coordinating Committee

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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.

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[1] During the first 5½ years of his term, Conrad was with the Washington State Department of Transportation. After retiring from that organization in 2008, he joined CH2M Hill.

Preface

Since 1992, the Research and Technology Coordinating Committee (RTCC) has served as an independent advisor on national and federal highway research. Its work over the past 15 years has been supported by the Federal Highway Administration (FHWA). During the years in which it has advised FHWA and other highway research sponsors, the committee has issued a number of reports addressing highway research topics, funding, and research management. It has also issued two previous reports addressing highway research at the national and federal levels.

In *Special Report 244: Highway Research: Current Programs and Future Directions* (1994), RTCC described and analyzed for the first time the wide range of highway research activities funded through government and industry and made recommendations regarding funding levels for research and development and priority areas for future investment. In 2001, RTCC issued *Special Report 261: The Federal Role in Highway Research and Technology*. In that report, the committee assessed the strengths and weaknesses of the federal program and made recommendations with respect to funding levels and priorities. In particular, the committee stressed the need for improved stakeholder involvement in the FHWA program and urged that research funding be allocated through merit review of competitively solicited proposals. In both of these reports, RTCC emphasized the importance of allocating a greater share of the federal investment in highway research to longer-term, higher-risk research and made recommendations regarding priority areas for future highway research investment.

In 2007 RTCC's statement of task was renegotiated with FHWA and was approved by the Governing Board of the National Research Council. It states:

> This project will provide an ongoing review of the FHWA research program. It will also analyze the federal investment in highway research made in the 2005 reauthorization of surface transportation programs and make recommendations to enhance the value of that investment. The criteria to be used for the committee's analysis will be those articulated by Congress in the eight basic principles for research and technology innovation in Section 5201 of the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU).

This report continues RTCC's tradition of periodically assessing the state of highway research and making recommendations to policy makers. In this report, and consistent with its statement of task, the committee evaluates the investments made in highway research through SAFETEA-LU.

The committee conducted its work over a 3-year period, during which it invited and received briefings from research program managers in FHWA and the Research and Innovative Technology Administration (RITA), as well as from a broad range of stakeholders in highway research. Appendix A lists the many people who made presentations on and discussed various highway research programs. This report reflects the committee's analysis of the information gathered and its collective, consensus judgment.

ACKNOWLEDGMENTS

This project would not have been possible without the cooperation and assistance of many individuals. The committee extends its appreciation and thanks to all the presenters and discussants listed in Appendix A who provided essential information about specific research programs and activities. In particular, the committee thanks staff at FHWA and RITA who facilitated the production of this report. The encouragement and support of Dennis Judycki, Associate Administrator for Research, Development, and Technology at FHWA, was vital to the production of this report. Other staff from the U.S. Department of Transportation who were particularly helpful in preparing presentations and descriptions of their programs include Susan Binder, Nelda Bravo, Debra Elston, Ewa Flom, Ian Friedland, Jack Jernigan, Marci Kenny, David Kuehn, Jeff

Lindley, Tom Marchessault, Jeff Paniati, Cheryl Richter, Gloria Shepherd, and Felicia Young. Several FHWA staff members—Flom, Friedland, Jernigan, Richter, and Young—were particularly gracious in responding to follow-up questions. Members of the staff of the Strategic Highway Research Program 2, including Neil Hawks, Ann Brach, Walter Diewald, and William Hyman, were also helpful.

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 National Research Council's (NRC's) Report Review Committee. The purpose of this independent review is to provide candid and critical comments that assist the authors and NRC in making the published report as sound as possible and to ensure that the report meets institutional standards for objectivity, evidence, and responsiveness to the study charge. The content of the review comments and draft manuscript remain confidential to protect the integrity of the deliberative process. The committee thanks the following individuals for their participation in the review of this report: Robert L. Lytton, Texas A&M University, College Station; Susan Martinovich, Nevada Department of Transportation, Carson City; Michael D. Meyer, Georgia Institute of Technology, Atlanta; Debra L. Miller, Kansas Department of Transportation, Topeka; Carl L. Monismith, University of California, Berkeley (emeritus); and David E. Newcomb, National Asphalt Pavement Association, Lanham, Maryland.

Although the reviewers listed above provided many constructive comments and suggestions, they were not asked to endorse the committee's conclusions or recommendations, nor did they see the final draft of the report before its release. The review of this report was overseen by C. Michael Walton. Appointed by NRC, he was responsible for making certain that an independent examination of the report was carried out in accordance with institutional procedures and that all review comments were carefully considered. Responsibility for the final content of this report rests entirely with the authoring committee and the institution.

Stephen Godwin, Director of Studies and Special Programs, managed this study and drafted the report under the guidance of the committee. Walter Diewald staffed RTCC from 1991 through the middle of 2006. Diewald, Beverly Huey, and Tom Menzies assisted with various portions

of the draft report. Suzanne Schneider, Associate Executive Director of the Transportation Research Board, managed the report review process. Special appreciation is expressed to Rona Briere, who edited the report; Alisa Decatur, who prepared the prepublication manuscript; and to Jennifer J. Weeks, who prepared the prepublication files for web posting; Norman Solomon, who provided final editorial guidance; and Juanita Green, who managed the production and printing, under the supervision of Javy Awan, Director of Publications. Amelia Mathis, Laura Toth, and Nikisha Turman assisted with meeting arrangements and communications with committee members.

Acronyms

3E	engineering, enforcement, and education
AAAS	American Association for the Advancement of Science
AASHTO	American Association of State Highway and Transportation Officials
ACS	adaptive control software
ASR	alkali–silica reactivity
BAA	Broad Agency Announcement
BEA	Bureau of Economic Analysis
BTS	Bureau of Transportation Statistics
CA4PRS	Construction Analysis for Pavement Rehabilitation Strategies
CADD	computer-aided drafting and design
CAD-TMC	computer-aided dispatch traffic management center
CAFE	corporate average fuel economy
CFS	Commodity Flow Survey
CICAS	Cooperative Intersection Collision Avoidance System
CLARUS	Latin word for clear—a road weather information initiative
CO_2	carbon dioxide
CSS	context-sensitive solution
DOD	Department of Defense
DOT	department of transportation
EFM	electronic freight management
EMS	emergency medical services
EPA	Environmental Protection Agency
ETG	expert task group
FAA	Federal Aviation Administration

FHWA	Federal Highway Administration
FMCSA	Federal Motor Carrier Safety Administration
FRP	fiber-reinforced polymer
FTA	Federal Transit Administration
FY	fiscal year
GAO	Government Accountability Office
GDP	gross domestic product
GHG	greenhouse gas emission
GIS	geographic information system
GPRA	Government Performance and Results Act
GPS	Global Positioning System
HCC	hydraulic cement concrete
HCM	Highway Capacity Manual
HOT	high-occupancy toll (lane)
HPC	high-performance concrete
HPMS	Highway Performance Monitoring System
HPS	higher-performing steel
IBRD	Innovative Bridge Research and Deployment
IDEA	Innovations Deserving Exploratory Analysis
IDIQ	indefinite delivery/indefinite quantity (contract)
IHSDM	Interactive Highway Safety Design Module
IPRD	Innovative Pavement Research and Deployment Program
ISTEA	Intermodal Surface Transportation Efficiency Act
ITE	Institute of Transportation Engineers
ITS	intelligent transportation system
LTAP	Local Technical Assistance Program
LTBP	Long-Term Bridge Performance (Program)
LTPP	Long-Term Pavement Performance (Program)
MCEER	Multidisciplinary Center for Earthquake Engineering Research
MDOT	Missouri Department of Transportation
MPO	metropolitan planning organization
NADO	National Association of Development Organizations
NAPA	National Asphalt Pavement Association
NBIS	National Bridge Inspection Standards

NCHRP	National Cooperative Highway Research Program
NDE	nondestructive evaluation/testing
NEMA	National Electrical Manufacturers' Association
NHS	National Highway System
NHTS	National Household Travel Survey
NHTSA	National Highway Traffic Safety Administration
NGO	nongovernmental organization
NIST	National Institute for Standards and Technology
NTIMC	National Traffic Incident Management Coalition
NTOC	National Transportation Operations Coalition
NO_x	oxides of nitrogen
NRC	National Research Council
NSF	National Science Foundation
OMB	Office of Management and Budget
psi	pounds per square inch
QC/QA	quality control/quality assurance
R&D	research and development
R&T	research and technology
RAP	reclaimed asphalt pavement
RD&T	research, development, and technology
REDARS	Risk for Earthquake Damage to Roadway Systems
RITA	Research and Innovative Technology Administration
RFP	request for proposals
RTCC	Research and Technology Coordinating Committee
SAFETEA-LU	Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users
SHRP	Strategic Highway Research Program
SP&R	State Planning and Research
STEP	Surface Transportation Environment and Planning Cooperative Research Program
STRDD	Surface Transportation Research, Development, and Deployment
TBD	to be determined
TCC	Technical Coordinating Committee
TEA-21	Transportation Equity Act for the 21st Century
TELUS	Transportation, Economic, and Land Use System

TFHRC	Turner–Fairbank Highway Research Center
TIM	Traffic Incident Management
TMIP	Travel Model Improvement Program
TRANSIMS	Transportation Analysis and Simulation System
TRB	Transportation Research Board
TTI	Texas Transportation Institute
TWG	technical working group
UHPC	ultra–high performance concrete
USDOT	U.S. Department of Transportation
UTC	University Transportation Center
VDOT	Virginia Department of Transportation
VIUS	Vehicle Information and Use Survey
VMT	vehicle miles traveled
VOC	volatile organic compound
WRI	Western Research Institute

Contents

Summary

The need for innovation in the highway sector has never been greater. The highway system is under severe stress and grossly underfunded. The current spikes in energy prices could have profound effects on highway transportation, the consequences of which are poorly understood. Public-sector research programs are vitally important to the development of innovations and insights that can help the highway system serve the nation under these conditions, but these programs are also under severe stress. Congress made some good investments in the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU) and increased overall funding for research, development, and technology (RD&T). Even so, the constraints of highly detailed program designations and earmarking of research funds for specific recipients reduced funding—in some cases eliminating it—for other important research initiatives. The Technical Corrections bill of 2008 was helpful, but addressed only a few of the problems.

This report presents the findings and recommendations resulting from the Research and Technology Coordinating Committee's assessment of the highway research programs funded under SAFETEA-LU according to a refined list of the principles for research articulated by Congress in the preamble to the research title (Title V) (see Box S-1), as well as additional principles the committee believes are important in sustaining a vital highway research program.

BOX S-1

Principles for Research Based on Title V, SAFETEA-LU

1. The federal portfolio should cover the full innovation cycle, including the following:
   - Agenda setting,
   - Conduct of research,
   - Support of research and technology transfer by the states,
   - Sharing of results, and
   - Deployment (including education and training).
2. Justification for federal investment requires that
   - Activities be of national significance,
   - There be public benefit and suboptimal private investment,
   - Efficient use of federal funds by states and local governments be encouraged, or
   - The activity be the best means to support federal objectives.
3. The content of the federal RD&T program includes the following:
   - Fundamental, long-term research;
   - The filling of significant gaps; and
   - Policy or planning.
4. Stakeholder input is addressed.
5. Awards are almost always made on the basis of competition and merit review.
6. Programs include performance review and evaluation.

NOTE: This list represents a distillation of eight principles included in Title V to combine two principles that overlap and eliminate one that is not relevant to this report.

MAIN FINDINGS

The main findings of the committee's assessment are as follows:

- Despite the progress made in overall funding under SAFETEA-LU, highway research programs are significantly underfunded compared with the level of investment in industry. Public and private highway research is funded at only about one-quarter the level of industrial research and development in the United States (highway RD&T represents only 0.9 percent of revenues provided to highway agencies, whereas industrial investment in RD&T is equivalent to 3.3 percent of revenues earned from sales).
- Extensive earmarking (62 percent) of the Title V University Transportation Centers (UTC) Program and additional earmarks scattered across Federal Highway Administration (FHWA) programs (equal to at least 18 percent of FHWA's funding) violate the SAFETEA-LU principle of awarding research funds on the basis of competition and merit review.
- The programs funded under SAFETEA-LU do not include all the content areas Congress requested. Because of funding constraints in Title V, FHWA was forced to cut important areas of research in safety, operations, planning and environment, and policy. Funding for research and data collection to support policy decisions was eliminated, and funding for planning was greatly reduced. Although funding is provided in certain other areas, such as deployment and technology transfer, it is at levels that are inadequate to the task.
- The 50-50 matching requirement for the UTC Program biases this program toward highly applied research and away from advanced research that is one of the main rationales for having a university research program.
- Because of funding constraints, FHWA has inadequate funds to follow through on commitments made in its Corporate Master Plan for Research and Technology to engage stakeholders more broadly in agenda setting, merit review, and program evaluation.
- The Strategic Highway Research Program (SHRP) 2 adheres to all the research principles of Title V but is funded at only 36 percent of the level and for 2 years less than stakeholders requested. The downscaled program will not be able to meet all the goals originally envisioned.

MAIN RECOMMENDATIONS

On the basis of its assessment and the findings presented above, the committee makes the following recommendations:

1. To the maximum extent practical, research funding should be awarded through competition and merit review.
2. All UTC funds should be awarded to universities competitively. The 50-50 matching requirement for UTC research should be reduced to a 20 percent university match to allow universities to conduct more advanced research. Competition should be open to all universities and not be limited by prior levels of transportation research activity.
3. The Exploratory Advanced Research Program should be continued.
4. The State Planning and Research Program should be continued.
5. Cuts in research in the areas of policy, safety, operations, and planning and environment at FHWA should be restored. Funding for research and data collection to inform policy decisions should be increased to meet pressing national needs. The surface transportation environment and planning research program should be authorized as a cooperative research program. In the planning area, additional funding for expanding data collection and improving regional travel forecasting models should be provided.
6. Congress should consider extending SHRP 2 for 2 years into the next authorization and funding it under Title I. (Under Title I, the funding would come from states' construction budgets, which they have approved.)
7. Other research programs strongly supported by stakeholders, such as the Long-Term Pavement Performance Program and the Long-Term Bridge Performance Program, should be continued.
8. Adequate resources should be provided to FHWA to support a robust program for dissemination of research results to states, local governments, and private vendors.
9. Resources should be provided to FHWA to institute a process of ongoing priority setting for highway research that engages the entire highway community. The results of these efforts would inform all highway research programs, improving their ability to focus on the highest priorities.

CONCLUSION

Even within current constraints, federal support for highway research is a sound investment. Publicly funded highway research programs have developed innovations that have resulted in longer-lived assets at lower costs, reduced environmental impacts, saved lives, and improved economic efficiency. Additional innovation will be needed to improve safety, reduce congestion, address environmental and energy concerns, and provide the quality highway system the nation's citizens expect. Adoption of the recommendations in this report will provide the nation with an improved program that will yield even greater dividends. These additional payoffs from research are urgently needed to meet the demands being placed today on the highway system.

1

Introduction

The American lifestyle is strongly dependent on highway transportation. Americans use personal vehicles for 87 percent of daily trips and 90 percent of long-distance trips (BTS 2006, 4). Moreover, highways are the backbone of the decentralized U.S. economy, whose functioning would be unimaginable without the access highways provide for motor carriers. Truck ton-miles represent about 30 percent of total U.S. ton-miles of freight; more important, that tonnage accounts for nearly 75 percent of the value of all freight shipped (BTS 2006, Tables B3 and B4).

The United States has the fourth-largest land area of any country and the greatest dependence on roads and highways. The nation has 3.2 million miles (8.4 million lane miles) of roads that connect metropolitan areas, towns, and counties to serve more than 300 million residents and 7 million business establishments (BTS 2006, Chapter 1). Although the U.S. economy has become increasingly dependent on the electronic transport of information over the Internet, there is no substitute for the physical movement of people to jobs and freight to its destinations. Furthermore, as the U.S. economy has become more dependent on trade, transportation has become even more important to the nation's global competitiveness. Between 1996 and 2006, for example, U.S. merchandise freight between the United States and Canada and Mexico more than doubled in value, from $419 billion to $866 billion; the bulk of this freight (88 percent by value) was moved by truck (Sprung 2007).

Although the crucial role of a good transportation system in economic growth is obvious, some have questioned the efficiency of public highway investments. Yet according to some studies (such as Mamuneas and Nadiri 2003) the benefits of the U.S. investment in highways over the past several decades rival the economic returns from private investment.

The advisory role of the Research and Technology Coordinating Committee (RTCC) represents an effort on the part of the Federal Highway Administration (FHWA) to maximize that investment.

This report presents RTCC's assessment of the highway research programs of FHWA; highway-related research funded through the Research and Innovative Technology Administration; and the Strategic Highway Research Program 2, which was authorized in the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU). This assessment was conducted in accordance with the principles for research articulated by Congress in Title V of SAFETEA-LU. These principles establish

- The elements the federal program should contain,
- The criteria that justify federal investment,
- The types of research (basic, applied, developmental) that should be included,
- The role of stakeholders in guiding agendas and reviewing results,
- The importance of merit review and competition in the awarding of research funding, and
- The need for evaluation.

BACKGROUND

Challenges

As valuable and important as highway transportation is, it faces enormous challenges. For example, demand on the system increased sharply over the past decade. In 2006, total highway travel by personal vehicles, motorcycles, and light and heavy trucks totaled 3 trillion miles, an increase of 25 percent since 1996 (FHWA 2006, Table VM-1). Much of the highway system is not only reaching or exceeding its expected service life but also carrying a much heavier burden than anticipated. The amount of traffic on rural Interstates more than doubled between 1970 and 2005, but the loadings placed on those highways, largely because of more trucks traveling more miles, increased sixfold during that period (FHWA 2005). Described below are safety, environmental, congestion, and maintenance challenges faced by the system; similarly daunting challenges could be cited for finance, energy, institutional reform, and others.

Safety

In 2007, motor vehicle crashes resulted in 41,059 fatalities and 2.49 million injuries (NHTSA 2008). The economic cost of motor vehicle crashes, to say nothing of the pain and suffering of injured victims and their loved ones, was estimated to total $230.6 billion in 2000, equivalent to 2.3 percent of gross domestic product (Blincoe et al. 2002). Injuries from motor vehicle crashes are the leading cause of death for those under age 35 (National Safety Council 2000, 10–11).

Environment

Although the environmental impact of highway transportation has been reduced considerably as a result of lower emissions per vehicle, the damage is nonetheless sizable. Highway vehicles remain a major source of air pollution. Since 1990, highway transportation's contribution to air pollution has decreased for all pollutants regulated under the Clean Air Act [carbon monoxide, nitrogen oxides (NO_x), volatile organic compounds (VOCs), and fine particulate matter], even as vehicle miles traveled (VMT) have increased (BTS 2007b, Figure 6-4). Even so, highway transport still accounts for 55 percent of carbon monoxide, 35 percent of NO_x, 26 percent of VOCs, and 2 percent of fine particulates emitted into the atmosphere (BTS 2007a, Tables 4-40–4-44). Although not currently regulated, carbon dioxide (CO_2) from highway transport accounts for 82 percent of transportation-generated CO_2 (BTS 2006, Table K-4); transportation as a whole represents about one-third of U.S. CO_2 emissions (BTS 2007a, Table 4-49).

The adverse human health effects of vehicle emissions are fairly well established. Although the consequences for ecosystems are much more challenging to measure, highway vehicle emissions are known to harm plants and animals, while roads and the noise from vehicles fragment and disrupt habitats. It is extremely difficult to assign the economic costs to society of the health and environmental consequences of highway transportation; doing so requires making many assumptions. To give some sense of scale, however, the midpoint in the range of estimates from one systematic and comprehensive effort to monetize the costs of highway transportation's impact, due largely to highway vehicle emissions, is about $290 billion annually in 2000 dollars (Delucchi 1998, Table 1-9a).

Congestion

The nation's heavy reliance on highway transportation results in more demand on the system in peak periods than can be supplied. Almost all of the 100 largest metropolitan areas in the United States are experiencing growing and frustrating delays in daily trips. The societal cost of congestion in U.S. metropolitan areas for 2005 is estimated at $78 billion, due to 4.2 billion hours of time wasted in delay and 2.9 billion gallons of wasted fuel (Schrank and Lomax 2007).

Maintenance

The nation's 8.2 million lane-miles of roads and highways represents the largest public works investment in U.S. history. The Bureau of Economic Analysis estimates the value of highway capital stock (in 1996) at $1.13 trillion (BEA 2007). Given the magnitude of this asset and natural aging and wear and tear, it should not be surprising that the cost to maintain the system is also extremely large.

The U.S. Department of Transportation estimates that it would cost all units of government about $79 billion annually (in constant 2004 dollars) merely to maintain the existing condition and performance of this huge inventory of assets under current use over the next 20 years. Improving deficient structures and pavements—limited to those investments that would be cost-beneficial—and improving system performance would cost about $132 billion annually (USDOT 2006). Maintenance of signals and intelligent transportation system technologies, an increasingly important component of highway investments and operations, would add to this total.

Most of the national highway system was built in the second half of the 20th century. Much of this infrastructure has reached or exceeded its design life and must be substantially restored or replaced. This massive reinvestment will be necessary even if high energy prices moderate future growth in VMT to below projections. The problem is compounded by lower-than-anticipated revenues for funding of highway capital programs. Lower-than-expected future VMT and a shift to more fuel-efficient vehicles would reduce gasoline taxes and other user fee revenues to the federal and state trust funds that support highway and transit capital programs.

Opportunities

The challenges facing the highway system cannot be addressed simply by spending more money, even if doing so were possible. Funding for highways is currently constrained by the sharp drawdown in the federal highway trust fund and a general unwillingness to raise fees or taxes that support transportation infrastructure. Successfully addressing many of the challenges discussed above will require new and more efficient ways of doing things—new materials, better and faster construction techniques, safer designs, better information for drivers, new financing mechanisms, options for pricing use of the system, and many more. This is the role that research, development, deployment, and training must fill. Described in boxes throughout this report are examples of cases in which publicly funded highway research programs have devised innovations that have resulted in longer-lived assets at reduced costs, reduced environmental impacts, saved lives, and improved economic efficiency. Additional innovation will be needed to improve safety, reduce congestion, address environmental and energy concerns, and provide the quality system the nation's citizens expect.

ILLUSTRATIVE RESEARCH BENEFITS

The Superpave® Design System

In the early 1980s, widespread concern about the premature failure of hot-mix asphalt pavements led Congress to mandate an aggressive, well-funded special research effort aimed at better understanding and improving the performance of asphalt pavements. The 7-year Strategic Highway Research Program (SHRP), which was managed by the National Research Council, developed a new system of standard specifications, test methods, and engineering practices for selecting materials and mix proportions for hot-mix asphalt pavement. This Superpave system better matches combinations of asphalt binder and crushed stone to the climatic and traffic conditions on particular highways. State departments of

(continued on next page)

Illustrative Research Benefits: The Superpave® Design System *(continued)*

transportation (DOTs) spend more than $10 billion annually on hot-mix asphalt pavements, so even modest improvements in pavement durability and useful life can produce substantial cost savings for agencies and time savings for motorists.

SHRP rolled out the Superpave system in 1993. However, it took years for individual states and their paving contractors to switch to the system, which represented a significant departure not only in design but also in the procedures and equipment used for testing. Each state DOT had to be convinced that the benefits would outweigh the modest additional costs of Superpave mixes, as well as the time and effort required to train its staff and acquire the necessary equipment. When surveyed in 2005, 50 state DOTs (including those of the District of Columbia and Puerto Rico) were using Superpave, and the remaining two states indicated that they would be doing so by the end of 2006. Throughout the implementation period, research continued with the aim of refining the system, for example, to consider the use of recycled asphalt pavements in mix design.

It may be years before the full benefits and costs of Superpave are known and quantified. A 1997 study by the Texas Transportation Institute projected that when it is fully implemented, net savings over 20 years should approach $1.8 billion annually—approximately $500 million in direct public savings and $1.3 billion in highway user savings. Moreover, analyses by individual states and cities have found dramatic advances in performance at little or no increase in cost. Superpave is an example of a successful research program; equally important, it demonstrates that a vigorous and sustained technology transfer effort is often required for innovation in a sector as decentralized as highway transportation.

SOURCE: Skinner 2008.

ORGANIZATION OF THE REPORT

Chapter 2 provides an overview of the various highway research programs in the United States. Although the federal program is the largest, it is only one of many; FHWA's program represents about 30 percent of all highway research funding. Chapter 3 provides a detailed description of each of the major highway research programs funded through Title V of SAFETEA-LU—the programs whose assessment is the focus of this report. Chapter 4 delineates the principles for highway research that Congress included in SAFETEA-LU and explains how they were slightly modified to form the basis for the committee's assessment of the programs described in Chapter 3. Chapter 5 presents the committee's detailed assessment according to these principles, as well as some additional criteria the committee deems important. In the final chapter, this assessment is consolidated into a set of summary findings and the committee's recommendations.

REFERENCES

Abbreviations

BEA	Bureau of Economic Analysis
BTS	Bureau of Transportation Statistics
FHWA	Federal Highway Administration
NHTSA	National Highway Traffic Safety Administration
USDOT	United States Department of Transportation

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2

Highway Research Programs in the United States

Highway research, like the management of the highway system itself, is decentralized. Roads and highways are owned and operated by the states, thousands of counties, and tens of thousands of cities and municipalities. These many and varied organizations make all the key decisions about investment in and operation and preservation of their roads and highways. Significant highway research and technology (R&T) work is funded by the U.S. Department of Transportation (USDOT); however, many other programs fund highway-related research, including several federal agencies, each of the states, University Transportation Centers (UTCs) (generally through USDOT funding), and private entities. This chapter provides a brief overview of the various programs, with emphasis on those analyzed in the remainder of this report. It ends with a comparison of the level of research and development (R&D) investment in highways and the R&D investment of private industry.

FEDERAL PROGRAMS

The focus of this report is on investments in highway research funded through the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU). These activities are described below, along with a brief overview of other federally funded highway-related research.

U.S. Department of Transportation

Highway research is funded and managed principally through the Federal Highway Administration (FHWA), but not exclusively. The intermodal Intelligent Transportation System (ITS) research program, administered by

the Research and Innovative Technology Administration (RITA), includes several highway initiatives funded by ITS but managed by FHWA. (This report addresses those ITS-funded activities managed by FHWA, but not those managed by other USDOT agencies.) Motor vehicle safety research is funded through the National Highway Traffic Safety Administration (NHTSA), while truck safety programs are funded through the Federal Motor Carrier Safety Administration (FMCSA). These programs, although highway-related, are not considered in this report because the scope of the Research and Technology Coordinating Committee (RTCC) is limited to R&D on infrastructure, highway operations, highway safety (other than vehicle design), environmental impact, and highway policy and planning.

The UTC Program, which is also managed by RITA, funds research in all modes of transportation. As described in Chapter 4, the majority of research projects conducted by UTCs are highway related. Hence, this assessment includes consideration of the UTC-funded research program as a whole.

FHWA

FHWA's research encompasses a wide array of topics of importance to highway planning, construction, operation, safety, environmental protection, and maintenance. Research programs are organized along lines of authorized funding. Title V funding includes several different categories: Surface Transportation Research, Development, and Deployment (STRDD), Training and Education, University Transportation Research, ITS Research, and the Bureau of Transportation Statistics (see Table 2-1). FHWA manages most of the STRDD funds and the Training and Education Programs. STRDD, with budgeted funding averaging about $156 million annually under SAFETEA-LU, is one of the main programs of interest in this report.[1] This category includes Infrastructure, Planning and Environment, Operations, Highway Safety, Policy, and Exploratory Advanced Research.

Most of the highway research analyzed in this report is managed through FHWA's Office of Research, Development, and Technology (RD&T). This

[1] In fiscal years (FY) 2006 and 2007, STRDD included SHRP 2, which averaged about $38 million in each of these two years. The estimate given of $156 million for STRDD excludes SHRP 2, which was moved to Title I of SAFETEA-LU in FY 2008 and is described separately from STRDD in this report.

TABLE 2-1 Estimated Average Annual Title V and SHRP 2 RD&T Funding by Program Category, Fiscal Years 2006–2009

Program Area	Average Annual Funding ($ millions)	Funding as Percentage of Total	Funding as Percentage of STRDD and SHRP 2
STRDD			
Infrastructure	60.4	14.5	30.4
Pavements	30.5		
LTPP	8.3		
Structures	21.5		
Planning and Environment	18.6	4.5	9.4
Operations	7.4	1.8	3.7
Highway Safety	13.7	3.3	6.9
Policy	0.7	0.17	0.4
Corporate Activities	24.6	5.9	12.4
Advanced Research	11.5		
Other USDOT R&T Programs[a]	30.7	7.4	15.5
Training and Education	24.2	5.8	
SHRP 2[b]	42.3	10.2	21.3
Subtotal	156.1		100.0
RITA Programs			
University Transportation Research	66.9	16.1	
ITS Research	99.9	24.0	
Bureau of Transportation Statistics	26.7	6.4	
Total	416.2	100.0	

NOTE: The figures shown are averages of 4-year estimates of budgeted amounts, which are less than the amounts authorized because of obligation limits, budget rescissions, and other adjustments. Based on tables provided by FHWA. LTPP = Long-Term Pavement Performance (Program); SHRP = Strategic Highway Research Program.

[a]These research programs and projects, mainly earmarks, are managed by various administrations within USDOT.

[b]SHRP 2 was funded in Title V for fiscal years (FY) 2006 and 2007. In the Technical Corrections legislation of 2008, SHRP 2 funding was taken from Title I for FY 2008 and 2009. To avoid confusion in this table, SHRP 2 is listed separately, even though in FY 2006 and 2007 it was a component of Title V Corporate Activities.

office also manages the Turner–Fairbank Highway Research Center, a federally owned and operated highway research facility in McLean, Virginia. Other offices within FHWA also manage research, development, and deployment. Planning, environmental, and realty research (4.5 percent of Title V R&D funding) is managed by the Office of Planning, Environment, and Real Estate Services. Policy research, for which there is very little funding under SAFETEA-LU (0.4 percent of Title V R&D funding) is managed

in the Office of Policy. Although the Office of RD&T manages most of FHWA's research, the research activities within the agency are closely coordinated with the offices responsible for delivering its programs, such as the Offices of Infrastructure, Operations, and Safety, as well as with the programs for Training and Education. Responsibilities for priorities and programs are shared between the Office of RD&T and the program offices. The research itself is managed through RD&T, but deployment activities are often led by program offices.

Training and Education activities receive about $24 million annually under SAFETEA-LU. The major programs are the National Highway Institute (about $8.7 million annually) and the Local Technical Assistance Program (about $10 million annually). These programs are not addressed explicitly in this report, but both are important elements of FHWA's overall deployment activities.

RITA

RITA administers two programs of particular interest to RTCC: the ITS Program and the UTC Program. The ITS Program funds several major highway-related research initiatives: road weather safety, intersection collision avoidance systems, electronic freight management, and emergency transportation operations, among others. Because ITS technologies apply to all modes, ITS activities are conducted throughout USDOT, most funded by the ITS Program, with related activities funded by the various modal administrations. Major ITS research activities in highway traffic operations and safety are managed within FHWA's Office of RD&T.

The UTC Program provides grants to more than 60 university centers around the country. The program is intended to encompass all aspects of transportation, but most of the funded centers sponsor and conduct highway research. As described in Chapter 4, about 70 percent of UTC research projects are highway research.

NHTSA

NHTSA is the USDOT agency responsible for regulating the safety of motor vehicles; conducting and reporting on crash tests; issuing motor vehicle recalls; establishing corporate average fuel economy standards; and collecting data on highway crashes, injuries, and fatalities. NHTSA also has a small R&D program on behavioral safety. NHTSA's activities are

funded through a separate title of SAFETEA-LU. The data that NHTSA collects on highway crashes, injuries, and fatalities are critical to the highway safety research of NHTSA, FMCSA, and FHWA.

FMCSA

FMCSA was established as a separate administration within USDOT on January 1, 2000, pursuant to the Motor Carrier Safety Improvement Act of 1999. Formerly, the truck safety activities within USDOT were conducted within FHWA. FMCSA's primary mission is to reduce crashes, injuries, and fatalities involving large trucks and buses. FMCSA has a modest research program aimed at gaining fundamental and applied knowledge to inform the development of new methods and technologies that can enhance truck and bus safety and security.

Federal Aviation Administration

Although most pavement research in USDOT is carried out through FHWA, the Federal Aviation Administration (FAA) conducts such research as well, on pavement design, materials, performance, and recycling. The largest commercial aircraft impose loadings on runways that are an order of magnitude greater than those imposed on highways by heavy trucks. Hence pavement design for airports differs from that for highways. FAA spends $10 million to $16 million annually on pavement research.

Other Federal Highway-Related Research Programs

A variety of research activities that are important to highway transportation are scattered throughout the federal government.[2] The Department of Energy funds most federal research on transportation fuels and propulsion systems. The Environmental Protection Agency funds research on health effects of motor vehicle emissions, emission control technologies, and biodiversity, among other environmental topics related to highways. Some highway-related basic research is typically funded each year through-

[2] Brach (2005) provides an overview of transportation research funding across federal agencies; information about this research is difficult to gather because of incomplete and inconsistent data. Information on highway research—a subset of transportation research—is even more difficult to locate. Actual highway research funded in federal agencies other than those discussed above is unknown but not likely to be substantial.

out the National Science Foundation, including research on materials, behavior, models, and information technologies that are or could be applied to highway transportation. Considerable pavement research related to military missions, bases, facilities, and runways occurs at the U.S. Army Corps of Engineers' Engineer Research and Development Center. For example, pavement research at the U.S. Army's Cold Regions Research and Engineering Laboratory includes the development and application of mechanistic–empirical design models for pavement subgrade design, research on seasonally frozen ground and frost heave, and design of Air Force runways.[3] The Geotechnical and Structures Laboratory includes a large-scale and sophisticated Concrete Research Facility and a Pavement Materials Laboratory that support physical, chemical, and mechanical characterizations of pavements and construction materials.[4]

STATE PROGRAMS

Each state department of transportation (DOT) has a research program. Most states fund this research through the State Planning and Research (SP&R) provision of Title I of SAFETEA-LU. FHWA oversight of this program is defined in Title V (as described in Chapter 4). The SP&R provision sets aside a small proportion (2 percent) of selected federal highway aid categories for SP&R activities, 25 percent of which must be spent on research. In fiscal year 2007, SP&R funding totaled approximately $663 million, about $166 million of which was the minimum required for research. Because some states spend more than the SP&R minimum, total state DOT highway R&D exceeds this amount. In 2006, the last time a national figure was estimated, states spent $326 million on highway research (see Table 2-2). State programs cover all kinds of research, and their size varies considerably. Large states, such as California and Texas, have sizable programs. California, unlike most states, also funds considerable research with state resources. The vast majority of state DOT research funding is invested in highly applied aspects of highway engineering, design, safety, environment, and planning.

[3] www.crrel.usace.army.mil/businessareas/technicalareas/ta-coldregions.html#pavement. Accessed Aug. 26, 2008.

[4] gsl.erdc.usace.army.mil/Ifac_info.html#CRF. Accessed Aug. 26, 2008.

TABLE 2-2 Funding for Highway and Highway-Related Research Programs

Funding Entity	Funding[a] ($ thousands)
Programs Funded Under Title V of SAFETEA-LU	
FHWA	
Surface Transportation R&D	133,000
Training and Education	23,000
SHRP 2	36,200
RITA[b]	
UTCs	60,000
ITS	94,700
States	
SP&R minimum[c]	165,800
Total state highway research	326,000[d]
Private-Sector Highway Research Programs[e]	
Associations	25,000–50,000
Companies	50,000–100,000

[a]For programs funded under Title V of SAFETEA-LU, funding for FY 2006; for private-sector highway research programs, estimated 2001 funding.
[b]Both programs administered by RITA cover all modes, but a substantial portion of both addresses highway topics.
[c]SP&R funding is based on a required minimum. Some states spend more than the minimum percentage, and some provide other state funding as well. (National Cooperative Highway Research Program funding of $32.7 million in 2006 is a subset of SP&R funding.)
[d]Based on a 2006 survey of member states, adjusted to account for missing state data by using the ratio of total state research spending to SP&R minimums (Skinner 2007).
[e]Private investments in highway R&D were estimated for 2000 by the committee in *Special Report 261* (TRB 2001).

Each state's having its own research program might suggest that duplication would occur. In fact, however, states share resources to study topics of collective interest, while at the same time having major differences in many areas that necessitate individual programs. Pavement design itself is highly dependent on local soil conditions, moisture levels, temperature ranges, and sources of local aggregate. Operational needs range widely between states with major metropolitan areas and those consisting mainly of rural areas. Policy concerns with respect to economic development, finance, environmental issues, and safety also vary considerably across states.

Because most state programs are funded through federal aid, FHWA has a role in overseeing these activities. The states themselves, however,

define their research agendas. States are required by FHWA to enter their research projects into a database (Research in Progress) and to check this database to avoid duplication.

SP&R Program funding plays a vital role in connecting USDOT programs with those of the states and in facilitating collaboration among the states. States use their SP&R funds in a variety of ways, but in general, the following uses are characteristic:

- To conduct state-specific research, development, and deployment projects;
- To support the National Cooperative Highway Research Program (NCHRP);
- To support pooled-fund projects with other states and FHWA;
- To provide matching funds for universities participating in the UTC Program;
- To provide support for the standing committee structure, conferences, and workshops of the Transportation Research Board (TRB); and
- For some states, to support programs for the transfer of technology to county and city engineers.

Each of these areas of expenditure facilitates innovation or collaboration, or both. State-specific research projects, for example, test or demonstrate innovations promoted by FHWA and other states. States also pool some of their SP&R funds for NCHRP, through which they fund and conduct research of collective interest. The program is overseen by the Standing Committee on Research of the American Association of State Highway and Transportation Officials and administered by TRB. NCHRP projects often result in manuals and handbooks that provide guidance for the implementation of new ideas and techniques and serve as technical resources for the establishment and revision of standards. The NCHRP process is highly competitive; most proposed projects (75 percent) are not funded. The pooled-fund program, administered by FHWA, allows groups of states with a common interest to fund research proposals made by other states and FHWA. Some projects not selected by NCHRP because of a lack of common interest among all states are supported as pooled-fund projects. Dozens of studies are in development or under way through this program. Many pooled-fund projects result in manuals and hand-

books for implementation. Matching funds for UTC research allow states to partner with universities to conduct research that state DOTs might otherwise be unable to fund. Funding for TRB facilitates the technical exchange of new knowledge and practice through TRB's 200 standing committees and numerous conferences and workshops organized each year. Finally, technology transfer programs help states encourage innovation by counties and cities, which in some states are responsible for the majority of road mileage.

SP&R funds, then, are used for a number of purposes other than fostering innovation directly through research. They provide the institutional mechanism that allows FHWA to serve in a coordinating role, create many opportunities for sharing information on research activities among states and with FHWA to avoid duplication, and support interchanges among practitioners and subject matter experts at TRB meetings and events.

PRIVATE-SECTOR R&D

There is no single, or even dominant, private-sector highway research program. Private-sector research is the sum of individual programs conducted or sponsored by national associations of industry components, engineering associations active in construction and highway transportation, and companies that design and construct highways and supply highway-related products.

Association programs reflect private-sector support for short-term, highly focused research that meets the specific needs of members. These programs range from those having their own research staff and laboratories to those relying entirely on contractors. Associations such as the American Trucking Associations, the National Asphalt Pavement Association, the Portland Cement Institute, and the American Institute of Steel Construction conduct research in their fields. Association research tends to be driven by considerations of cost-efficiency, safety, and productivity and addresses issues affecting business operations or output. The committee has estimated in the past that annual highway R&T expenditures by associations total between $25 million and $50 million (TRB 2001).

Except for a handful of companies, information on corporate research activities and expenditures is scarce because of the large num-

ILLUSTRATIVE RESEARCH BENEFITS

Rapid Rehab—Construction Analysis for Pavement Rehabilitation Strategies

Aimed at reducing highway construction time and its impact on traffic, Construction Analysis for Pavement Rehabilitation Strategies (CA4PRS) is a schedule and traffic analysis tool that helps designers select effective, economical rehabilitation strategies. The software's scheduling module estimates the duration of highway projects, incorporating alternative strategies for pavement designs, lane-closure tactics, and contractor logistics. On the I-15 Devore reconstruction project, CA4PRS software justified implementing the one-roadbed continuous (24/7) closure scenario, which saved $6 million in construction costs and $2 million in road user delay costs. The project was completed in 18 days by closing down one direction of traffic and reconstructing the freeway. This project would normally have taken 10 months to complete with nighttime closures.

CA4PRS was funded through an FHWA pooled-fund, multistate consortium (California, Minnesota, Texas, and Washington). It was developed by the University of California Pavement Research Center through the university's Berkeley Institute of Transportation Studies. More than 700 people have been trained in its use.

SOURCE: Iwasaki 2008.

ber of firms involved and the proprietary nature of their research programs. Many companies simply do not report actual research expenditures. Private companies undertake research on such subjects as roadside safety equipment, traffic control devices, and flexible pipes. Limited data indicate that annual spending by private companies for research on highway-related topics is between $50 million and $100 million (TRB 2001).

COMPARATIVE R&D INVESTMENTS

It is useful to put the investment in highway research in some perspective. The total amount of funding for highway-specific research (amounts funded through Title V of SAFETEA-LU and the private sector) is approximately $823 million annually, a figure that reflects a generous assumption about the total level of private-sector R&D (Table 2-2). Although this may appear to be a large figure, it pales by comparison with total industrial R&D in the United States, which is funded at about $225 billion annually when private ($204 billion) and public ($22 billion) investments are combined (Wolfe 2007, Tables 2 and 3). To help put these figures in perspective, industrial investment in R&D represents about 3.34 percent of total sales (see Table 2-3), while highway RD&T as a percentage of total public-sector highway expenditures (a rough comparison to private sales) is about 0.88 percent—comparable with the percentage in the lowest-technology industrial sectors and only 26 percent of the overall industrial percentage.

SUMMARY

Management and decision making with respect to highway research in the United States are fairly decentralized, and appropriately so. A wide range of conditions affect highway design and performance across the country. The largest single highway research program is managed by FHWA. RITA manages and funds the UTC and ITS Programs, both of which include substantial highway research. State programs allow state DOTs to focus on topics of specific concern and are flexible enough to allow for sharing of resources across all states and among groups of states with common interests. The SP&R Program, funded through Title I, provides a foundation that links the states with the federal programs and provides a vehicle for implementing innovations.

Although the organization of the highway research effort fits the federalist structure of the U.S. political system and the decentralized responsibilities for highways, the level of funding is far out of proportion to the importance of highway transportation to U.S. society and the nation's economy and current challenges to the ability to meet mobility needs. The level of investment in highway research as a percentage of expendi-

TABLE 2-3 Industrial R&D as a Percentage of Sales in 2005 Versus Highway RD&T as a Percentage of Total Public-Sector Highway Expenditures

Source of Funds[a]	Funding[b] ($ millions)	Sales or Expenditures[c] ($ millions)	Funding as Percentage of Sales or Expenditures
Manufacturing industries	142,555	3,998,256	3.57
Food	2,710	374,342	0.72
Textiles, apparel, leather	811	51,639	1.57
Chemicals	42,826	624,344	6.86
Plastics and rubber products	1,747	90,176	1.94
Fabricated metal products	1,323	174,165	0.76
Machinery	8,244	230,941	3.57
Computer and electrical products	42,463	472,330	8.99
Electrical equipment	2,322	101,398	2.29
Transportation equipment	28,321	957,951	2.96
Miscellaneous manufacturing	5,061	83,103	6.09
Nonmanufacturing industries	61,695	2,120,877	2.91
All industries	204,250	6,119,113	3.34
USDOT and SHRP 2	347		
States	326		
Private sector	150		
Total	823	93,643	0.88

[a]For industries, source of R&D funding; for USDOT and SHRP 2, states, and private sector, source of highway RD&T funding.
[b]For industries, R&D funding; for USDOT and SHRP 2, states, and private sector, highway RD&T funding.
[c]For industries, domestic net sales; for USDOT and SHRP 2, states, and private sector, total public-sector expenditures.
SOURCE: For industry, Wolfe 2007, Tables 2 and 3; for highways, this report, Tables 2-1 and 2-2.

tures is comparable with the research investment of the lowest-technology industrial sectors as a percentage of sales. Given the magnitude of the economic, safety, and environmental issues associated with highway transportation, these funding levels are simply inadequate. The roughly $673 million invested by the public sector annually in highway RD&T pales in comparison with the nearly $300 billion in societal costs (such as costs resulting from injuries and deaths due to crashes, including medical expenses and lost wages, and from the value of time wasted in congestion) borne each year by the citizens of the United States. If environmental costs could be quantified, they would make this discrepancy more dramatic still.

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Abbreviation

TRB Transportation Research Board

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3

Highway Research Programs Funded Under Title V

This chapter describes each major highway research program funded through Title V of the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU). Program areas reviewed include advanced research, infrastructure, operations, planning and environment, safety, policy, and the University Transportation Centers (UTC) program. The intelligent transportation system (ITS) research projects funded by the Research and Innovative Technology Administration (RITA) but managed by the Federal Highway Administration (FHWA) are subsumed under the appropriate topic areas (operations and safety), as is the Strategic Highway Research Program (SHRP) 2 (discussed under infrastructure, operations, safety, and planning and environment).

ADVANCED RESEARCH

In 2001, the Research and Technology Coordinating Committee (RTCC) recommended that "FHWA's R&T program should focus on fundamental long-term research aimed at achieving breakthroughs in the understanding of transportation phenomena" (TRB 2001b, 6). In 2005, SAFETEA-LU, Section 5201(g), authorized $14 million annually for advanced research, or "longer-term, higher-risk research with potentially dramatic breakthroughs for improving durability, efficiency, environmental impact, productivity, and safety (including bicycle and pedestrian safety) aspects of highway and intermodal transportation systems." This compares with an authorization of $1 million annually for advanced research under the previous authorization. Research

topics are defined as those the Secretary determines appropriate, including:

- Characterization of materials used in highway infrastructure, including analytical techniques, microstructure modeling, and the deterioration processes.
- Assessment of the effects of transportation decisions on human health.
- Development of surrogate measures of safety.
- Environmental research.
- Data acquisition techniques for system condition and performance monitoring.
- System performance data and information processing needed to assess the day-to-day operational performance of the transportation system in support of hour-to-hour operational decision making.

The committee views fundamental, long-term research, or advanced research, as somewhere in the middle of the continuum from basic to applied research. "It involves and draws upon basic research results to provide a better understanding of problems and develop innovative solutions" (TRB 2001b, 7). In contrast with applied research, a specific application may not be apparent at the outset of this work. Before SAFETEA-LU, FHWA had been supporting a small advanced research activity for several years (Asmerom and McCrae 2006). Examples of research topics included measurement of concrete moisture content at the nanometer scale, measurement of tension in steel cables based on principles of magnetorestrictive sensing, and development of algorithms describing traffic behavior.

The Exploratory Advanced Research Program is receiving about $11.5 million annually for fiscal years (FY) 2006 to 2009. FHWA initiated the program by soliciting preproposals through a Broad Agency Announcement (BAA) in January 2007. The BAA solicited preproposals for "research and development projects that could lead to transformational changes and truly revolutionary advances in highway engineering and intermodal surface transportation in the United States." Eligible topics in the first BAA included highway safety, planning and environment, transportation policy, traffic congestion, highway infrastructure, and crosscutting topics. From the hundreds of preproposals submitted in the first round in response to this BAA and after extensive merit

review of completed proposals, FHWA selected 11 projects, nine of which had been awarded at the time of this writing (see Table 3-1).

In May 2008, FHWA issued a second BAA. In contrast to the first BAA, which was broadly open to innovative proposals, the second BAA solicited proposals in five specific areas:

1. Understanding of empirical decomposition mode analysis and development of a new data analysis method in support of integrated safety system for highway safety,
2. Development of methodologies to evaluate the nighttime safety implications of the roadway visual scene under varying cognitive task loads,
3. Making driving simulators more useful for behavioral research,
4. Greatly increased use of fly ash in hydraulic cement concrete for pavement layers and transportation structures, and
5. Sustainability of freight movements: methods to measure and reduce the United States carbon fuel emissions associated with freight movements.

TABLE 3-1 Exploratory Advanced Research Program, Round 1 Awards as of July 2008

Topic	Institution
Intelligent Multi-Sensor Measurements to Enhance Vehicle Navigation and Safety Systems	Auburn University, GPS and Vehicle Dynamics Laboratory
Intersection Control for Autonomous Vehicles	University of Texas, Austin
Next Generation of Smart Traffic Signals	University of Arizona, ATLAS Center
Development and Evaluation of Selected Mobility Applications for Vehicle–Infrastructure Integration	University of California, Berkeley, PATH Program Institute of Transportation Studies
Development of Soil Stiffness Measuring Device for Pad Foot Roller Compactor	Colorado School of Mines, Division of Engineering
Development and Demonstration of Systems-Based Monitoring Approaches for Improved Infrastructure Management Under Uncertainty	University of Central Florida, Department of Civil and Environmental Engineering
High-Performance Stress-Relaxing Cementitious Composites for Crack-Free Pavements and Transportation Structures	Texas Transportation Institute
Increased Understanding of Driver Visibility Requirements	Science Applications International Corporation
Layered Object Recognition for Pedestrian Collision Sensing	Sarnoff Corporation

Selection of these areas was preceded by research and consultation with experts. A total of $3.275 million in research funding from FHWA was made available in the second BAA.

The Exploratory Advanced Research Program represents about 6 percent of the combination of FHWA's share of Title V funding and SHRP 2 funding. The program, however, is not the only source of funding for advanced research through Title V. There are two substantial earmarks for asphalt research, which is mostly advanced, that total about $29 million in budgeted funds over the life of SAFETEA-LU. SHRP 2, discussed later, is not designed as an advanced research activity; nonetheless, it includes research totaling about $43 million in its Safety Program and about $3 million in its Renewal Program that could be classified as advanced. Together, these funds represent about 15 percent of FHWA's share of Title V funding and SHRP 2 and about 8 percent of all of Title V and SHRP 2 research funding. There may also be a few projects throughout the research programs discussed in this report that could be classified as advanced. The UTC program surely includes some advanced research, but, as described in the section of this chapter on that program, the program as a whole is biased toward applied research by the dollar-for-dollar matching requirement.

INFRASTRUCTURE RESEARCH, DEVELOPMENT, AND TECHNOLOGY

Infrastructure research, development, and technology (RD&T), addressing pavements and structures, is a central and long-standing area of FHWA research activity. The "ultimate goal of FHWA's pavement research and development is to provide performance-based models and tools to facilitate effective management of the national highway infrastructure."[1] The structures programs are intended to result in four outcomes:

- Outcome 1: Highway structures are designed, constructed, and rehabilitated with standards and materials that provide longer and more reliable performance.
- Outcome 2: Highway structures are constructed or rehabilitated with systems, methods, and practices that reduce congestion and improve safety.

[1] www.tfhrc.gov/pavement/pave.htm. Accessed Feb. 15, 2008.

- Outcome 3: Highway structures provide a high level of safety and service under all conditions.
- Outcome 4: Highway structures fit their environment through the application of context-sensitive solutions principles.

Expected funding for infrastructure (actual amounts budgeted), including FHWA's programs and the Renewal Program of SHRP 2, totals about $270 million for FY 2006–2009. FHWA's pavements and structures programs and SHRP 2's Renewal Program are described below.

Pavements

FHWA pavements RD&T includes three designated programs and two significant earmarks. Annual funding for pavements RD&T averages about $30.5 million.

Designated Programs

SAFETEA-LU provides for three programs that are managed by FHWA's Pavement Technology Program:

- The Innovative Pavement Research and Deployment (IPRD) Program,
- The Long-Term Pavement Performance (LTPP) Program, and
- The Alkali–Silica Reactivity (ASR) Program.

The IPRD Program was established to promote, demonstrate, support, and document the application of innovative pavement technologies, practices, performance, and benefits. Congress specified a number of program goals, including the following:

- Deployment of new, cost-effective, innovative designs, materials, recycled materials (including taconite tailings and foundry sand), and practices to extend pavement life and performance and improve customer satisfaction;
- Reduction of initial and life-cycle costs of pavements, including the costs of new construction, replacement, maintenance, and rehabilitation;
- Deployment of accelerated construction techniques to increase safety and reduce construction time and traffic disruption and congestion;
- Deployment of engineering design criteria and specifications for innovative practices, products, and materials for use in highway pavements;

- Deployment of new nondestructive and real-time pavement evaluation technologies and techniques;
- Evaluation, refinement, and documentation of the performance and benefits of innovative technologies deployed to improve life, performance, cost-effectiveness, safety, and customer satisfaction;
- Effective technology transfer and information dissemination to accelerate the implementation of innovative technologies and to improve life, performance, cost-effectiveness, safety, and customer satisfaction; and
- Development of designs and materials to reduce storm water runoff.

SAFETEA-LU specifically allocates portions of the IPRD funding to research on asphalt pavement, concrete pavement, alternative materials used in highway pavements (including those used in highway drainage applications), and improved aggregates used in highways on the National Highway System. In total, these suballocations account for approximately 65 percent of IPRD funds, leaving some flexibility within the overall IPRD framework.

LTPP provides for continued testing, monitoring, and data analysis under a program that was initiated as part of the original SHRP and has been managed by FHWA since 1992. The final year of SAFETEA-LU, FY 2009, marks the end of the originally planned 20-year monitoring period for the program. At that time, FHWA will deliver an updated database that

- Contains complete data sets—inventory, materials, traffic, climate, maintenance and rehabilitation, and pavement performance data—for most LTPP test sections;
- Has been reviewed and checked through quality control/quality assurance processes and data studies and is as error-free as time and the program budget allow;
- Is documented in terms of not only its content but also how the data were collected and their quality;
- Is accessible to the public; and
- Conforms to federal guidelines on the quality of information dissemination.

The ASR program provides for further development and deployment of techniques to prevent and mitigate ASR, including lithium-based tech-

niques, and for assistance to states in inventorying existing structures for ASR. Unlike the other programs discussed here, the ASR program encompasses not only pavements but also bridges and structures.

Earmarks

Pavements RD&T is subject to two earmarks:

- Fundamental Properties of Asphalts and Modified Asphalts, and
- Asphalt Research Consortium.

The Fundamental Properties of Asphalts and Modified Asphalts earmark is a continuation of a long-standing earmark that directs funding (about $3.4 million annually) to the Western Research Institute to conduct, as the title suggests, research on the fundamental properties of asphalts and modified asphalts. The Asphalt Research Consortium earmark (about $6.2 million annually) calls for a grant to "the asphalt research consortium led by the Western Research Institute to research flexible pavement and extending the life cycle of asphalts." Other consortium members include the University of Nevada, Reno; the Texas Transportation Institute; the University of Wisconsin, Madison; and Applied Asphalt Technologies. Together, these two earmarks account for about a quarter of the total funding authorized by SAFETEA-LU for pavement research.

Structures

SAFETEA-LU authorized a number of research programs in the structures area that address FHWA and stakeholder needs and priorities; these include both designated programs and earmarks. Funding for the structures RD&T program averages about $21.50 million annually (actual, not authorized amounts) through FY 2009, of which about $2.4 million was earmarked annually for FY 2006 through 2009. The primary designated programs are

- The Long-Term Bridge Performance (LTBP) Program,
- The Innovative Bridge Research and Deployment (IBRD) Program,
- The High-Performance Concrete (HPC) Bridge Research and Deployment Program,
- The Ultra-High-Performance Concrete (UHPC) Research Program,

- The Higher-Performing Steel (HPS) Bridge Research and Technology Transfer Program, and
- The Steel Bridge Testing Program.

The earmarks are in two areas:

- Seismic research, and
- Wood/fiber-reinforced polymer (FRP) composite materials and structures.

Designated Programs

The LTBP Program is an ambitious multiyear research effort that is being modeled somewhat after the LTPP Program. The LTBP Program has been designed as a 20-year effort that will include detailed inspection and periodic evaluation and testing of a representative sample of bridges throughout the United States to monitor and measure their performance over an extended period. The LTBP program also includes a set of instrumented bridges that can provide continuous, long-term structural bridge performance data, as well as detailed forensic autopsies on bridges using some of the structures that are decommissioned by state transportation agencies. The intent is to collect actual performance data on deterioration, corrosion, or other types of degradation; structural impacts from overloads; and the effectiveness of various maintenance and improvement strategies typically used to repair or rehabilitate bridges. The resulting LTBP database is expected to provide high-quality, quantitative performance data for highway bridges that will support improved designs, improved predictive models, and better bridge management systems.

The IBRD Program was established to encourage highway agencies to accept more rapidly the use of new and innovative materials and technologies or practices in the construction of highway structures.[2] The intent of the program is to promote, demonstrate, evaluate, and document the application of innovative designs, materials, and construction methods in the construction, repair, and rehabilitation of bridges and other structures. The

[2] This program was not funded in FY 2008 because of a budget rescission enacted by Congress that affected selected items in the federal budget. At the time of this writing, it was not clear whether the program would be rescinded again in FY 2009. For the purposes of this report, the funding is not included for FY 2008 but is included for FY 2009.

goals are to increase safety and durability, reduce construction time and traffic congestion, and reduce the maintenance and life-cycle costs of bridges. The program includes support for innovative research in the areas of hydraulics, aerodynamics, and geotechnical engineering; another part of the program supports the deployment of innovative approaches in the construction of bridges throughout the United States.

The HPC Bridge Research and Deployment Program is a subset of the IBRD Program; it is intended to continue the advancement of HPC applications through targeted research that addresses needed improvements in design, fabrication, erection, and long-term performance to achieve the strategic goals of the IBRD Program. HPC research is focused on material and casting issues, including improved performance criteria, lightweight concrete, curing, and test methods; structural performance concerns, including compression, shear, and fatigue behavior for both seismic and nonseismic applications; and concepts related to accelerated construction and bridge system design and performance.

ILLUSTRATIVE RESEARCH BENEFITS

Prefabricated Components

Manufacturing steel and reinforced concrete components offsite for bridges and tunnels is nothing new. Today, however, the task of reconstructing or replacing heavily used highway facilities has expanded the use of prefabricated components in some startling ways. In some cases, the components are manufactured thousands of miles from the job site; in others, they are manufactured immediately adjacent to the site. Either way, the highway community is seeing a rethinking of how design and construction can be better integrated.

When the Texas Department of Transportation needed to replace 113 bridge spans on an elevated Interstate highway in Houston, it was able to reuse the existing columns, but the bent caps (the horizontal connections between columns) needed to

(continued)

be replaced. As an alternative to the conventional and time-consuming cast-in-place approach, researchers at the University of Texas developed and tested new methods for installing precast concrete bents. Used on the project, the precast bents cut construction time from 18 months to just over 3 months.

As part of a massive project to replace the San Francisco–Oakland Bay Bridge, the California Department of Transportation and the Bay Area Toll Authority needed to replace a 350-foot, four-lane viaduct section on Yerba Buena Island. In this case, the contractor, C. C. Myers, prefabricated the section immediately adjacent to the existing viaduct. The entire bridge was shut down for the 2007 Labor Day weekend while the existing viaduct was demolished and the new 6,500-ton segment was "rolled" into place. All of this was accomplished 11 hours ahead of schedule.

Probably the most extensive and stunning collection of prefabricated applications on a single project was used on the Central Artery/Tunnel Project ("Big Dig") in Boston. For the Ted Williams Tunnel, twelve 325-foot-long steel tunnel sections were constructed in Baltimore, shipped to Boston, floated into place, and then submerged. For the tunnel section underneath the Fort Points Channel, which is part of the I-90 extension, bridge restrictions made such an approach infeasible. Instead, a huge casting basin was constructed adjacent to the channel, where thirty 50-ton concrete tunnel sections were manufactured. When all of the sections were complete, the basin was flooded, and the sections were winched into position with cables and then submerged. To build the extension tunnel under existing railroad tracks with poor underlying soil conditions, an even more complex process was used. Concrete and steel boxes were built at one end of the tunnel and then gradually pushed into place through soil that was frozen, by using a network of brine-filled pipes.

SOURCE: Skinner 2008.

In addition to the program funding research and development (R&D) on HPC, but funded separately from IBRD, the UHPC Research Program continues R&D of optimized applications for the use of UHPC. UHPC, also known as reactive powder concrete, is a unique material that is reinforced with short steel fibers and requires no conventional steel reinforcement. Prior FHWA research on UHPC focused on basic material characterization and the development of optimized structural systems using this very high-performance but costly material. Under the UHPC Research Program, additional work is being conducted to further characterize the material and assess its corrosion-resistance properties while addressing its use in other structural components, including precast bridge deck panels and prestressed I- and bulb-tee girders.

The HPS Bridge Research and Technology Transfer Program is a broad-based effort aimed at resolving a number of issues and concerns with respect to the design, fabrication, erection, and long-term performance of both conventional and high-performance steels. The program is focused on research and technology transfer and education in the areas of materials and joining (e.g., optimized welding processes and procedures), long-term performance (including advanced knowledge of the performance limitations of weathering steels and the potential development of a 100-year shop-applied permanent steel coating system), innovative design (including testing and deployment of modular steel bridge super- and substructure systems), and fabrication and erection tools and processes.

Finally, the Steel Bridge Testing Program is focused on the further development and deployment of advanced nondestructive evaluation (NDE) tools that can be used to detect and quantify growing cracks in steel bridge members and welds. As defined in SAFETEA-LU, the NDE technology should be able to detect both surface and subsurface cracks in a field environment for flaws as small as 0.010 inch in length or depth.

R&D Earmarks

SAFETEA-LU directed FHWA to conduct research in two specific areas with designated research institutions. The earmarks for seismic research are for the University of Nevada, Reno, and the University of New York at Buffalo, Multidisciplinary Center for Earthquake Engineering Research (MCEER).

ILLUSTRATIVE RESEARCH BENEFITS

Specialty Portland Cement Concretes

New generations of specialty concretes have emerged that improve one or more aspects of performance and allow for greater flexibility in highway design and construction.

High-performance concrete typically achieves compressive strengths of at least 10,000 pounds per square inch (psi). Today, ultra-high-performance concretes are emerging whose formulations include silica fume, quartz flour, water reducers, and steel or organic fibers. They achieve improved durability and compressive strengths of up to 30,000 psi, allowing engineers to employ thinner sections and longer spans.

Latex-modified concrete overlays have been used for many years to extend the life of existing deteriorated concrete bridge decks. The Virginia Department of Transportation has pioneered the use of very early strength latex-modified concretes for this application. In high-traffic situations, the added costs are more than offset by the savings in traffic control costs and reduced delays to users.

Concrete is seldom poured on highway projects when air temperatures dip below 40°F because costly insulation techniques are required. Using commercially available admixtures that depress the freezing point of water, the U.S. Army Cold Regions Research and Engineering Laboratory has developed new concrete formulations that retain the necessary strength and durability properties and allow for concrete construction at temperatures as low as 23°F. This significantly reduces construction costs compared with insulation techniques and can extend the construction season in cold-weather regions.

As useful as these and other specialty concretes are, the introduction of nanotechnology and nanoengineering techniques to concrete research, now in its infant stages, holds the potential for even more dramatic improvements in the performance and cost of concrete.

SOURCE: Skinner 2008.

The focus of the program at the University of Nevada, Reno, is on improving the seismic resilience of the federal-aid highway system. The specific objectives are to provide a comprehensive assessment tool for measuring highway resilience by improving on the current Risk for Earthquake Damage to Roadway Systems technology developed under the previous Transportation Equity Act for the 21st Century (TEA-21) seismic research program, develop design aids for the design of structures subjected to near-fault effects, develop new technologies to improve bridge seismic design, work with stakeholders to implement the developed methodologies and technologies, and conduct outreach to transfer knowledge and improve seismic safety. The objective of the program at MCEER is to develop innovative technologies and demonstrate their applications for enhancing the seismic performance of highway bridges, with a focus on cost-effective methods for implementing design and retrofit strategies.

The earmark for wood/FRP composite materials and structures is for the University of Maine. This research focused on the development and application of wood/FRP composite materials as primary structural members in highway bridges.

SHRP 2 Renewal Program

SHRP 2 is funded by FHWA and administered by the Transportation Research Board (TRB). TRB convenes the committees that govern the program and oversee specific program areas, manages the process by which researchers compete for the research funding, and establishes the processes for merit and peer review.[3] The formation of SHRP 2 included an intensive priority-setting process, which included substantial opportunities for stakeholder input (TRB 2001a).

SHRP 2 follows the general structure outlined in TRB's *Special Report 260: Strategic Highway Research: Saving Lives, Reducing Congestion, Improving Quality of Life,* which was requested by Congress in TEA-21. Following the publication of that report in 2000, the states and FHWA collaborated

[3] FHWA is included in the program governance. The FHWA administrator is on the main oversight committee, two FHWA participants are on the Technical Coordinating Committee, and FHWA staff are involved in the Expert Task Groups.

on the development of detailed research programs for a new strategic highway research program. SHRP 2 was promoted aggressively by the states with the understanding that they would accept having some of their capital program funds shifted to research. Instead of funding the program under Title I (the highway funding title) of SAFETEA-LU, however, Congress funded the program through Title V (the research funding title) until passage of the Technical Corrections legislation in June 2008, which shifted the program's funding to Title I. The governance structure for the program is designed so that stakeholders set the program direction and approve research funding. SHRP 2 funds research across four different areas, one of which—the Renewal Program—involves infrastructure. (A listing of all SHRP 2 projects as of July 2008 appears in Appendix B.)

The goal of the SHRP 2 Renewal Program is to renew aging infrastructure through rapid design and construction methods that cause minimal disruption and produce long-lived facilities. The $28.9 million program takes an integrated approach encompassing engineering, finance, contracting, planning, safety, maintenance, and customer relations. The emphasis is on innovation in project delivery through integrated, systemic changes in the processes used to design, fund, and build new infrastructure.

By a commonly used definition in the highway field, SHRP 2 is an earmark because the amount and recipient are specified. The American Association for the Advancement of Science (AAAS), however, uses a more nuanced definition for earmarks in its tracking of R&D earmarks in all fields of science (AAAS 2006). Its definition depends on the "performer" of the funded activity.[4] Whereas TRB administers SHRP 2, all research funds (80 percent of the total amount of funding received) are awarded on a "full and open" competitive basis, and the proposals of universities, consulting firms, and research institutes are subject to merit review by peers. SHRP 2 retains a share of the total funding (about

[4] In AAAS's definition, R&D earmarks are defined as "congressionally designated performer-specific R&D projects not included in agency budget requests." In describing its interpretation of earmarks, AAAS notes that "Congress often designates funding for specific projects or research topics; in some cases such as in DOD's peer reviewed medical research programs the topics may be congressionally designated but the performers are selected competitively so that they are not counted as earmarks" (AAAS 2006).

20 percent) for administration, which includes the costs of meetings for the development of requests for proposals, research oversight, and merit and peer review. Thus SHRP 2 is in a gray area—an earmark by one definition, but not by the definition used by the association representing the scientific community.

ILLUSTRATIVE RESEARCH BENEFITS

Visualization, Global Positioning Systems, and Other New Tools for Design and Construction

For more than 20 years, highway engineers have used two-dimensional computer-aided drafting and design systems to speed the design process and reduce its cost. As important as these systems have been, their benefits have derived essentially from automating the conventional design process, with engineers doing more or less what they had done before, albeit much faster and with greater flexibility.

Today, new generations of three- and four-dimensional systems are introducing innovative ways not only to design roads but also to build them. For example, while three-dimensional visualization techniques are clearly useful for engineers, it is their role in communicating potential designs to affected communities and public officials that represents a new design paradigm. Four-dimensional systems are helping engineers and contractors analyze the constructability of proposed designs well in advance of actual construction. Global Positioning System applications in highway construction include surveying/layout, automated guidance for earth-moving equipment, and quantity monitoring. Other innovations include the use of in situ temperature sensors coupled with data storage, transmission, and processing devices that provide on-site information about the maturity and strength of concrete as it cures.

SOURCE: Skinner 2008.

OPERATIONS RD&T

The safe and efficient operation of the nation's highway system is of great importance to the federal government, which grants states more than $40 billion each year to improve the system's quality and performance. RD&T in traffic operations can make a substantial difference in system performance through improved signaling systems, traveler information, electronic transmission of documents for carriers, and development of techniques to improve practice. This section reviews the operations RD&T programs of FHWA's Offices of Operations and Operations RD&T and the SHRP 2 Travel Time Reliability Program.

FHWA's Offices of Operations and Operations RD&T

In May 2006, the Secretary of Transportation stressed the importance of improving operational performance by issuing a *National Strategy to Reduce Congestion on America's Transportation Network* (USDOT 2007). This strategy outlines a series of actions aimed at making more efficient use of the system, ranging from the promotion of operational and technological improvements to the forging of federal partnerships with urban communities willing to test new congestion relief policies, methods, and tools.

The Secretary's initiative has prompted the U.S. Department of Transportation (USDOT) to focus more attention on operations-related projects and programs, particularly those aimed at congestion relief. During the past decade, the federal government has invested more than $1 billion in ITS research, much of which is aimed at improving highway operations and reducing congestion through traffic, road weather, freight, and incident management (GAO 2005). Funding for the ITS Program (which is administered by RITA) under SAFETEA-LU totals about $100 million per year. Also available is about $7.4 million per year for USDOT to conduct research that assists state and local jurisdictions in measuring and addressing congestion problems, and $800,000 per year to improve freight planning capacity. Despite these RD&T investments, however, congestion continues to grow in metropolitan areas, at a societal cost most recently estimated to total $78 billion annually (Shrank and Lomax 2007).

Within USDOT, responsibility for RD&T addressing highway operations is shared by FHWA's Offices of Operations and Operations RD&T

and supported by the ITS Joint Program Office. This report covers those ITS programs managed by FHWA, as well as the congestion relief and freight capacity building activities. The Office of Operations has integrated the roughly $7.4 million RD&T budget available to it annually through SAFETEA-LU into its program delivery; hence it does not have a discrete program for RD&T. Instead, this funding supports research activities embedded in many services the office provides to states and local governments. (In this review of the $7.4 million for RD&T, the committee selected a few projects to examine in depth that illustrate the nature and range of the RD&T activities supported with this funding.) In addition, FHWA manages some of the ITS R&D projects funded through the ITS Program, examples of which are also discussed.

In alignment with SAFETEA-LU and the Secretary's congestion initiative, FHWA has grouped its operations-related RD&T activities—including those in ITS—into the following priority areas:

- Reducing *recurring* congestion,[5]
- Reducing *nonrecurring* congestion,[6]
- Improving global connectivity by enhancing freight management and operations, and
- Creating a foundation for 21st-century operations.

RD&T activities in the first of these areas, reducing *recurring* congestion, range from the development of a traffic signal timing manual to the scanning of travel demand management practices in Europe. Two activities in this priority area are examined in this section—Adaptive Control Software (ACS) Lite and Congestion Pricing. RD&T aimed at reducing *nonrecurring* congestion ranges from the development of performance metrics for work zone management to the ITS CLARUS initiative to develop and evaluate advanced road weather information products. An example activity in this priority area that is reviewed in this section is the Traffic Incident Management (TIM) Program.

The priority areas of improving global connectivity and creating a foundation for 21st-century operations include RD&T to assess state-of-the-art

[5] Recurring congestion is that created more or less routinely when more users are attempting to use a facility than it can handle at one time.

[6] Nonrecurring congestion is caused by special events, unusual weather, and crashes.

models for freight forecasting, support demonstration projects for regional transportation collaboration, and develop metrics for measuring operational performance. The Electronic Freight Management (EFM) Program, a key initiative in the priority area of improving global connectivity, is examined in this section.

The four example activities noted above—ACS Lite, Congestion Pricing, TIM, and EFM—reflect the range of operations-related RD&T. Each is described in turn below. This is followed by a discussion of the SHRP 2 Travel Time Reliability Program.

ACS Lite

ACS for intersection signals has been used in some large U.S. cities since the mid-1990s. This technology, which has received much attention in the ITS Program, can improve the operational performance of arterial roads by enabling real-time changes in signal timing in response to changes in traffic flows, especially unanticipated or short-term changes that cannot be accommodated by timing patterns developed for assumed volume levels. Full-scale ACS, however, requires a significant investment in hardware and software and thus is suitable primarily for large cities with hundreds of signalized intersections. Except for a handful of large cities, therefore, pretimed and actuated traffic controls are used at most signalized intersections in the United States.

FHWA estimates that an appreciable share (about 5 percent) of highway congestion can be attributed to poor signal timing and that some medium-sized and smaller cities may have traffic conditions suited to adaptive control methods. A survey of public highway agencies conducted by FHWA revealed that most were reluctant to invest in ACS because of concern about purchase costs, maintenance requirements, and incompatibility with existing signal control systems. Accordingly, FHWA has sought to develop a simplified, or "lite," adaptive control product that would leverage the large ITS investment in ACS but would be affordable for smaller cities and could be retrofitted to their existing closed-loop traffic control systems.

Working with the National Electrical Manufacturers Association, FHWA invited signal system manufacturers to participate in research aimed at developing an ACS Lite product. Four companies accepted the invitation. FHWA used a competitive bidding process for software devel-

opment, contracting with a team of researchers from Siemens, Purdue University, and the University of Arizona. The researchers worked with the four vendors to develop generic software that could be modified to work with each vendor's controller software and application programs.

On the basis of a 2005 field test of ACS Lite, researchers estimated that savings in vehicle fuel and delay time averaged $340 per day, or $88,500 per year (Ghaman 2006, 28). Following additional deployments, the savings in vehicle fuel and delay time from the Houston area field test were estimated to be about $2,000 per day (Ghaman 2006, 29). On the basis of data from these initial deployments, FHWA estimates average annual benefits of $800,000 per system, with a system consisting of 10 to 12 controlled intersections. The estimated cost for system installation is $30,000 to $80,000. FHWA spent $500,000 on the ACS Lite software development effort and anticipates 800 ACS Lite systems being installed by 2010.

Congestion Pricing

The Secretary's congestion initiative positions USDOT in a leadership role in finding and implementing solutions to congestion, including solutions that involve pricing the use of transportation facilities to manage demand. Meanwhile, SAFETEA-LU gives states greater flexibility to use pricing to manage congestion. Several provisions in SAFETEA-LU pertain to congestion pricing. These include the Value Pricing Pilot Program, funded at $59 million through FY 2009 to support the costs of implementing up to 15 variable-pricing pilot programs nationwide, and the Express Lanes Demonstration Program, which allows for a total of 15 pricing demonstration projects through FY 2009. (These two programs are not funded through Title V of SAFETEA-LU. Some of the $7.4 million in operations RD&T supplements these programs with funding for evaluation.)

FHWA supports congestion pricing through various means, including funding research to assess the impact of road pricing on vehicle throughput, sponsoring congestion pricing workshops, developing primers on congestion pricing techniques and experiences, and providing state and local governments with a central source of information on pricing strategies and techniques. Through the Value Pricing Pilot Program, FHWA has worked with agencies in more than a dozen states to demonstrate the feasibility and benefits of congestion pricing on transportation facilities.

Traffic Incident Management

The National Strategy to Reduce Congestion calls for USDOT to advance low-cost operational and technological means of improving highway operations. The TIM Program, funded at $1 million in FY 2007, is intended to advance such means by providing research and technology assistance for the development of comprehensive and performance-oriented TIM programs in communities. The basic goal of TIM is to further a multipronged approach to managing traffic incidents, which are major causes of nonrecurring congestion on urban highways.

TIM consists of a number of RD&T activities. A major area of research is the development of performance measures for TIM. Through workshops, conferences, and other means of communication and outreach, FHWA division offices are working with states to identify appropriate measures and sources of measurement data. FHWA is also aiding in the development of a self-assessment process that states and local communities can use for collaborative assessment of their TIM programs and sharing of their experiences to identify opportunities for improvement.

FHWA is preparing a handbook to aid states and local communities in implementing full-service patrols for emergency response and TIM. This handbook describes the functions of these patrols and explains equipment and training requirements. FHWA is also developing documents describing best practices for TIM, covering such subjects as the development and adoption of clearance laws, incident management in work zones, and traffic control during incident management.

To aid in training personnel for effective TIM, the National Highway Institute is offering a course for emergency responders on the use of incident command systems during highway incidents. To further the adoption of comprehensive and multijurisdictional approaches to incident management, FHWA is working through the National Traffic Incident Management Coalition (NTIMC) to promote comprehensive TIM programs. Organized by the American Association of State Highway and Transportation Officials (AASHTO), NTIMC comprises national organizations of agencies and providers of transportation, emergency medical services, law enforcement, and towing and recovery. NTIMC is committed to promoting, developing, and sustaining multidisciplinary, multijurisdictional TIM programs to achieve enhanced responder safety; safe, quick traffic incident clearance; and more prompt, reliable, interoperable communications.

FHWA also participates with the ITS Joint Program Office in the development and demonstration of integrated computer-aided dispatch traffic management centers (CAD-TMC). While most major metropolitan areas have advanced TMCs, many of these centers are not integrated with the CAD systems used for incident response. To demonstrate how the integration of these systems can improve TIM and how institutional barriers to their integration can be overcome, FHWA and the ITS Joint Program Office are sponsoring operational tests and evaluations of CAD-TMC. A CAD-TMC user group, composed of transportation and public safety practitioners, has been formed to discuss technical, institutional, and operational issues encountered in implementing these systems.

Electronic Freight Management

One of the reasons given for the Secretary's congestion initiative is that delays and unreliability are so pervasive in the transportation system that they are threatening the productivity of the freight supply chain on a national level. FHWA's Office of Freight Management and Operations, within the Office of Operations, has responsibility for numerous freight-related activities within FHWA, including those related to freight forecasting and research, the promotion of cost-effective infrastructure for freight, and border-crossing issues and technologies. One of the office's responsibilities is to promote the deployment of technology to facilitate the smooth flow of goods through the nation's transportation system. Freight movement, particularly international movement, involves numerous information exchanges among multiple entities, both public and private. To facilitate these exchanges, the Office of Freight Management and Operations is involved in EFM, an ITS initiative.

The aim of EFM is to improve shipment visibility, reduce redundant data entry, facilitate exchanges with government authorities, and enhance security by simplifying and streamlining the exchange of information among supply chain partners. From the public sector's standpoint, improving freight efficiency and data exchange offers a number of potential benefits that justify government involvement, including faster and more reliable filing of government-required information, better access to freight data for the purpose of transportation infrastructure planning and investment, reduced congestion on transportation facilities and resultant emissions, and opportunities to enhance freight safety and security.

ILLUSTRATIVE RESEARCH BENEFITS

Intelligent Transportation Systems

Investments in ITS research over the past decade or more have yielded many technological and system improvements. The development and application of monitoring and sensing systems is providing real-time travel information in many corridors. Software based on complex algorithms developed by studying traffic flows is improving the ability of traffic control systems to adapt traffic signals to optimize traffic flow; these improvements, in turn, reduce congestion and the excess vehicle emissions resulting from stop-and-go travel. In-vehicle technologies, combined with traffic management systems for transit, are providing customers with real-time information about when the next bus or train will be arriving and allowing operators to maintain headways by avoiding bus bunching. Monitoring systems and information dissemination technologies are providing travelers with better information about traffic incidents, which allows those who can do so to choose alternative routes or travel times. Electronic information is making the collection of tolls and parking fees more efficient for both agencies and travelers. Dynamic pricing enables operators to manage scarce capacity more effectively and allows travelers to select the level of service they desire and pay for superior service quality (for example, the use of high-occupancy toll lanes in some states). Real-time information about weather conditions is giving automobile and truck drivers better information about the safety of travel conditions during adverse weather. Electronic transmission and screening of freight carriers and cargo documents are reducing delays to private carriers and improving the quality of information available to public agencies.

As these and other ITS technologies continue to be deployed and improved, definitive estimates of their impacts on mobility, safety, and the environment will become available. The popular-

(continued on next page)

Illustrative Research Benefits: Intelligent Transportation Systems *(continued)*

ity of information about travel conditions and weather and the time savings associated with electronic transactions make it likely that passengers and private carriers value the benefits accruing from investments in ITS research. Many more benefits can be expected as more advanced technologies are proven in the laboratory and the marketplace.

Most large carriers and shippers already track cargo within their system and transmit cargo information outside their system to public and private organizations. EFM is intended to provide an open system by which all carriers and shippers have this capability, using Internet-based technologies. Use of the Internet to make data broadly available to authorized and authenticated users in real time is viewed as key to improving information exchange and to making freight networks more efficient and secure. The idea is to develop a system that is able to accommodate a multitude of organizations, both public and private, and is able to adapt to changing business environments and user needs.

FHWA is working with the freight industry through the Intermodal Freight Technology Working Group (managed by the Intermodal Association of North America) to identify specific EFM projects to be pursued. EFM is also building on the outcomes of other freight-related ITS programs, including the electronic supply chain manifest. A limited demonstration of Internet-based EFM services for information sharing using some of the suppliers and carriers involved in the working group is being planned. During the test, the role of EFM and its value to FHWA, the Federal Motor Carrier Safety Administration (FMCSA), and other government agencies will be examined.

SHRP 2 Travel Time Reliability Program

The $18 million SHRP 2 Reliability Research Program targets the variability of travel time, which affects how much time is needed to reach a destination and how much extra time drivers must allow to arrive within a

desired time window. Travel time reliability is important to both travelers and shippers; it is also an aspect of the congestion problem on which transportation agencies can make significant gains even as travel demand grows. The original RD&T plan for SHRP 2 operations, prepared before SAFETEA-LU was authorized, anticipated a much larger level of funding than was ultimately available to the program. The plan was subsequently restructured to accord with available funding levels.

SHRP 2 reliability research addresses the root causes of unreliable travel times by focusing on how the highway system is operated. Research projects will develop reliability data, performance measures, and monitoring programs; design and assess institutional architectures; improve the means of integrating operations activities into planning, modeling, and decision making; aid the implementation of operations strategies; and examine trends, alternative futures, concepts of operations, and innovations.

Because travel time reliability is a relatively new field of investigation, opportunities for early impact may exist. For example, techniques have been developed to manage special events, but they may not have been made available for wider application. A greater challenge is to be forward looking, to evaluate the potential contributions of advanced technologies that could reinvent the frame of reference for operations strategies. The first two SHRP 2 research projects discussed below address this challenge.

Overall guidance for reliability research is provided by a Technical Coordinating Committee (TCC) made up of experts and stakeholders. This group decides about overall program goals and direction and the scope of projects and recommends the funding allocation among projects. The SHRP 2 Oversight Committee approves the funding allocation. Requests for proposals for each research project are prepared under the guidance of Expert Task Groups (ETGs). The ETGs also conduct merit review of the proposals received and make recommendations to the Oversight Committee, which makes final decisions on contract awards to bidders. All contracts are competed and awarded in full and open competition.

The travel time reliability research plan is based on four themes that provide context for individual projects:

- Data, metrics, analysis, and decision support;
- Institutional change, human behavior, and resource needs;
- Incorporating reliability in planning, programming, and design; and
- Fostering innovation.

Data, Metrics, Analysis, and Decision Support

The first issue addressed by SHRP 2 reliability research is the need for data on travel times, how they are influenced by nonrecurring incidents, and how well travel time variation is reduced by different methods. Research in this area will determine data types, measurement methods, and analysis tools. An archival system will be developed to support transportation agencies at all levels in monitoring travel times and related reliability measures, developing and using performance measures and models, and evaluating actions to control and mitigate nonrecurring congestion. A guidebook will help practitioners establish reliability monitoring programs. Technical relationships between mitigation measures and performance will be developed so that practitioners will have a basis for making informed choices. And mechanisms will be devised to incorporate reliability estimation into planning and operations models.

Institutional Change, Human Behavior, and Resource Needs

In any complex system, the human actors are critical. In the area of highway operations and incident management, these actors are numerous and quite diverse: managers of highway agencies and their technical staff; the political leaders who provide authorization, budgets, and oversight; drivers; emergency responders; maintenance and construction workers; and businesses and sponsors of special events. Reduction of congestion related to nonrecurring events will require significant modifications to the intra- and interorganizational structures and business practices of transportation and public safety agencies. Impact mitigation will require new organizational systems, practitioner interactions, and effective communications. Research in this area will provide agency managers and practitioners with information to guide them in making business process and institutional changes in support of improved reliability. Managers will be given guidance for effectively disseminating travel time reliability information to road users in several alternative formats so they can make informed driving decisions.

Case studies from both domestic and international transportation organizations and from nontransportation industries, together with the insights gained from research in organizational behavior, are identifying the most effective practices and organizational structures for managing 24-hour facilities, with a specific emphasis on how these management

approaches can improve incident management and travel time reliability. A focused training program is being developed to ensure that all professionals who respond to highway incidents—transportation staff, firefighters, police, emergency medical personnel, tow truck operators, material spill responders—are well versed in the state of the art of safe and efficient incident response procedures in traffic environments. Driver behavior is being addressed in two ways. One project addresses travel time information by examining the accessibility and utility of mechanisms and technologies for providing this information and then assessing their effects on system performance. A second involves the use of video and other data collected in past studies and SHRP 2's safety field study to learn how drivers behave in work zones or in the vicinity of crashes, special events, or other incidents. Results from these driver-oriented studies should lead to better traffic management and more effective communication with drivers.

Incorporating Reliability in Planning, Programming, and Design

The data, tools, and information about institutional and human behavior developed in the above two areas will need to be consolidated and incorporated into the planning, programming, and design processes used by transportation agencies to improve traffic conditions and reduce and mitigate nonrecurring congestion. Currently, the technical procedures needed to incorporate mobility and reliability performance measures into the transportation investment process are not available, and as a result, the effects on traditional capital expenditures of short- and long-term strategies aimed at achieving improved reliability cannot be determined. Similarly, the effects of alternative design features that can improve reliability have not been fully evaluated, and those features that have been evaluated are not included in design manuals.

Research in this area addresses the need for improved tools to identify and evaluate the effectiveness of infrastructure and operational countermeasures and to quantify the impacts of nonrecurring congestion on overall highway capacity. The research will link changes in performance measures to individual reliability improvement strategies so that trade-offs between capital and operating costs can be integrated into the traditional programming process. The effort will include pilot studies of the procedures in a number of agencies. In coordination with work in the

capacity area of SHRP 2, travel time reliability will be included among the factors considered in the highway planning and programming process. Reliability performance and the costs and effectiveness of measures to improve reliability will be incorporated into the key steps that lead to decisions about how the transportation system evolves and is operated.

Highway design features—such as median crossovers and wide pavement shoulders—and crash investigation sites are being studied to assess their costs and effectiveness in managing incidents to reduce travel time variability. Many such features are currently in use but not included in standard design guides because of perceived high costs and the lack of data on potential cost savings. The research will also address other designs used in countries outside of the United States, such as active traffic management, which combines lane control, variable speed limits, hard shoulders, and handling of accident investigation sites so highway system managers can control traffic flow both laterally and longitudinally. Results of these analyses will be used to develop nonrecurrent congestion factors for the *Highway Capacity Manual* and the *AASHTO Policy on Geometric Design*—standard reference materials for highway designers. Translating research results into practical guidance that meets the requirements of these design documents is essential in influencing actual highway designs.

Fostering Innovation

The research described thus far is focused largely on making significant improvements in the short term and takes much of the current highway environment as given. Yet many technological, social, and institutional developments are occurring and will continue to do so; thus highway operations must be capable of functioning in new environments and even of generating these environments. Research in this area will focus on fostering innovative thinking that can form the foundation for long-term reductions in nonrecurring incidents and improvements in travel time reliability. One project will define user requirements, performance standards, and present and future concepts of operations to provide guidance for agencies on the best alternative operations strategies to improve travel time reliability. A second project will develop a portfolio of innovative ideas, supported by accompanying proofs of concept, aimed at improving reliability. The intent is to undertake several small experiments or pilot studies to explore innovative ideas deemed promising for future application.

PLANNING AND ENVIRONMENTAL RD&T

FHWA's planning and environmental RD&T covers a wide range of topics and engages many different stakeholder groups. Annual budgets average $18.6 million over the life of SAFETEA-LU. Included in this amount are two earmarks totaling about $1.3 million annually in FY 2007–2009 (a third earmark for $700,000 in FY 2006 was for 1 year only). Under SAFETEA-LU, total funding for RD&T in planning and environmental RD&T declined by at least 13 percent from the previous authorization.[7] Aside from the earmarks, the main source of FHWA's RD&T funding for planning and environmental topics comes from the Surface Transportation Environment and Planning (STEP) Cooperative Research Program, which was authorized and funded in SAFETEA-LU.

The SHRP 2 Capacity Program is designed to foster highway improvements in full compliance with planning and environmental requirements. The $18 million program of activity includes several significant projects dealing explicitly with planning and environmental issues associated with adding or improving highway capacity.

Approximately $13.9 million is allocated annually for the STEP Program, which is a new initiative for FHWA. A similar surface transportation planning and environmental cooperative research program was authorized in TEA-21, but specific funding was not authorized or appropriated. TEA-21 did call for an advisory committee to recommend environmental research. This committee of experts from academia, environmental groups, and transportation agencies, convened by TRB with funding from FHWA, recommended a research agenda and governance structure for a cooperative research program (TRB 2002). AASHTO and others encouraged funding for the program during reauthorization. SAFETEA-LU authorized the STEP Program and required stakeholder involvement in merit review of proposals and program governance; it also left administration of the program up to the discretion of the Secretary. Because of funding constraints, FHWA lost funding it had previously relied on for research,

[7] With regard to research funding only, funding for the planning and environmental program declined by 13 percent between TEA-21 and SAFETEA-LU. In the prior legislation, however, this area also received substantial technology deployment funding, which, when combined with research funds, results in a percentage decline between the two authorizations that is almost twice as large.

technical assistance, outreach, training, and other services to constituents in the planning and environmental area. As a result, the agency has had to rely on the STEP Program for such purposes.

FHWA's STEP Program for FY 2008 is divided among planning and environmental topics, development of technical tools, and administration and outreach. It is further subdivided into 17 emphasis areas intended to support 55 different activities. Each year the STEP Program plan may vary on the basis of departmental priorities and stakeholder input; the topic areas and funding amounts given in Table 3-2 and described below are those proposed for FY 2008.[8]

Planning

One could describe the bulk of the activities in the planning area as efforts on each of the topics listed in Table 3-2 to identify and share best practices and encourage technical exchange through websites, training and technical assistance, peer exchanges, workshops, and conferences. The program could include research on a diverse set of topics, such as visualization practices (use of three-dimensional imagery of proposed projects) to improve the quality of public involvement, the ramifications of various new financing techniques, strategies to better link land use and transportation planning, opportunities for metropolitan planning organizations (MPOs) to work together, analysis of causes of border congestion, quantification of the costs of border delay, digital mapping of the National Highway System, and case studies of the economic development consequences of rural highways.

Environment

Possible research activities in FY 2008 in the area of air quality include updating, expanding, and testing tools and strategies to reduce transportation-related greenhouse gas (GHG) emissions; analyzing how national GHG reduction strategies might affect transportation; examining GHG reduction strategies; and providing funding for USDOT's Climate Change Center. Other activities could include outreach and

[8] Program and research plans can be found at www.fhwa.dot.gov/hep/step/fy08rp.htm.

TABLE 3-2 FY 2008 Surface Transportation Environment and Planning Program Budget by Emphasis Area (Before Technical Corrections)

Emphasis Area	Number of Recommended Activities	Proposed FY 2008 Budget ($)
Planning		
Congestion	1	750,000
Safety Planning	1	100,000
Freight Planning	1	100,000
Public Involvement, Environmental Justice, Visualization in Planning	1	375,000
Other Activities That Support State/Local/Tribal Planning Capacity Building	9	2,425,000
U.S./Canada and U.S./Mexico Border Planning	2	400,000
National Security, Defense, and Interstate Planning	3	300,000
Environment		
Air Quality and Global Climate Change	4	1,148,500
Water, Wetlands, Vegetation, Wildlife Habitat, Brownfields	8	1,070,000
Historic Preservation	2	225,000
Bicycle/Pedestrian and Health	1	70,000
Noise	1	200,000
Outdoor Advertising Control/Realty Program Management	4	300,000
Environmental Streamlining/Stewardship	5	1,663,500
Context-Sensitive Solutions	2	500,000
Tools to Support Planning and Environment		
Travel Modeling	1	730,000
Geographic Information Systems/Spatial Information for Improved Decision Making	6	400,000
Program Management and Outreach	3	1,000,000
Associate Administrator for Planning, Environment, and Realty		659,491
Total	55	12,416,491

communication, evaluation of new emission models, and analysis to support project-level emissions estimates.

In the Water, Wetlands, Vegetation, Wildlife Habitat, Brownfields area, possible activities include technical exchange of research and other information with professionals; support for a best management practices storm water database; collaboration on research with other federal agencies; development, compilation, and sharing of the latest informa-

ILLUSTRATIVE RESEARCH BENEFITS

Waste and Recycled Materials

Highway construction has a long history of employing waste and by-product materials from other industries. The motivations have been simple—help dispose of materials that are otherwise difficult to deal with and reduce the initial costs of highway construction. The challenge has been to achieve these benefits without compromising critical performance properties or introducing materials that are potentially harmful to people and the environment. As concerns about sustainability have become more prominent in public thinking, the incentives to use by-product materials have grown. In addition, because reconstruction and resurfacing of highways create their own waste, the recycling of construction materials increasingly makes economic and environmental sense. Research and demonstration have generated many success stories about the use of by-product and recycled materials in ways that simultaneously meet performance, environmental, and economic objectives.

- Crumb rubber from old tires, for example, has received increased acceptance as an additive for selected hot-mix asphalt pavement mix designs, and a number of patents have been issued concerning the production and design of "crumb rubber" or "asphalt rubber" pavements. Several states, notably California and Arizona, use asphalt rubber hot mix as an overlay for distressed flexible and rigid pavements and as a means of reducing highway noise. Materials derived from discarded tires have also been used successfully as lightweight fill for highway embankments and as backfill for retaining walls and for asphalt-based sealers and membranes.
- Fly ash and silica fume—residues from coal-burning power plants and metal-producing furnaces, respectively—are

(continued)

becoming relatively common additives to portland cement concrete. Fly ash concretes can reduce the alkali–silica reactions that lead to premature deterioration of concrete, and increased reliance on fly ash reduces the carbon dioxide emissions resulting from cement production. Silica fume is a component of ultra-high-performance concrete.

- After many years of experimentation and trials, reclaimed asphalt pavement (RAP) is now used routinely in virtually all of the states as a substitute for aggregate and a portion of the asphalt binder in hot-mix asphalt, including Superpave® mixes. Typically, the reclaimed material constitutes 25 to 50 percent of the "new" mix. The National Asphalt Pavement Association (NAPA) estimates that each year, 90 percent of the asphalt pavement removed is recycled, and approximately 125 million tons of RAP is produced, with an annual savings of $300 million. NAPA reports that asphalt pavement is the most recycled material in the country.

SOURCE: Skinner 2008.

tion on managing the environmental aspects of rights-of-way; development and sharing of information on fish passages under bridges and through culverts; and assessment of infrastructure impacts on endangered species.

Much of the activity in the environmental area could be characterized as developing and sharing information and providing technical assistance:

- Historic preservation work will involve identifying and sharing information on best practices for integrating the protection of historic places into early planning activities while also making the process more efficient.
- Bicycle/pedestrian and health funds will be devoted to data gathering.

- Activities dealing with noise will be limited to improving and updating a noise model developed by FHWA for use by state departments of transportation (DOTs).
- Outdoor Advertising Control/Realty Program Management will fund the development of stewardship tools for local governments; stakeholder dialogue, communication, and outreach; and peer exchanges.
- Efforts in the Environmental Streamlining/Stewardship area will focus on developing and applying performance measures, identifying and sharing best practices with states, and providing technical assistance.
- In the Context-Sensitive Solutions area, a clearinghouse of information and targeted technical assistance will be provided.

Technical Tools

Funding provided for travel modeling will support the outreach components of the Travel Model Improvement Program, which include training; technical assistance; development of case studies of best practices; support for peer exchanges on modeling topics; and mechanisms to share information through websites, reports, brochures, and workshops. The funding will also support follow-up work to respond to the recommendations made with regard to improvements to travel models and modeling practice in *Metropolitan Travel Forecasts: Current Practice and Future Direction* (TRB 2007). Work on geographic information systems (GIS) is designed to assist practitioners through enhancement of the GIS website, identification and communication of best practices, peer exchanges, and development of methodologies for using GIS to support decision making.

Program Management and Outreach

The funding provided for this area will be used to assess and facilitate the implementation of the STEP Program, provide resources to support dissemination, and support stakeholder outreach. Potential RD&T activities include program support, website development, workshops, scans, training, technical assistance, publications, and conferences.

Other FHWA Planning and Environmental Activities

SAFETEA-LU designated funding in two environmental areas: a Center for Environmental Excellence (about $1 million annually) and Advanced Travel Forecasting ($2.2 million annually). The former, which was competed for and won by AASHTO, serves as a resource for transportation professionals to promote environmental stewardship and streamlining of the transportation delivery process. The latter funds implementation of the Transportation Analysis and Simulation System (TRANSIMS) modeling system in pilot locations. TRANSIMS is an advanced modeling system developed by Los Alamos National Laboratory through a $25 million earmark in TEA-21.

There are two earmarks. One is for implementation of the Transportation, Economic, and Land Use System (TELUS) (about $800,000 annually), a software and decision-support system for MPOs that links transportation improvement planning processes with state air quality implementation planning processes. TELUS was developed through earmarks in previous legislation to the New Jersey Institute of Technology. The software is used by MPOs nationwide. The other earmark (about $500,000) goes to the National Association of Development Organizations for the Center for Transportation Advancement and Regional Development, a technical resource for development officials in rural areas and small communities.

SHRP 2 Capacity Research

The original vision of the SHRP 2 Capacity Program was for an $80 million, 6-year effort to develop fully integrated planning and programming processes that would take advantage of new technology. "Fully integrated" meant that the program would result in earlier and more complete consideration of all important community, environmental, economic, and other issues in the planning process for highway capacity expansion. When the Capacity Program was reduced to $18 million over 4 years in SAFETEA-LU, the TCC overseeing the program had to start over; the reduced funding would not have been sufficient to allow for the envisioned levels of process and technological innovation.

The 78 percent cut in funding resulted in a radically curtailed effort, far short of original program goals. The reduced and restructured program

focuses on evaluating key decision points and developing approaches to resolve the issues that emerge in a more timely fashion than is currently the case. Projects include development of a broader understanding of the multiagency decision-making framework; investigation of improved methods for analyzing economic, community, environmental, and conservation issues as part of the analysis of alternatives; development and testing of more sensitive transportation demand models; evaluation of the extent to which smart-growth development reduces highway travel demand; and better integration of freight transportation needs into highway planning. Improved understanding of these key issues and the sharing of this information with state and local decision makers and planners should enhance the quality of state and local decisions and reduce some of the delays in project development associated with the planning process. SHRP 2 is closely coordinated with FHWA and state planning activities to make efforts complementary and avoid duplication.

SAFETY RD&T

Safety RD&T funded through Title V includes (*a*) about $13.7 million annually for FHWA safety RD&T activities, about 20 percent of which is earmarked to four different organizations, and (*b*) about $12 million annually for the SHRP 2 Safety Research Program. FHWA's safety RD&T activities were reduced by about 30 percent between TEA-21 and SAFETEA-LU.

FHWA Safety Programs and Safety Research

The mission of FHWA's safety RD&T programs is to help reduce highway crashes and related fatalities and injuries by developing and implementing a program of nationally coordinated research and safety-related technological innovations. The programs are guided by the four E's of highway safety: engineering, education, enforcement, and emergency response. FHWA's Office of Safety and the safety research activities conducted at the Turner–Fairbank Highway Research Center are closely coordinated in the development of products and guidance for practitioners. The program is focused on roadway departure (58 percent of fatalities); intersections (21 percent); pedestrians (11 percent); and, beginning in 2008, speed

(estimated to be a contributing factor in 32 percent of fatal crashes). Funding is split fairly evenly between safety programs and research.

Roadway Departure

Addressing the roadway departure problem requires focusing on the multiple factors that contribute to crashes: driver, vehicle, and infrastructure. Within USDOT, FHWA's primary responsibility is infrastructure-related factors (both roadway and roadside).[9] The key objectives for reducing crashes due to roadway departure and their severity are as follows:

- Keep vehicles safely in their appropriate places on the roadway (decrease the number of vehicles leaving their lanes or the roadway).
- Provide clear recovery areas off the roadway and traversable side slopes to reduce the likelihood of a crash should a vehicle inadvertently leave the roadway.
- Provide crashworthy road and roadside features to reduce the severity of crashes that occur when clear and traversable roadsides are not possible for errant vehicles.

The program is focused on developing and promoting a greater knowledge base on roadway departure and advancing analysis methods and tools that can help improve the effectiveness of countermeasures aimed at keeping vehicles on the road and reducing the consequences of leaving the roadway. A goal of the program is to enhance guidance on the proper deployment of countermeasures and the systematic assessment of risk to maximize the application of cost-effective treatments.

The website for FHWA's safety programs offers a variety of practitioner-oriented documents on such topics as markings and signage, nighttime visibility, rumble strips, resurfacing, pavement edge drop, and roadside hardware. Research activities include development of the Interactive Highway Safety Design Module for analyzing the design of rural two-lane roads to improve safety and the development of Safety Analyst, a set of software tools for safety analysis of existing roads. Both of these tools represent a considerable advance over merely designing to standards.

[9] To ensure that federal efforts are coordinated, FHWA works closely with the National Highway Traffic Safety Administration, which has primary responsibility for driver- and vehicle-related contributing factors, and FMCSA, which has responsibility for truck crashes.

ILLUSTRATIVE RESEARCH BENEFITS

Median Cable Barriers

After the Missouri Department of Transportation (MDOT) identified as a major concern crashes in which drivers leave the roadway and cross the median into the path of oncoming vehicles, it initiated a research project to investigate possible solutions. MDOT determined that for long-distance installation on rural Interstates, cable barriers are a more cost-effective safety device than concrete barriers or guardrails.

When a cable barrier is struck, the posts yield, and the cable deflects up to 12 feet, effectively catching and decelerating the vehicle and keeping it in the median. A cable barrier therefore has an advantage over more rigid systems because the striking vehicle is less likely to reenter the driving lanes after hitting it.

MDOT began installing cable barriers in the medians of Interstates on which crashes were frequent but then decided to install the barriers systemwide on highways whose medians were 60 feet or less in width. Installation costs varied from $60,000 to $100,000 per mile, depending on the amount of grading required, and maintenance costs range from $6,000 to $10,000 per mile, depending on the frequency of hits.

The cable barriers were shown to keep striking vehicles from crossing the median in 95 percent of cases, which dramatically reduced fatalities. On Missouri's heavily traveled I-70, the state experienced 24 cross-median fatalities in 1999 before any median barriers had been installed. After about 20 miles of cable barrier had been installed, the number of fatalities declined to 14 in 2004. After 179 miles of the barriers had been installed, the number of cross-median fatalities fell to only two in 2006.

SOURCE: Chandler 2007.

Intersections

Reducing intersection and intersection-related fatalities is a key goal of FHWA's national safety programs. The Intersection Safety Program includes strategies and projects that address this goal by focusing on the development of tools, technologies, and services to assist decision makers and practitioners. The program has the following objectives:

- Provide support to encourage the most effective use of existing intersection safety information, strategies, countermeasures, and analysis techniques.
- Identify, develop, refine, expand, and share new analysis tools, success stories and best practices, research results, information on the effectiveness of countermeasures, and new technologies for intersection safety.
- Develop, evaluate, and market nontraditional intersection and interchange designs.
- Develop and market major new ITS technologies, such as the Cooperative Intersection Collision Avoidance System.

Examples of materials for practitioners on the FHWA website include guidebooks and manuals for dealing with new designs (diamond interchanges and roundabouts) and guidance on pedestrian and bicycle safety at intersections.

Pedestrians

Through the Pedestrian Safety Program, FHWA works to raise the quality of pedestrian facilities—for example, by offering technical assistance in the development of pedestrian safety action plans with the potential to have immediate results. The program is also aimed at ensuring that engineers are educated about pedestrian safety and accommodation so they will consistently incorporate these considerations into the design of pedestrian facilities. The program's specific objectives are to

- Develop and implement pedestrian safety plans in cities and states with significant numbers of pedestrian fatalities per year,
- Provide practitioners with tools and technologies to help identify and solve their pedestrian crash problems,
- Develop and evaluate promising countermeasures for reducing pedestrian crashes,

- Form partnerships to facilitate technology transfer activities for the wide range of pedestrian safety strategies, and
- Evaluate and develop ITS technologies for pedestrian detection and warning systems to prevent potential pedestrian–vehicle collisions and determine which of these systems will significantly reduce pedestrian fatalities and injuries.

The FHWA website includes practitioner-oriented documents related to pedestrian safety, such as road audit procedures for analyzing pedestrian risk.

Speed Management

Speed management applies a balanced engineering, enforcement, and education (3E) approach to achieve safe and appropriate speeds for conditions on the basis of scientific research and, when appropriate, includes technologies designed to aid in mitigating a specific problem. No single technique can effectively accomplish the goal of reducing speed-related fatalities and injuries. Accordingly, the Speed Management Strategic Initiative was developed jointly with the National Highway Safety Traffic Administration and FMCSA in 2005. It consists of 18 strategies and 53 key actions grouped under five main areas of focus—data, engineering, enforcement, education, and integration. FHWA is the lead agency accountable for most of the engineering efforts. However, state and local agencies and stakeholder organizations play important roles in ensuring desired outcomes.

The strategies being developed in the Speed Management Program are designed for implementation across various jurisdictions and on different types of roadways. They include the following:

- Improve knowledge, understanding, and awareness of the dangers of inappropriate speed.
- Identify and promote engineering methods for creating a safer road environment with appropriate travel speeds, consistent speed limits, and condition-responsive warnings.
- Identify and promote effective speed enforcement and penalties that target dangerous drivers, on dangerous roads, at dangerous times.
- Work with governmental and nongovernmental organizations to promote an integrated 3E approach and encourage local action to manage speed and crash risk more effectively.

The FHWA website mentions a specific research project—a field operational test of variable speed limits—and provides guidance on speed management in work zones.

SHRP 2 Safety Research

The goal of the $43.2 million SHRP 2 Safety Research Program is to improve understanding of driver behaviors in the roadway environment, particularly those associated with the risk of crash involvement. Despite the known importance of driver error as a cause of crashes, understanding of behaviors associated with this risk has been lacking, in large part because of the difficulty of conducting such research. The development of in-vehicle technologies to monitor behavior, coupled with successful pilot studies employing these technologies and demonstrating approaches to data management and risk measures, has opened up an entirely new and promising area of highway safety research.

The committee classifies this research area of SHRP 2 as advanced research. The research has two overall components. The largest is a naturalistic driving study that will involve about 2,500 drivers of instrumented vehicles. The other is a smaller initiative to design a program of site-based collection of driver performance data. Both vehicle- and infrastructure-based technologies will be used to gather precrash, crash, and exposure data that have never before been collected on such a large and systematic scale. The resulting information may substantially enhance understanding of precrash factors and thereby improve the design of safety countermeasures.

Although a major share of the cost of the SHRP 2 safety research goes to the program's massive data collection efforts, the research should yield a "comprehensive assessment of the interaction of driving behavior and performance with roadway, environmental, vehicular, and human factors, and the influence of these factors and interactions on collision risk, especially on lane departure and intersection collisions" (Campbell and Mason 2008, 5). In the naturalistic driving study, data will be collected from volunteer drivers of 2,500 vehicles over a 2- to 3-year period. Their vehicles will be instrumented with cameras and sensors to observe the driver, driver views, steering, braking, lane keeping, and other behaviors. Detailed data will also be collected on the roads used by the volunteer

drivers. For the site-based study, data will be gathered on all traffic passing through given road segments. These two studies will collect massive amounts of visual and other data. Part of the effort in both studies will be devoted to developing new procedures for extracting and analyzing data on events that could lead to crashes. The large amount of data being gathered will be necessary to establish statistical relationships among behavior, traffic conditions, roadway conditions, and other factors.

POLICY RESEARCH

FHWA's Office of Policy and Governmental Affairs is the locus of research and analysis to inform policy decisions in support of USDOT, the executive branch, and Congress. In addition to supporting research, the office collects, analyzes, and distributes highway-related data; provides access to international sources of information on highway practice and research; initiates key policy reports on the condition and performance of highways that inform decisions about total levels of funding needed for the federal-aid highway system and provide the technical basis for federal highway taxes on various classes of highway users; develops analytical tools and data systems for policy development and studies; conducts analyses and studies to support the formulation of transportation policy and legislative initiatives; and monitors and forecasts economic, demographic, and personal and commercial travel trends.

Policy research at FHWA is an important but relatively small-scale activity within FHWA's overall RD&T activities. In the last year of funding under TEA-21, the Office of Policy and Governmental Affairs received about $9.5 million, $470,000 of which went to international activities, whereas under SAFETEA-LU, the only funding received ($211,000 in FY 2006 and 2007) went to the international program. In the 2008 Technical Corrections legislation, the funding for policy research increased to $1.2 million, which, while welcomed, is still 87 percent less than was received under TEA-21. This significant cut was inadvertent on Congress's part. Policy research under TEA-21 was funded through authorized but undesignated funds for RD&T. Because of funding constraints, however, FHWA had no funds available for policy research and analysis and the development of related technical tools. For the technical aspects of its report to Congress, the National Surface Transportation Policy and Revenue

Study Commission (2007) relied heavily on the staff of the Office of Policy and Governmental Affairs, the office's data programs, and the models developed for reports the office prepares for Congress on a regular basis; these activities of the office were supported by funds dedicated to the commission.

The Office of Policy and Governmental Affairs has several "product lines" that are well known and relied on by professionals working in transportation policy. Perhaps best known is the semiannual *Status of the Nation's Highways, Bridges, and Transit: Conditions and Performance.*[10] These reports to Congress are relied upon for several purposes, including the development of estimates of the funding levels for surface transportation reauthorization legislation. Also well known are reports on truck size and weight that inform national and state regulations on truck dimensions, the most recent example of which is the *Comprehensive Truck Size and Weight Study* (USDOT 2000). From time to time, the office also prepares a highway cost allocation report, which forms the technical basis for the allocation of tax rates for different highway users, particularly trucks. The last such report was produced in 1999 and updated in 2000.[11] Research funds have been used in the past to develop the suite of complex models required to support these reports. As indicated above, no funding is authorized for these activities under SAFETEA-LU. The 2006 *Conditions and Performance* report was made possible by work initiated in 2002. Before passage of the Technical Corrections legislation, the 2008 report was being updated with no improvement to the technical tools used in developing estimates of condition and performance. (The Technical Corrections legislation designated $1 million for FY 2008 and 2009 for updating of the *Conditions and Performance* report.)

The Office of Policy and Governmental Affairs is also responsible for important data systems and reports. These include the Highway Performance Monitoring System,[12] which uses sample data provided by states to develop measures of the highway system's condition and performance, and the *Highway Statistics* series,[13] which provides annual statistical reports on highway mileage, finance, condition, and performance.

[10] www.fhwa.dot.gov/policy/olsp/reportspubs.htm.
[11] www.fhwa.dot.gov/policy/olsp/reportspubs.htm.
[12] www.fhwa.dot.gov/policy/ohpi/hpms/index.htm.
[13] www.fhwa.dot.gov/policy/ohpi/hss/index.htm.

ILLUSTRATIVE RESEARCH BENEFITS

Roundabouts—A Successful Innovative Technology

As a result of exposure to new designs and research results during an international scan, U.S. practitioners became excited about the potential of modern roundabouts to improve traffic flow and safety. The publication *Roundabouts: An Informational Guide* (FHWA 2000) provided a wealth of information on the international benefits of roundabouts, design practices, and many adaptations from AASHTO policies on geometric design that would permit wide-scale use of an improved roundabout design in the United States. Although a few roundabouts had already been constructed before its publication, the guide lent legitimacy and credibility to an alternative intersection design and control proven to be safer, with operational benefits. FHWA promoted this innovative technology through training and workshops presented by staff of its Safety R&D and Resource Center. Before the publication of the FHWA guide, two states—Florida and Maryland—had developed preliminary guidelines. Many states have now adopted the FHWA guide, and several have developed their own detailed guidelines inspired by that publication.

Approximately 800 roundabouts have been built in more than a dozen states. More states and cities are adopting the technology as its benefits are further analyzed and confirmed. The safety benefits of one- and two-lane U.S. roundabouts range from a 68 to 82 percent reduction in injuries and fatalities and an average 35 percent reduction in total crashes (Rodegerdts et al. 2007).

Currently, roundabouts are applicable mainly for low and medium traffic levels with balanced flows. Safety and operational evaluations of other innovative approaches to serve most inter-

(continued)

section and interchange conditions are under way. FHWA is working on several research studies and a report designed to provide information on the safety and operational benefits of these innovations, along with design recommendations and accommodations for all users. These innovative treatments include continuous-flow intersections, median U-turn intersections, superstreet intersections, quadrant designs, diverging diamond interchanges, and displaced-left diamond interchanges.

Policy research funds have also been used in the past to support econometric research on the value and economic return of highway investments. Such macroeconomic information is useful to policy makers in deciding on levels of highway funding in reauthorizations of the highway program. Funding has not been available for this activity under SAFETEA-LU.

The Office of Policy and Governmental Affairs is involved in international activities as well. These include seeking out and sharing information about innovations and practice throughout the world that would be useful to FHWA and the states. The best known of the office's international activities is a series of international scans, funded jointly with AASHTO through the National Cooperative Highway Research Program, which have introduced many innovations to U.S. practice. One example of a successful scan and follow-up research and implementation is the remarkable safety improvements achieved through modern roundabouts. Because of the severe cuts to this program under SAFETEA-LU (from $470,000 in the last year of TEA-21 to $247,000 during SAFETEA-LU), the number of international scans has been reduced.

Lacking in the international research arena is a single office within USDOT with information on ongoing international research collaborations. Interest and activity in this area involving U.S. and European and other partners have grown in recent years. Such collaborations hold promise for sharing insights across borders and reducing the potential for duplicative effort, but an office within USDOT is needed to collect information on these activities, monitor progress, and provide guidance.

UNIVERSITY TRANSPORTATION CENTERS PROGRAM

Although the UTC Program is multimodal and managed through RITA rather than FHWA, the committee has taken a keen interest in this program for several reasons: (*a*) most of the research conducted through the program is on highways; (*b*) universities are the best institutions to conduct the advanced research the committee believes is so urgently needed; (*c*) the program is building the workforce of the next generation of highway researchers and administrators; and (*d*) the funding for this program has grown sharply over the last three authorization cycles to the point where it represents a significant portion of the total research authorized under Title V, and therefore an important share of the total highway research funded by Congress.

The UTC Program was initiated under the Surface Transportation and Uniform Relocation Assistance Act of 1987, which authorized $10 million annually for the establishment and operation of transportation centers in each of the 10 federal regions. The program was reauthorized in the Intermodal Surface Transportation Efficiency Act (ISTEA) and expanded in subsequent reauthorizations. TEA-21 increased its size through earmarking of specific centers, added an emphasis on education by specifying this as one of the primary objectives of a UTC, and reinforced the program's focus on multimodal transportation. SAFETEA-LU again expanded the program by adding substantially more funding and earmarking even more centers.

TEA-21 authorized about $32.4 million annually for grants to establish and operate up to 33 UTCs throughout the United States in FY 1998 to 2003. Ten of these centers, designated as Regional Centers, were selected competitively in 1999. The other 23 UTCs were located at universities earmarked in TEA-21. (See Appendix D for more detail on participants in the UTC Program as of July 2008.) Congressional designations for the UTC Program in FY 2001 amounted to 93 percent of the potential grants. During FY 2002, 17 existing centers competed among themselves for funding for the final 2 years of TEA-21 authorization.

SAFETEA-LU authorized 60 UTCs and earmarked funds for another 16 universities outside of the UTC Program.[14] Total authorized funding

[14] Eight of these UTCs are earmarked in Title III of SAFETEA-LU (the Transit title), but they are not restricted to transit topics.

for the UTC Program under Title V was increased in SAFETEA-LU to about $67 million annually. In Title V, SAFETEA-LU provides funding for universities in four separate categories: national, regional, Tier I, and Tier II. Ten universities in the national category are earmarked to receive the largest level of funding for individual centers (see Appendix D). National schools are authorized $3.5 million each for FY 2006 to 2009.[15] In the regional category, 10 universities were selected in a competition to represent each federal region. Regional schools are authorized $2 million each for FY 2006 and 2007 and $2.25 million for FY 2008 and 2009. In the Tier I category, 10 schools competed against other earmarked schools for continued funding during the final 2 years under TEA-21. These schools recompeted in FY 2006 and will compete on a 4-year cycle. They are authorized to receive $1 million annually. The 22 earmarked Tier II schools are authorized to receive $500,000 annually through FY 2009.

UTCs authorized through Title V must match their federal funding with nonfederal funds (with limited exceptions) on a dollar-for-dollar basis. The committee is most interested in this program for the research it will fund but recognizes that it is also an important educational program that can serve to attract students to the transportation profession. Some of the UTC research funds are supporting graduate students for this very purpose. This funding may or may not result in groundbreaking research; in either case, it is providing support to train the next generation of transportation professionals.

Program Components

Oversight of the original program begun under ISTEA was based on the detailed proposals universities submitted as part of the competition. There is little program oversight, however, for the earmarked universities.[16] The

[15] Actual funds received will be less because of the obligations limit on total authorized funding and because of the overdesignation and overearmarking of activities in the legislation (more funds were approved by Congress for programs and earmarks than were actually authorized in total).

[16] RITA does require all UTCs to develop detailed strategic plans, and funding is dependent on RITA's approval of those plans. Recipients are also required to collect and report various output measures.

legislation itself provides little specificity as a basis for program oversight other than stating that the program objectives are to "advance significantly the state-of-the-art in transportation research" and "expand the workforce of transportation professionals." These activities are to be conducted through peer-reviewed research, education, and technology transfer.

Issues

The UTC Program began under ISTEA as a small program ($10 million annually for 10 centers) that was designed around a competitive process to ensure quality and relevance. The program has grown sixfold in funding over three authorization cycles, while the number of funded centers has increased fivefold. The bulk of the funding is awarded and the involved universities (about 60 percent) are selected without competition. In reviewing the UTC Program, RTCC identified three significant issues: (*a*) relevance, (*b*) fragmentation, and (*c*) quality control.

Relevance

The new, broad requirement SAFETEA-LU places on UTCs conducting highway research is that their work support the research priorities identified by a loose coalition of highway experts and interested parties in the National Highway R&T Partnership (2002) report *Highway Research and Technology: The Need for Greater Investment* and the Federal Transit Administration's (FTA's) National Research and Technology Program.[17]

For competitively awarded funds, the Secretary of Transportation has discretion in specifying the content for proposals, and schools are encouraged to propose unique themes to avoid duplication. SAFETEA-LU does not impose these quality control requirements for grants to earmarked institutions, but RITA has encouraged this approach for all funded pro-

[17] The *Highway Research and Technology* report identifies a large number of high-level research priorities. It was intended to provide justification by stakeholders for a much larger total investment in highway research than existed under TEA-21; it was not designed to be a research program plan. Thus almost any discrete surface transportation R&D activity could be made to fit within the broad range of R&D identified in the document. FTA's National Research and Technology Program is described in the agency's *Strategic Research Plan* (FTA 2005), which is expected to be updated and revised over time but is still at a fairly general level.

grams. The Secretary is required to evaluate each of the programs at least annually. SAFETEA-LU initially did not include increased funding for USDOT or for staff that oversee the expanded UTC Program; the limited funding for program coordination, annual review, and oversight (about $300,000 annually in contract authority for FY 2006 and 2007) amounted to about $5,000 per UTC per year. The Technical Corrections legislation increased authorized funding for program administration and UTC evaluation to about $1.15 million annually for FY 2008 and 2009.

The main mechanism for ensuring the relevance of the UTC Program is the matching requirement: as noted, both competitively selected and earmarked schools funded through Title V must match federal funding on a one-to-one basis. (Those universities earmarked in Title III—the Transit title—are not required to match funding.) The matching requirement applies to both the research and education components of the UTC Program. For the most part, UTCs seek matching funds from state DOTs. Many state DOTs support research through individual universities, and some have designated a state school or a statewide consortium to conduct some or all of their research agenda. (State DOTs, however, typically decline to provide the match for education.) Although matching does ensure relevance to the cosponsoring institution, it also has at least two unintended consequences.

First, because state DOTs provide a large portion of the matching funds and because states, for the most part, are interested in applied, problem-solving research, much of the matched research conducted through the UTC Program is highly applied. Indeed, one could argue that much of the work supported by State Planning and Research funds would be better characterized as demonstration or implementation of research than as applied research. To gain a sense of what topics the UTCs were using the funds to research, RTCC searched all UTC projects in the Research in Progress database, maintained by TRB, as of May 23, 2008. Of the 1,130 UTC research projects in the database, 779 (69 percent of the total) were self-reported by UTCs as addressing highways. The specific topics encompassed administration, design, energy and environment, finance, maintenance, operations, pavements, planning, safety, and structures. Examination of a 10 percent sample of these projects indicated that at

least 80 percent were highly applied research; the remaining 20 percent may have been advanced research under a liberal interpretation of advanced, but that proportion is probably too high. This applied research bias diverts the program away from the strength of universities, which is in knowledge creation through basic and fundamental research.[18] Another disadvantage of the matching mechanism is that it inhibits the ability of professors and graduate students to undertake self-initiated research projects on important topics that are not currently of priority interest to the state DOTs with matching funds, such as research on strategies to reduce energy consumption or respond to climate change. The applied research bias resulting from the matching mechanism also conflicts with the reward system for most university professors and university programs, which are rated in part on the basis of publications in the most prestigious journals (which usually do not accept papers reporting highly applied research).

Second, FHWA is unable to influence the direction of UTC programs because it has almost no resources to provide as matching funds. Moreover, SAFETEA-LU restricts the use of federal funds for matching purposes. For example, FHWA might build on the strengths of universities through its advanced research program, where it does have discretion, but these funds are not allowed as a match for the UTC Program.

In summary, the matching requirement does bolster relevance and has surely strengthened the ties between state DOTs and universities within their states. Because most matching funds are used for applied research, however, the program diverts universities from their natural strength in knowledge creation. In addition, the limitation on sources of federal funds for matching makes it difficult for FHWA to influence university programs. Many UTCs welcome the opportunity to partner with federal agencies. The last matching dollar into the program, however, tends to be the most influential.

[18] This is not a new observation. In 1993, a TRB committee tasked to help USDOT review the UTC Program commented, "The centers continue to operate under operating constraints and requirements that are not always conducive to achieving stated goals. For example, the matching requirements compel centers to be responsive to the goals and priorities of local and federal sponsors; typically, local sponsors are interested in applied research and not the high-risk, cutting edge research envisioned by the program's founders" (TRB 1993, 2).

Fragmentation

Although university funding has expanded significantly under SAFETEA-LU, so has the number of schools. Indeed, the program appears to be fragmented, for in addition to the 52 centers funded in Title V, some centers are consortia, often with several partners. UTC Program staff estimate that there are probably about 120 universities participating in the program. If so, the average annual funding per institution would be about $500,000.[19] A further disadvantage of having so many different institutions involved is that relatively little of the funding actually goes to research.

Moreover, because most schools in the program are earmarked and there are no requirements for project content other than to support the national research strategy identified in *Highway Research and Technology: The Need for Greater Investment* (National Highway R&T Partnership 2002) and the FTA National Research and Technology Program, the overall university research effort lacks coherence. Thus, there is the risk that considerable funds will be provided for the program each year, but those funds will be divided up in so many ways that by the time they reach individual researchers, the amounts may be too small to "advance significantly the state-of-the-art in transportation research," a SAFETEA-LU criterion for the UTC Program.

The lack of overall coordination could also lead to duplication of research. To address this, RITA requires UTCs to post their ongoing research in the online Research in Progress database. Although this requirement at least provides a place for individual researchers to check to see whether peers are already addressing potential topics of interest, it does not by itself lead to a coherent strategy.

Quality Control

Scientific knowledge has advanced dramatically in recent decades in the United States in part through the normal processes of quality control. Among the most important of these processes are competition for funds and merit review in the selection of finalists (TRB 2001b, 6). Only 38 percent of the Title V UTCs are awarded their funding competitively.

[19] Contract authority for the Title V UTC Program in FY 2006 was about $61 million annually (lower than the authorized amount of more than $70 million), and the funds were not divided evenly since national centers were authorized to receive $3.5 million, regional centers $2 million, Tier I centers $1 million, and Tier II centers $500,000.

Although most UTCs are earmarked, some distribute the funds they receive through a competitive process. Competitive awarding of research funds received by universities is one means of ensuring accountability for the public funds provided. Yet the researchers allowed to compete are typically restricted to the center's faculty or universities that make up its consortium.[20] RITA requires UTCs to have a peer or merit review process for awarding their research funds, but it does not require that the funds be competed outside of the home institution or consortium.

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Abbreviations

AAAS	American Association for the Advancement of Science
FHWA	Federal Highway Administration
FTA	Federal Transit Administration
GAO	Government Accountability Office
TRB	Transportation Research Board
USDOT	United States Department of Transportation

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[20] The competitive process varies widely, but one common example is selection of the best research proposals from among a pool of those solicited.

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4

Principles for Highway Research and Technology Investments

This chapter describes the principles for highway research that Congress included in the Safe, Accountable, Flexible, Efficient Transportation Act: A Legacy for Users (SAFETEA-LU). The first section below describes all eight principles contained in SAFETEA-LU. The second section reduces this number to six principles that inform this assessment: two overlapping principles are combined, and another that is not relevant to this report is dropped from further discussion.

EIGHT PRINCIPLES FOR HIGHWAY RESEARCH

In Title V of SAFETEA-LU, Congress articulated the following eight principles for highway research, development, and technology (RD&T):

1. **Full innovation cycle,** which stipulates that the RD&T program should include all activities leading to implementation.
2. **Justification for federal role,** which describes the criteria under which federal investment in RD&T is justified.
3. **Federal role,** which specifies the kinds of activities the federal program should include.
4. **Program content,** which defines the kind of RD&T the Federal Highway Administration (FHWA) should pursue.
5. **Stakeholder input,** which stipulates that FHWA research must address the needs of stakeholders.
6. **Competition and peer review,** which requires open competition and merit review by peers of almost all proposals for grants, contracts, and cooperative agreements.[1]

[1] The committee interprets the congressional intent to be that competitively solicited proposals should be selected for award on the basis of a merit review by peers.

7. **Performance review and evaluation,** which requires that all projects include a component of performance review and evaluation.
8. **Technical innovation,** which requires that the activities carried out by FHWA be consistent with the surface transportation research and development (R&D) strategic plan mandated by SAFETEA-LU.

In the following subsections, these principles are described in greater detail.

1. Full Innovation Cycle

As stated in SAFETEA-LU, "Surface transportation research and development shall include all activities leading to technology development and transfer, as well as the introduction of new and innovative ideas, practices, and approaches, through such mechanisms as field applications, education and training, and technical support." Thus the definition of R&D encompasses a wide range of innovations and explicitly includes technology transfer and implementation. In brief, this principle stipulates that FHWA RD&T includes the entire innovation cycle (agenda setting, research, development, demonstration, peer review, implementation, and evaluation), as well as activities that support implementation (education, training, and technical support). As will become clear, this principle and the "federal role" principle overlap.

The intent of this principle is that federal highway research activities as a whole should include all the elements that lead to innovation. As is clear in the description of the highway research programs of FHWA and the Research and Innovative Technology Administration (RITA) in Chapter 3, some of the programs are devoted to particular elements of the innovation cycle; for example, the advanced research program is devoted exclusively to the conduct of fundamental research. However, it is not necessary that each program encompass the full innovation cycle, but that the entire portfolio of federal programs do so.

2. Justification for Federal Role

The following four criteria would justify federal expenditures on highway RD&T:

- The work is of national significance;
- There is a clear public benefit, and private-sector investment is less than optimal;
- The work supports a federal stewardship role in ensuring efficient use of national resources by states and local governments; or
- The work represents the best means to support federal policy goals compared with alternatives.

Other than the stewardship criterion, these criteria are the same as those developed by the Office of Management and Budget for justifying federal investment in research, development, and related activities. They are intended to be applied at the program rather than the project level.

The "national significance" of some research may be, to some degree, in the eyes of the beholder. At a minimum, this criterion would appear to mean that RD&T activities should be of importance beyond a single jurisdiction or small region and to a variety of stakeholders. One operational definition would be that (*a*) the research should be on topics of value to multiple jurisdictions, on subjects other programs are unlikely to address, and uniquely suited to the attributes of the federal program; (*b*) it should be mission-driven to serve national goals; and (*c*) it should be uniquely suited to the federal program.

With regard to "public benefits," FHWA's RD&T program is a tool for achieving such federal goals as improved safety, enhanced mobility, and protection of the environment. A public investment can be justified because private-sector highway R&D is typically less than optimal because of disincentives that discourage privately funded highway research (TRB 2001, 36–38). Because of the nature of public highway procurements, which are highly specified and typically awarded to the lowest bidder, private entities are unlikely to benefit from research in many areas. Examples are new construction techniques, because competitors could easily copy them, and paving or bridge materials or mix designs, because these are typically specified in bid documents. Private R&D is less challenged by procurement practices in some other areas, such as sign materials, traffic signals and controllers, asphalt mixing plant efficiency, and highway construction equipment, and in these areas there is an innovative and competitive private sector. It is worth noting that some private innovations are stymied by highway agencies' reluctance to purchase

proprietary products, since they are typically available only from a single supplier.

The federal stewardship role to ensure efficient use of federal highway funds by states and local governments could be exemplified in any number of ways. Examples are investing in the development of intelligent transportation system technologies that could allow for greater, safer throughput on existing highways; conducting research to improve demand forecasting and planning techniques to help ensure that planned facilities are appropriately sized to meet future demand; or funding environmental research to support better state and local decisions about materials and facilities. Another example is investing in research to gain a better understanding of life-cycle performance so that state and local investments can be made on the basis of life-cycle costs rather than initial costs. Along with federal-aid highway funds, FHWA research programs reflect this criterion by providing policy guidance, technical assistance, and technology transfer to states and local governments.

With regard to the criterion of "the best means to support federal policy goals," research may be the best approach to program efficiency when the means to this end are too difficult to specify or regulate. More broadly, major elements of the federal highway program have become more like a block grant over the years, giving states greater discretion in use of the funds they receive. Thus, FHWA acts less like a regulator than was previously the case by approving program plans rather than projects, and RD&T may be the best way to encourage the risk taking necessary to test and implement innovations.

3. Federal Role

Consistent with the responsibilities defined above, SAFETEA-LU directs the Secretary of Transportation to conduct research, support and facilitate research and technology transfer activities by the states, share the results of completed research, and support and facilitate the deployment of technology and innovation. These elements of the federal role are essentially the same as the "full innovation cycle" principle defined above. Worth noting in particular is the emphasis on support for "the research and technology transfer activities of state highway departments." To a large degree, state departments of transportation (DOTs) are the primary

owners and operators of highways in the United States and are the main vehicle through which federal research and technology innovations reach local governments. The above specific language was included in Title V to incorporate the federal role in coordinating the State Planning and Research Program, which is actually authorized under Title I.

4. Program Content

SAFETEA-LU states that "a surface transportation research program shall include: A. fundamental, long-term highway research; B. research aimed at significant highway research gaps and emerging issues with national implications; and C. research related to policy and planning." These content elements derive from recommendations made by the Research and Technology Coordinating Committee (RTCC) in 2001 (TRB 2001, 6–8).

First, the committee recommended that approximately one-quarter of FHWA's R&D program be fundamental, long-term research. The terms "advanced" and "fundamental, long-term" research are nearly interchangeable. Advanced, or fundamental, research is not as driven by the development and testing of theory as is basic research (knowledge creation for its own sake) and is not as focused on specific solutions as is applied research (development of knowledge to solve a specific problem or meet a specific need).

RTCC also recommended that research aimed at significant highway research gaps and emerging issues account for about one-half of the FHWA RD&T program. The committee's view was that the state DOT R&D programs and the National Cooperative Highway Research Program, as valuable as they are, tend to be focused on solving specific problems defined by practitioners. Among funders of highway research, FHWA is in the best position to review from a strategic perspective the scope of highway RD&T activities under way to determine whether those programs are neglecting important topics. Thus the gaps that should be filled by FHWA are topics of national significance, including emerging issues such as strategies for reducing energy consumption and making reasonable adaptations to climate change, and alternative sources of user fees for funding highway programs. These gaps might also include large-scale applied projects that are simply too big for individual states to undertake.

5. Stakeholder Input

In *Special Report 261,* RTCC recommended that the FHWA program be more responsive to stakeholders. The committee took note of efforts FHWA had made through the National Highway R&T Partnership (2002), but also stated that "more substantive stakeholder involvement in decision making, priority setting, and resource allocation for FHWA's research program is essential" (TRB 2001, 8). In SAFETEA-LU, Congress adopted the committee's recommendations with regard to stakeholder input.

SAFETEA-LU states that "federal surface transportation research and development activities shall address the needs of stakeholders. Stakeholders include States, metropolitan planning organizations, local governments, the private sector, researchers, research sponsors, and other affected groups, including public interest groups." Different stakeholders have different roles at various stages of the RD&T process (Brach 2005). Sponsors (those who pay for the research) have key roles in agenda setting. Scientific and technical experts have essential roles in merit and peer review. Users should be involved at various stages, particularly agenda setting, deployment, and evaluation of effectiveness.

RTCC itself serves as one form of stakeholder input, and an important one, but the committee believes that the full range of stakeholders should be engaged throughout the RD&T process, from helping to identify priorities to assisting in review of proposals and project evaluations. Moreover, the committee has urged that FHWA develop greater transparency in its R&D activities so that stakeholders will know how to become involved and be able to see the results of their participation.

6. Competition and Peer Review

SAFETEA-LU states: "Except as otherwise provided in this chapter [Title V]," "the Secretary shall award, to the maximum extent practicable,[2] all grants, contracts and cooperative agreements for research and development under this chapter based on open competition and peer review

[2] The "maximum extent practicable" was intended to allow for sole-source contracts and uncompeted cooperative agreements when these approaches are appropriate.

of proposals." In *Special Report 261,* the committee stated that "competition and merit review are the best ways of ensuring the maximum return on research funding" (TRB 2001, 8). The committee specifically encouraged Congress to provide funding to FHWA so that experts other than FHWA staff could assist in merit review. Although the committee's intent was to encourage open competition throughout the FHWA program, the main concern behind this proposal was Congress's increased earmarking of FHWA RD&T funds.

7. Performance Review and Evaluation

SAFETEA-LU requires that every project include a component of performance measurement and evaluation and that evaluations be outcome based.[3] This principle is consistent with the overall emphasis on performance measurement of federal programs, but the outcome measures that are appropriate for individual research projects are difficult to specify, particularly because the outcomes of research may not become apparent until long after the research has been completed. At the same time, it is appropriate to evaluate R&D programs in terms of their quality, their relevance, and the results obtained. Such evaluation is a valuable, if not critical, component of providing for accountability in the expenditure of public funds.

8. Technological Innovation

The text for this principle states simply that "the programs and activities carried out under this section shall be consistent with the surface transportation strategic plan developed under section 508." The RD&T strategic plan was subsequently prepared under the leadership of RITA and was itself reviewed in draft form by a committee of the Transportation Research Board (TRB). That committee concluded that the plan was simply a compendium of activities authorized or appropriated rather than being strategic (TRB 2006). Thus, the various pro-

[3] The administration proposal for this language was that it apply to "programs" rather than "projects"; the Government Performance and Results Act requires annual measurement and reporting at the program level.

grams authorized under Title V, conducted by FHWA and RITA, and reviewed by the TRB committee for that report will all be consistent with the RD&T plan, and therefore this principle is not considered further in this report.

SIX PRINCIPLES INFORMING THIS ASSESSMENT

To inform the assessment documented in this report, the committee refined the above eight principles to form a set of six. As will become apparent in the next chapter, not every principle or subprinciple applies to every program. For example, one would not expect to see deployment and training as a major element of an advanced research program. The six principles applied for this assessment are as follows:

1. The federal portfolio should cover the full innovation cycle, including
   - Agenda setting,
   - Conduct of research,
   - Support of research and technology transfer by the states,
   - Sharing of results, and
   - Deployment (including education and training).
2. Justification for federal investment requires that either
   - Activities be of national significance,
   - There be public benefit and suboptimal private investment,
   - Efficient use of federal funds by states and local governments be encouraged, or
   - The activity be the best means to support federal objectives.
3. The content of the federal RD&T program includes
   - Fundamental, long-term research;
   - Filling significant gaps; and
   - Policy and planning.
4. Stakeholder input is addressed.
5. Awards are almost always made on the basis of competition and merit review.
6. Programs include performance review and evaluation.

In the next chapter, individual programs are assessed according to these principles. These assessments together provide an overall evaluation

of the federal investment in highway research and technology in terms of the principles articulated by Congress.

Although the above list is fairly comprehensive and the committee agrees with these principles, this list by itself does not provide for a complete assessment of research programs funded by SAFETEA-LU. In Chapter 5, the committee applies other important criteria, such as the following:

- Are the investments within each area adequate to address vital needs as identified by stakeholders or RTCC?
- Are important areas of RD&T omitted from the programs funded?
- Are important technical topics being neglected?

REFERENCES

Abbreviation

TRB Transportation Research Board

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5

Assessment of Authorized Programs

This chapter presents the committee's assessment of the Title V–authorized programs described in Chapter 3 according to the principles delineated in Chapter 4. The program areas assessed include advanced research, infrastructure, operations, planning and environment, safety, policy, and the University Transportation Centers (UTC) Program. As in Chapter 3, the intelligent transportation system (ITS) research projects funded by the Research and Innovative Technology Administration (RITA) but managed by the Federal Highway Administration (FHWA) and the Strategic Highway Research Program (SHRP) 2 are discussed under the appropriate topic areas (operations and safety for the former, and infrastructure, operations, safety, and planning and environment for the latter).

ADVANCED RESEARCH

Assessment Based on Principles of the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users

The Exploratory Advanced Research Program adheres to the principles articulated by Congress, as refined for this assessment.

1. Full Innovation Cycle

The Exploratory Advanced Research Program is specifically dedicated to fundamental, long-term research and provides a critical opportunity to improve understanding that can lead to enhanced applications.

2. Justification for Federal Investment

The program is clearly a federal responsibility. Very little advanced research in highway transportation is being conducted. The private

sector has little or no incentive to perform this sort of work, and state research and development (R&D) is devoted almost exclusively to applied, problem-solving research. As noted in *Special Report 261* (TRB 2001), this area of research by FHWA will ultimately help provide new ideas for state and federal applied research programs to pursue toward implementation.

3. Content

The Exploratory Advanced Research Program is the only FHWA program dedicated to fundamental, long-term highway research. As noted in Chapter 3, there are also two substantial earmarks for asphalt research—one awarded to a single institution totaling about $3.4 million annually and another to that same institution totaling $6.2 million annually, shared with four other partners—most of which is advanced research.

4. Stakeholder Input

FHWA sought stakeholder input for the initial program Broad Agency Announcement (BAA) during three stakeholder forums held in 2005 and 2006. This information was used to help shape the focus areas of that BAA. Stakeholders for advanced research differ from those for applied research. In applied research, the problem is well defined, and much of the research involves testing known solutions; appropriate stakeholders are those with an understanding of the problem and the potential for known strategies to address it. In advanced research, there may be some idea of the problem to be solved, but the solutions are unknown; thus, appropriate stakeholders are those with a long-term vision and expertise in fundamental areas of research who can guide decisions about promising opportunities for investment (Brach 2005). FHWA interacted with such individuals in preparation for the second round of funding for the Exploratory Advanced Research Program in 2008.

5. Awards Based on Competition and Merit Review

FHWA awards funds on the basis of review of preproposals invited through full and open competition solicited through a BAA. Merit review is conducted by staff experts and experts external to FHWA and the U.S. Department of Transportation (USDOT) from the National Institute for Standards and Technology, the National Science Foundation,

the Transportation Research Board (TRB), RITA, and the National Highway Traffic Safety Administration (NHTSA).

6. Performance Review and Evaluation

Proposals funded under this program are by definition "longer term and higher risk" than the applied research typically funded by USDOT. Therefore, a different set of standards for review and evaluation should apply. Agreements with researchers are designed with regular milestones appropriate for evaluating advanced research. Lead staff for each project are responsible for engaging outside experts with appropriate technical expertise to help in reviewing results once initial projects selected for the program have been completed.

Assessment Based on Additional Criteria

The Research and Technology Coordinating Committee (RTCC) views the Exploratory Advanced Research Program as a genuine opportunity to expand the federal investment in R&D in a fashion that complements the highly applied activities of state programs and the majority of the FHWA program. The current level of investment in the Exploratory Advanced Research Program (about 6 percent of FHWA's program) is well below the 25 percent recommended by the committee in *Special Report 261.* As indicated above, if the asphalt earmarks and SHRP 2 Safety Program funds are included in the definition of advanced research, then the share of FHWA's Title V and SHRP 2 funding devoted to advanced research increases to 15 percent. As discussed in the following section on infrastructure research, development, and technology (RD&T), the committee believes that advanced research should not be earmarked. The committee was previously concerned about the funding requirements imposed on the Exploratory Advanced Research Program. The 50-50 match required for the program by the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU) appeared to be inappropriate for this kind of research and inconsistent with funding for advanced research available in other federal agency programs. This requirement may well have been inhibiting university faculty and other researchers with promising new concepts from participating in the program. Fortunately, the 2008 Technical Corrections legislation reduced the match to 20 percent.

The committee is also concerned about some elements of program execution. The first round of research solicitations appropriately cast a broad net to gather ideas from researchers. The topics for the second round depended more on previous scanning and research by FHWA, thus resulting in a narrower set of potential topics. The committee is concerned about the extent to which this strategy is narrowing the field of possible research topics. Moreover, about 23 percent of the funding allocated through fiscal year (FY) 2008 was retained for intramural research (research conducted by FHWA staff or contractors). Such research, although appropriate at a modest level, is not subject to the same level of competition as extramural research. Thus, the committee would prefer to see most of the advanced research funding allocated for extramural research.

INFRASTRUCTURE RD&T

Assessment Based on SAFETEA-LU Principles

Brief assessments of each infrastructure program described above in terms of the SAFETEA-LU principles are contained in Appendix C and are summarized in Table 5-1. The following consolidated assessment covers all the FHWA and SHRP 2 programs, with variations noted as appropriate.

1. Full Innovation Cycle

The wide variety of research activities in the infrastructure area encompasses agenda setting, advanced research, applied research, evaluation, and technology transfer (deployment and training).[1] The Fundamental Properties of Asphalts and Modified Asphalts Program is, as its name suggests, conducting advanced research, along with the Asphalt Research Consortium, albeit, as discussed below, earmarking is inappropriate for this type of research.[2] Specific programs for deployment include the

[1] It makes better sense to apply this principle to FHWA's entire portfolio of programs rather than attempting to apply it to each program; some programs are limited in scope by their nature (applied research, technology transfer).

[2] FHWA estimates that about 60 percent of consortium funding is advanced research, and about 40 percent is applied.

TABLE 5-1 Summary Assessment of Infrastructure RD&T Programs Based on SAFETEA-LU Principles

Program	Average Annual Funding ($ millions)	1. Full Innovation Cycle	2. Justification for Federal Investment	3. Content	4. Stakeholder Input	5. Competition and Merit Review[a]	6. Performance Review and Evaluation[b]
Innovative Pavement Research and Deployment	18.6	Mainly deployment and evaluation	Suboptimal private investment/ efficient use of federal dollars	Gap filling/ deployment	ETGs	70 percent competed through RFPs	TRB Pavement Technology Committee
Long-Term Pavement Performance	8.3	Data collection	Suboptimal private investment/ efficient use of federal dollars	Gap filling	Ongoing external review committee	Competitive selection of main contractor	TRB LTPP committee
Alkali–Silica Reactivity	2.0	Development, deployment	Suboptimal private investment	Gap filling/ deployment	Alkali–Silica Reactivity ETG	Competitive contractor selection	Alkali–Silica Reactivity ETG
Fundamental Properties of Asphalts and Modified Asphalts	3.4	Advanced	Not a national priority	Advanced	FHWA funding through its limited discretionary funds	None (earmark)	None required (earmark)
Asphalt Research Consortium	6.2	Advanced/ applied	Suboptimal private investment	Gap filling	FHWA funding through its limited discretionary funds	None (earmark)	None required (earmark)

(continued on next page)

TABLE 5-1 *(continued)* Summary Assessment of Infrastructure RD&T Programs Based on SAFETEA-LU Principles

Program	Average Annual Funding ($ millions)	1. Full Innovation Cycle	2. Justification for Federal Investment	3. Content	4. Stakeholder Input	5. Competition and Merit Review[a]	6. Performance Review and Evaluation[b]
Long-Term Bridge Performance	6.4	Data collection/ applied	Suboptimal private investment/ efficient use of federal dollars	Gap filling	AASHTO support along with local governments	Competitive contractor selection	AASHTO bridge subcommittee review
Innovative Bridge Research and Deployment	14.6 in FY 2006 and 2007	Full cycle	Efficient use of federal dollars	Mainly gap filling	Road maps developed with stakeholders	Grant program competed; RD&T conducted at FHWA	Usually reviewed by end-user groups
High-Performance Concrete Bridge Research and Development	4.0 in FY 2006 and 2007	Full cycle	National priorities	Mainly gap filling	Guided by working group of stakeholders	About 35 percent competed, remainder intramural	Usually reviewed by end-user groups
Ultra-High-Performance Concrete Research	0.5	Full cycle	Suboptimal private investment/ efficient use of federal dollars	Mainly gap filling/ deployment	Stakeholders guide work to be done	None—all internal	Usually reviewed by end-user groups

Higher-Performing Steel Bridge Research and Technology Transfer	3.4	Full cycle	Nationally significant/ efficient use of federal dollars	Mainly gap filling/ deployment	TWG guidance	50 percent of funding competed	TWG evaluation
Steel Bridge Testing	1.0	Applied/ deployment	Not a national priority	Gap filling/ deployment	Stakeholder guidance	Full and open	Stakeholders
Seismic Research	2	Applied/ deployment	National priority	Gap filling	Stakeholder guidance	None (earmark)	Stakeholders
Polymer–Wood Composite Materials and Structures	0.7 in FY 2006 and 2007	Applied	Not a national priority	Gap filling	None	None (earmark)	None required (earmark)
SHRP 2: Renewal	7.9	Applied/ deployment	Suboptimal private investment/ efficient use of federal dollars	Gap filling/ deployment	Stakeholder governance, merit review, peer review	Full and open with merit review by expert stakeholders	Peer review by expert stakeholders

NOTE: AASHTO = American Association of State Highway and Transportation Officials; ETG = Expert Task Group; RFP = request for proposals; TWG = Technical Working Group.

[a]Merit review of FHWA programs is normally conducted by technical staff from various offices. External experts are occasionally involved.

[b]Various levels of project and program review are conducted by FHWA staff and managers; this applies to each program in this column. The cells in this column comment on external/stakeholder evaluation of products and peer review of completed research.

Innovative Pavement Research and Deployment Program, the Innovative Bridge Research and Deployment Program, and elements of the Alkali–Silica Reactivity (ASR) Program. The vast majority of the infrastructure RD&T program is applied research and technology transfer to the states and local governments through deployment, training, preparation of manuals, and the like.

Although deployment is a major theme of the FHWA program, the committee questions whether RD&T deployment activities at FHWA are organized to be most effective. As a result of FHWA reorganizations beginning in 1998, virtually all deployment activities have been decentralized to the program offices. This change coincided with substantial cuts in funding for FHWA's technology transfer activities. In the Transportation Equity Act for the 21st Century (TEA-21), compared with a request for $100 million annually, Congress provided only $40 million, and much of that total was earmarked (TRB 1999). In a September 2007 letter report to FHWA, the committee noted that the lack of a central resource within FHWA with explicit expertise in technology transfer could be hampering deployment activities, an observation based on a previous RTCC report (TRB 1999). There is something of a science to technology transfer that requires matching an appropriate strategy to a new technology or practice. There are certainly innovative practices occurring in some programs (see the discussion below regarding operations). The committee also applauds FHWA's efforts to (*a*) identify, market, and track the deployment of market-ready technologies and (*b*) develop and implement a strategic plan for deployment across all of its pavement activities (TRB 2008a). The committee also applauds the Highways for LIFE program, which is funded and being conducted outside of the RD&T program. SAFETEA-LU authorized $75 million in funding for Highways for LIFE—$15 million for FY 2006 and $20 million annually for FY 2007–2009 for activities including demonstration construction projects, stakeholder input and involvement, technology transfer, technology partnerships, information dissemination, and monitoring and evaluation. The missing element among all of FHWA's deployment activities appears to be a resource within the agency with explicit expertise in technology transfer and deployment that could provide guidance to the various efforts agencywide.

2. Justification for Federal Investment

Most of the research funded under infrastructure RD&T could easily be justified by the criterion of public benefit and suboptimal private investment. Virtually all the nation's roads and bridges are owned and operated by some level of governmental or public authority; hence, research to reduce the cost and improve the performance of these assets is public-sector by nature. Much of the research can also be justified under the criterion of national significance. The Long-Term Pavement Performance (LTPP) Program, for example, once brought to fruition, should significantly enhance knowledge about loadings and environmental factors that significantly affect highway design. Given that the nation invests more than $10 billion annually in pavements and that the influence of loadings and environmental factors on pavement service life and performance has not been established, this activity promises considerable future benefit. Most of the infrastructure RD&T on pavements and bridges is also designed to assist states and local governments in making decisions about infrastructure investments that should improve efficiency, another criterion justifying these investments. Evaluation of past FHWA RD&T programs in materials and structures has found substantial savings (and extension of the service life of assets) that far exceed the cost of the research (Battelle et al. 2003).

Some of the research authorized by Congress in the infrastructure area fails to meet the criterion of national significance. FHWA would not have proposed the Steel Bridge Testing Program, given that it considers existing nondestructive evaluation techniques for detecting flaws and cracks to be adequate. Nor is the earmark for research on polymer–wood composites, for which there is little public-sector demand, of national significance.

3. Content

Almost all of the infrastructure research discussed here is filling gaps that are not being addressed by other programs (see Table 5-1). Most of these gaps, but not all, are significant, as indicated above. A small portion of the research is fundamental or advanced in nature. None of it could be classified as planning or policy research, and this represents a significant gap in the program. State departments of transportation (DOTs) face many

policy decisions regarding levels of investment in fixed assets that could be informed by research to address questions such as the following:

- How much should be invested in maintenance to optimize the life-cycle performance of pavements and structures?
- What is the minimal level of asset condition below which replacement costs exceed maintenance and rehabilitation costs?
- What should it cost a state DOT to achieve a percentage point increase of its pavements to an acceptable condition, and what is the benefit–cost ratio of doing so?
- What should government entities negotiate for in concession agreements regarding asset condition at the end of a term, how should this be monitored, and what incentives are required to ensure that private-sector managers meet this commitment?
- With the recent sharp increase in the cost of petroleum and as the cost of asphalt approaches that of concrete, what is the tipping point at which states would make a better investment, on a life-cycle basis, in concrete pavements?

There are many such policy questions in the infrastructure area that are of concern to the states but are not being addressed in the federal program.

4. Stakeholder Input

A number of mechanisms exist across infrastructure RD&T programs for engaging a variety of stakeholders. SHRP 2 is perhaps the most impressive in this regard, in that stakeholders have more than an advisory role, actually setting priorities, deciding about research topics, and approving funding levels and contractors for individual research projects. Several programs in FHWA's pavements and structures area have impressive stakeholder involvement as well. FHWA staff have participated with the asphalt and concrete industries and other pavement stakeholders in the development of research road maps that have influenced the agency's pavement research (to the extent possible given that most pavement research in FHWA's budget is earmarked or designated). The bridge subcommittee of the American Association of State Highway and Transportation Officials (AASHTO) and other bridge stakeholders have been involved in agenda setting and program design in several of

the structures research programs, and products are routinely reviewed by end-user groups. In a presentation to the committee, the chairman of this AASHTO subcommittee commended FHWA for its extensive engagement with the state DOT bridge community. In the pavements area, the LTPP Program has had an external committee of state stakeholders and pavement experts from industry, states, and academia providing ongoing program review and guidance since 1992. FHWA established a high-level committee of experts and stakeholders to provide similar guidance for its entire portfolio of pavement research and deployment activities in 2006. FHWA routinely forms Technical Working Groups (TWGs) representing industry, states, and academia to provide guidance in particular technical areas. For example, a TWG representing state DOTs, industry, consulting, and academia was formed to provide feedback on the ASR Program.

The long-standing congressional earmark for the Fundamental Properties of Asphalts and Modified Asphalts Program, which dates back to at least 1992, has been a notable exception to stakeholder involvement. Funding decisions and research topics have been set by the recipient itself, with little input or support from external stakeholders in the asphalt community. To help address this problem, FHWA asked the Asphalt TWG to review the program.

5. Awards Based on Competition and Merit Review

Of the designated programs that FHWA administers, some [LTPP, Long-Term Bridge Performance (LTBP), Steel Bridge Testing] are completely subject to full and open competition. Several programs devote a share of funding to in-house staff and contractors. Most award at least some share of their funding through competition and merit review. In the Higher-Performing Steel Bridge Research and Technology Transfer Program, half of the funds are competed outside of FHWA. In the High-Performance Concrete Bridge Research and Development Program, 35 percent of funds are competed. In the Innovative Bridge Research and Deployment Program, 70 percent of funds are competed. A good argument can be made that some share of RD&T funding should be intramural to ensure that FHWA staff remain current in their technical fields and have opportunities to make technical contributions. Indeed, RTCC

has made such a recommendation to FHWA in the past. The contractors that support FHWA laboratories are selected competitively. But whether the researchers who make up the teams of the selected contractors have the best talent for individual research projects to which they are assigned is an open question, as elaborated in the following discussion of indefinite-delivery/indefinite-quantity (IDIQ) contracts.

Contracting mechanisms at FHWA range from contracts, to assistance agreements (grants and cooperative agreements), to task order IDIQ contracts. Like other federal agencies, FHWA conducts full and open competition for contracts and cooperative agreements. Competition is also relied on in the awarding of IDIQs. Typically, IDIQs are competed in a full and open fashion. Once a small number of contractors have been selected, however, tasks under these agreements are usually offered for competition among these preapproved bidders. The issue that arises for universities with IDIQs is that university researchers are often listed as subcontractors. This helps the main contractor to be selected as a qualified bidder on subsequent tasks, but the subcontractors feel they do not have an adequate opportunity to work on individual tasks that are awarded. IDIQs have a significant advantage over regular contracts: it takes 5 to 7 months for both to be finalized, but once an IDIQ is in place, the individual tasks under that IDIQ can be competed in a matter of days. IDIQs thus appear to be appropriate for discrete tasks that assist research programs, and they certainly have a place when getting research under way quickly is a high priority. RTCC, however, questions whether IDIQs are appropriate for pure research activities because of the way they reduce the field of potential competitors.

Contractor selection for projects competed by FHWA is based on merit review, and the decisions made depend heavily on the capability of government staff. External experts are not regularly involved in merit review for contractor selection. FHWA has no funds to support this activity; this is one of many consequences of having no budget flexibility because of budgetary constraints. External reviewers are occasionally included in the review of the technical portions of a proposal. (Only government employees can review the cost and staffing portions of proposals.)

Congressionally earmarked programs (Fundamental Properties of Asphalts and Modified Asphalts, Asphalt Research Consortium, Seismic

Research, and Polymer–Wood Composite Materials and Structures) all fail to meet the criteria for competition and merit review. The $49.2 million allocated to these earmarked programs in FY 2006–2009 represents about 20 percent of the total infrastructure RD&T budget. The committee finds it disappointing that such a large share of infrastructure research is earmarked for such a small number of institutions. The public is not receiving the benefits that would accrue from the dozens of organizations with talented researchers that would compete for these funds.

As noted earlier, SHRP 2 awards 80 percent of its funds through full and open competition (with the remaining 20 percent being used for administration and meeting costs). Contractors are selected through merit review, in which stakeholders are heavily involved. As with all SHRP 2 programs, an Expert Task Group (ETG) evaluates the merits of proposals for the Renewal Program and forwards its analysis to a Technical Coordinating Committee (TCC) for recommendation to the SHRP 2 Oversight Committee.[3]

6. Performance Review and Evaluation

Performance review takes place at both the project and program levels. At the project level, FHWA staff review results of contractors' efforts for acceptability; staff regularly involve end users in a separate review to test customer satisfaction. For research projects conducted internally, work of internal contractors is reviewed by FHWA staff; research conducted by individual staff is reviewed by team leaders, technical directors, and managers. In addition, research managers track outputs, costs, and timeliness (efficiency measures). To obtain external peer review, FHWA encourages publication of FHWA-funded research in peer-reviewed journals.

At the program level, FHWA involves peer committees, such as RTCC, the TRB committee for the LTPP Program, and the TRB committee for FHWA's pavement research and deployment activities, in ongoing assessments. The laboratories at the Turner–Fairbank Highway Research Center (TFHRC) that support all of FHWA's RD&T programs, including infrastructure programs, are peer reviewed on a regular cycle by

[3] Research projects are recommended for each SHRP 2 strategic focus area by TCCs, whose membership is made up of experts from the public, private, and academic sectors. The SHRP 2 Oversight Committee awards contracts and selects contractors.

external experts. Because RD&T is viewed as a tool for achieving the strategic goals of USDOT and FHWA, FHWA's goal indicators, such as highway-related fatalities, pavement condition, and congestion, serve as the overall performance measures for RD&T programs. FHWA examines these indicators to help determine whether its RD&T activities are focusing on the right things—for instance, not just reducing highway-related fatalities but also examining how these fatalities occur, such as run-off-the-road and intersection collisions. These indicators also enable FHWA to determine whether the RD&T program is meeting the annual milestones in multiyear program plans and making progress toward long-term goals.

SHRP 2 projects and their products are reviewed by the TCCs established for each program area, with ETGs providing additional peer review when reports have highly technical content. The program is governed by stakeholders, and they assess the results of projects and the merits of the program on an ongoing basis. Senior FHWA and AASHTO representatives serve in an ex officio capacity on the SHRP 2 Oversight Committee to ensure coordination and ongoing evaluation of the program as it progresses. As required by Congress, the Government Accountability Office (GAO) also evaluates the program.

Assessment Based on Additional Criteria

Congress's extensive designation of research programs large and small, as well as congressional earmarks that total about 23 percent of infrastructure RD&T in Title V, has compromised some important programs. The LTPP Program, which emerged from the original SHRP with high levels of stakeholder support, had to be cut by 12 percent to make room for other designations and earmarks. This 20-year program, intended to be completed by 2009, has now been reduced to essential data collection. The benefits of this $260 million[4] pavement experiment, however, will not be fully realized until the data can be thoroughly analyzed. Recent estimates indicate that the data collection can be completed and basic data analyses conducted for about $9 million annually through 2015

[4] This figure refers to the federal share. Many state DOTs also contributed funds, efforts, and materials, but the total level of state expenditures is not known.

(FHWA 2007; TRB 2008b). Similarly, the LTBP Program was envisioned by FHWA and AASHTO's bridge subcommittee as being modeled on the LTPP Program. It has been cut back even more than the LTPP Program, delaying its benefits until far into the future. Some of the activities designated or earmarked by Congress, such as those focused on steel bridge testing and polymer–wood composite materials and structures, would not rank high among federal or state DOT priorities for research. Within some programs, the details specified by Congress, such as the share of funding among asphalt, concrete, and aggregates, limit FHWA's ability to exercise technical judgment in optimizing resource allocation. SHRP 2 received about one-third of the funding envisioned by stakeholders, and the lifetime of the program is 2 years less than expected because the duration of funding is shorter than anticipated. These reductions in both money and time have greatly compromised what the program can accomplish.

The constraints on Title V also left FHWA without any direct funding for RD&T program support and with no budget flexibility for FY 2005–2007. The 2008 Technical Corrections legislation restored funding for part of FY 2008 and 2009 for the operation of TFHRC and gave FHWA some flexibility in the allocation of Title V funds—about $14 million after full funding of all other designations and earmarks, which is still below authorized levels.

OPERATIONS RD&T

Assessment Based on SAFETEA-LU Principles

The operations RD&T activities of FHWA and SHRP 2 are assessed collectively below.

1. Full Innovation Cycle

Operations RD&T, both at FHWA and in the ITS Joint Program Office, consists of an assortment of activities that collectively encompass most elements of the innovation cycle. For the four examples described in Chapter 3, the primary emphasis is on applied research, particularly the development, application, and evaluation of technologies. This is especially true for the Adaptive Control Software (ACS) Lite and Electronic Freight Management (EFM) Programs, which are aimed at developing

and evaluating software and web service programs. The Congestion Pricing and Traffic Incident Management (TIM) Programs are oriented more toward information and technology transfer, each seeking to promote the application of promising practices, policies, and tools in the field. By and large, the four programs are problem and solution oriented and thus do not consist of longer-term, higher-risk advanced research. (FHWA also supports more advanced RD&T projects on traffic analysis, modeling, and simulation and on the causes of congestion that are not reviewed in detail in this section.)

SHRP 2 travel time reliability research is focused on applied research. The agenda-setting phase of the program, which involved stakeholders, occurred before SAFETEA-LU funding became available. Planned deployment activities for SHRP 2 have had to be substantially curtailed because of a lack of funding and the shorter-than-expected funding cycle for the program.

2. Justification for Federal Investment

Responsibility for highway operations rests primarily with state and local highway agencies; in particular, the operating performance of urban road networks is a main responsibility of municipal and county governments. In general, however, federal support for operations RD&T in both the FHWA and SHRP 2 programs is justified for the same reason given for infrastructure RD&T. A main rationale is that the federal government contributes much of the funding for the highway system and therefore must act in a stewardship role, ensuring that its large investment is put to good use and the system performs efficiently.

The national significance of a well-functioning, efficiently operating national network of highways is commonly accepted grounds for federal support for highway operations RD&T. The Secretary's National Congestion Initiative maintains that urban traffic congestion is a widespread problem that has the collective effect of reducing the nation's economic productivity and standard of living while also contributing to other national concerns, such as air pollution and energy consumption.

3. Content

Although there is some advanced work in the ITS Program, the examples given above are filling significant gaps, such as the adaptation of

complex ACS software for use by smaller cities, evaluation of congestion pricing demonstrations, development of open-source EFM software, analysis of performance measures and monitoring programs for traffic operations, and appropriate institutional structures for managing operations. R&D to inform the operations of roads and highway systems has been considerably underfunded over the years relative to the significance of the congestion problem. Many gaps need to be filled, and SHRP 2 projects are designed to do so in practical ways that can be implemented.

4. Stakeholder Input

All four FHWA RD&T efforts described in Chapter 3 illustrate the agency's engagement with stakeholders, but at different points in the cycle and with differing degrees of involvement. After surveying state and local highway agencies, FHWA concluded there was a need for a simplified version of ACS and worked with the National Electronics Manufacturers Association to obtain assistance from vendors to field test this technology. FHWA is also a member of the National Transportation Operations Coalition (NTOC), an informal alliance of national associations, practitioners, and private-sector groups with interest and expertise in highway operations and management. NTOC promotes ACS Lite in its electronic newsletter and through Internet communications.

Being implementation oriented, TIM is characterized by extensive stakeholder involvement, which is essential for promoting comprehensive, performance-driven incident management programs in communities. The primary stakeholders with interest in TIM are public safety and transportation agencies. FHWA solicits the involvement of these stakeholders through the National Traffic Incident Management Coalition, a forum of national organizations representing providers of emergency medical services, law enforcement, public safety communications, towing, and transportation services. The program has also reached out to stakeholder associations outside the traditional highway community, such as the International Association of Chiefs of Police and the Towing and Recovery Association of America. Stakeholders are engaged through workshops, conferences, and Internet communications.

Stakeholders are also involved during all phases of the EFM program. The EFM concept was initiated by the private sector, and the program

content (operational concept, design, and test plans) is being guided by the Intermodal Freight Technology Working Group of the Intermodal Association of North America.

As described above, SHRP 2 is guided by committees comprising stakeholders who set priorities, choose among bidders, evaluate proposals, provide merit review, and perform peer review of results. The TCC for the travel time reliability program includes representatives from state DOTs, FHWA, AASHTO, metropolitan planning organizations (MPOs), first responders (firefighters), academia, and consulting.

5. Awards Based on Competition and Merit Review

In the case of ACS Lite, the federal contract for development of the software was awarded through a competitive process. TIM, by comparison, is a more dispersed program consisting of a number of projects and initiatives, including many intramural activities. For extramural projects, contractor selection is competitive. In the case of EFM, a competitive process to select the development and deployment team is anticipated.

In SHRP 2, as described in the section on infrastructure above, ETGs prepare requests for proposals (RFPs) and provide merit review. All SHRP 2 proposals are subject to full and open competition.

6. Performance Review and Evaluation

The success of the results of FHWA's RD&T program will in many cases be determined by the marketplace, and especially by the public entities that are the customers for those results. ACS Lite software has undergone field evaluations and proven its value; it has been turned over to suppliers for further development and implementation. FHWA expects to have an ongoing role in promoting the product and keeping it current. Because TIM activities are closely coordinated with stakeholder interests, they are subject to constant iterative reviews and evaluations by customers. One element of TIM is annual self-assessments, a formal process by which state and local transportation and public safety agencies collaboratively assess their TIM systems to identify opportunities for improvement and for federal assistance. EFM will likewise depend on the stakeholders in the industry working group to provide ongoing feedback and assessment of EFM design and deployment.

In the case of the Congestion Pricing Program, USDOT and FHWA track the program's results to a limited extent—for instance, by report-

ing experiences and best practices from the Value Pricing Pilot Program. Evaluation funds are provided to participants as part of the grant program, and project partners are expected to assist FHWA by providing data on project results in reports to Congress.

Performance review and evaluation for SHRP 2 was discussed above in the section on infrastructure RD&T.

Assessment Based on Additional Criteria

Because of funding constraints, important activities of the Office of Operations are unfunded, including updating of the *Manual on Uniform Traffic Control Devices* and work on truck size and weight issues and emergency traffic operations. The level of funding in this area was cut by 50 percent between TEA-21 and SAFETEA-LU. An argument can also be made that investments in RD&T in operations, even with the ITS Program, are considerably out of alignment with the size and consequences of the nation's congestion problem. Non-ITS operations RD&T funds are insufficient to permit full exploration of issues in such areas as management and operations, congestion management, pricing, and freight management. The reduction in funding for SHRP 2 to levels well below what had been planned has hurt the program. Before SAFETEA-LU, the research plan was designed from a systems perspective as an integrated package. The required deletion of certain projects has reduced the program's coherence.

PLANNING AND ENVIRONMENTAL RD&T

Assessment Based on SAFETEA-LU Principles

1. Full Innovation Cycle

FHWA's planning and environmental RD&T is oriented toward a wide range of technical assistance and other implementation activities, as indicated by the efforts described in Chapter 3 and highlighted by FHWA in its presentation to RTCC (see Table 5-2). SHRP 2 activities have more of an applied research component; the projects are focused on achieving specific results that can be implemented. Much of SHRP 2's Capacity Program is designed to identify key decision points in the planning process and develop strategies to facilitate resolution of the issues that impede decision making.

TABLE 5-2 Illustrative FHWA Planning and Environmental Research Projects

Title	Funding ($)	Funding Mechanisms	Stakeholders
Survey State and Local Climate Change Activities	150,000	Task order	State DOTs, MPOs
Climate Change Clearinghouse	85,000	IDIQ task order	State DOTs, MPOs
Integrating Climate Change Considerations into Planning Processes	69,000	IDIQ task order	State DOTs, MPOs
Mobile Source Air Toxics near Roadway Dissemination Study	818,000	Interagency agreement, IDIQ task order	State DOTs, EPA, NGOs
Context-Sensitive Solutions Pooled Fund	200,000	TBD	State DOTs, local agencies
Advancing Methods, Maps, and Tools Used for Decision Support and Impact Analyses for Transportation, Wildlife, and Ecological Systems	400,000	TBD	Federal agencies, state DOTs
Regional Approaches to Tolling and Pricing	20,000	IDIQ task order	State DOTs, MPOs
Metropolitan Accessibility: Performance Indicators for Planning Reform	63,900	Cooperative agreement	State DOTs, MPOs
Safety Planners Guidebook and Communication Materials	249,000	IDIQ task order	State DOTs, MPOs
Geographic Information Systems (GIS) Best Practices for Planning and Environmental Linkages	30,000	Task order	State DOTs
Ecological Grants Integrating Transportation and Resource Planning to Develop Ecosystem-Based Infrastructure Projects	1,000,000	TBD	Federal agencies, State DOTs

NOTE: EPA = Environmental Protection Agency; NGO = nongovernmental organization; TBD = to be determined.

2. Justification for Federal Investment

Planning and environmental protection are clearly national priorities. Most of the FHWA and SHRP 2 activities described above would foster improved implementation of federal planning and environmental requirements by states, MPOs, and other levels of government. These activities

address planning, environmental, and stewardship goals that are high priorities for state DOTs.

3. Content

Activities in the planning and environmental area funded through the Surface Transportation Environment and Planning (STEP) Cooperative Research Program, designated programs, and earmarks fall mainly on the implementation end of the development spectrum. They might be described as gap filling with respect to technical assistance and program support. SHRP 2 could also be described as gap-filling applied research.

4. Stakeholder Input

FHWA's Office of Planning, Environment, and Realty conducts a wide range of stakeholder involvement activities, including monthly meetings with stakeholder groups. The office is particularly responsive to state DOT and MPO staffs. RTCC invited representatives of these stakeholders to comment on the FHWA and SHRP 2 planning and environmental programs; all commended the activities under these programs as much needed by their constituencies.

Although the FHWA program is responsive to stakeholder needs, the surface transportation environment and planning cooperative research program envisioned in TRB *Special Report 268* (TRB 2002) would have given stakeholders a decision-making role in project funding, similar to their role in SHRP 2 and other transportation cooperative research programs. With the STEP Program being administered by FHWA as a federal program, decisions about resource allocation must of necessity be made by federal officials. Even so, FHWA's planning and environmental staff make a considerable effort to gather stakeholder input before making decisions.

5. Awards Based on Competition and Merit Review

FHWA's Office of Planning, Environment, and Realty awards funding through various competitive means, including contracts, grants, and cooperative agreements. It also occasionally assigns projects to the Volpe

National Transportation Systems Center.[5] As indicated by the list in Table 5-2, IDIQ contracts and task orders appear to be a popular means of funding contractors. In SHRP 2, 80 percent of funds are awarded through full and open competition with merit review. About 7 to 8 percent of FHWA's planning and environmental funds are earmarked to two organizations, obviously without competition and merit review.

6. Performance Review and Evaluation

The Office of Planning, Environment, and Realty utilizes performance review and evaluation at the staff level to review scoping, schedule, deliverables, and other aspects of contract performance. TWGs or other informal stakeholder groups (including federal as well as state partners) follow specific projects to review results related to several initiatives, including the Center for Environmental Excellence, activities related to climate change, travel model improvements, Eco-Logical grants, traffic noise model development, transportation planning capacity building, binational border activities, and outdoor advertising control.

Performance review and evaluation for SHRP 2 was discussed above in the section on infrastructure RD&T.

Assessment Based on Additional Criteria

Funding Levels

Undoubtedly the most significant issue facing RD&T in the planning and environmental area is funding. As noted earlier, FHWA's overall planning and environmental RD&T resources declined by at least 13 percent between TEA-21 and SAFETEA-LU. FHWA lost all the resources it had previously used to engage with stakeholders; offer technical assistance; provide its own program support; and develop the planning capacity of state, MPO, and local staffs to meet federal planning and environmental requirements. This loss required FHWA to orient the STEP Program to serve these purposes, which greatly reduced the amount of applied and advanced research that would be possible with STEP Program funding.

[5] The Volpe Center, administered by USDOT's RITA, is a federal fee-for-service organization.

The SHRP 2 Capacity Program was designed for a budget of $80 million but received only $18 million under SAFETEA-LU. The original vision for the planning and environmental topics incorporated into SHRP 2 simply could not be achieved with the level of funding available, even after the modest increases made possible by the 2008 Technical Corrections legislation. As a result, the Oversight Committee for the program had to drastically scale back the effort as originally planned and redesign a coherent program. Although the outputs of the newly designed program should be useful, they fall far short of the vision articulated by stakeholders.

Stakeholder Governance

As noted, a result of the reduced funding under SAFETEA-LU was FHWA's need to rely on the STEP Program to fund information sharing and technical assistance in addition to research. FHWA has focused its funding on activities requested by stakeholders. Even so, the committee that recommended the research agenda for a surface transportation environment and planning cooperative research program wanted the program's governance to be modeled on that of other cooperative research programs, wherein stakeholders determine priorities and allocate funding (TRB 2002). The committee believed that the cooperative research process of having stakeholders collectively set priorities, monitor research projects, and evaluate research outputs would itself be important in addressing and resolving some of the fundamental disagreements that exist among various stakeholder groups concerned about highway planning and environmental issues.

Diffuse Program

FHWA is attempting to address an expanding and complex set of issues, such as the health effects of air pollutants, the role of highway transportation in climate change, and security, even as its resources in this area have diminished. The pressure to address a wide variety of topics (55 projects for FY 2008) for a diverse set of stakeholders with declining resources has resulted in a fairly large number of activities, including several projects funded relatively modestly at less than $100,000 each. Whether such small projects can have a significant impact is doubtful.

Data and Research Gaps

Federal law requires MPOs to develop transportation plans to accommodate mobility needs for persons and goods within their regions. Many of the guidebooks and manuals and the technical assistance provided through the programs described above relate to meeting federal requirements. MPOs discharge these planning requirements by forecasting future personal and freight demand with complex computer models. A recent report documents notable shortcomings of these models for conducting the kinds of analysis needed by state and local officials (TRB 2007). Addressing the technical issues identified in that report through research, development, and deployment of improved models would require more resources than are currently available to FHWA. The report also points to critical data gaps that impede current forecasting.

In SAFETEA-LU, Congress reduced funding for the Bureau of Transportation Statistics (BTS). One consequence of this cutback was that BTS dropped funding for the National Household Travel Survey (NHTS). This national survey, conducted every few years, provides basic information about individual and household travel behavior. Moreover, when the NHTS is conducted, many states pay to supplement their sample to collect data needed for federal planning purposes (TRB 2003). The models described above, as well as needed improvements to these models, can be only as good as their input data allow. Because BTS is unable to fund the NHTS, FHWA is a logical alternative to carry on this important effort (FHWA funded the survey before BTS was created), and in 2008 FHWA reassumed this responsibility. FHWA, however, is constrained by budgetary restrictions under the current authorization. For FHWA to discharge this responsibility in the future, it will need the authorization and appropriation to do so.

One of the key threats to the NHTS and other efforts to understand how people travel is the increasing problem of gathering representative information through telephone surveys (TRB 2003). With more and more people choosing not to respond to surveys or relying solely on cell phones rather than land lines, survey response rates have been steadily declining. An important research effort would be to develop cost-effective systems for gathering information from a sample of willing participants (TRB 2003). Some pilot efforts to this end have involved outfitting

vehicles to take advantage of the Global Positioning System (GPS) and having people carry small GPS data recorders with them, but much greater effort is needed to develop cost-effective methods for gathering statistically reliable data.

Improved insight into travel behavior is critical for local-level planning. Regional travel modelers in the past completely missed large-scale demographic trends because of a lack of research on nonwork trips, automobile ownership, and the labor force participation of females. As a result, many past model forecasts and long-range capacity expansion plans greatly underestimated current peak-period travel demand. Assumptions about travel demand are critical inputs to regional travel models. Once used primarily to help local governments determine the size and location of new highway and transit facilities, these models are now being used to help understand how travel demand and patterns might change in response to congestion and new policies to address it, such as high-occupancy toll lanes and other road and parking pricing strategies. The models are poorly designed for answering such questions, however. Also lacking is adequate information on how travelers respond to such policies that could be used in calibrating the models (TRB 2007). The conduct of research in this area is an essential complement to ongoing and planned improvements to the models themselves.

These models are also used to conduct analyses necessary to forecast over 20 years whether proposed transportation capital plans are consistent with state implementation plans for meeting mandates of the Clean Air Act Amendments. Aside from the question of whether forecasts 20 years into the future can be made with the level of precision required, improved models and data are needed to make such exercises more credible. In *Special Report 288: Metropolitan Travel Forecasting: Current Practice and Future Direction* (TRB 2007), a program of research to advance both models and practice is recommended. The level of funding needed to make these improvements would exceed current FHWA resources.

The main source of data on national freight movement is the Commodity Flow Survey (CFS), which is funded by BTS and administered by the Census Bureau. This survey has been hampered in the past by inadequate planning and funding for a large enough sample to allow for planning at the state and MPO levels (TRB 2003). Users are particularly

concerned about having more timely data (the data are often released 2 or more years after completion of the survey). Both the NHTS and CFS are critical data sources for planning and research.

Other data sources in the freight area have declined over time in ways that hamper analysis and planning for freight demand. The Form M Program was formerly a mandatory annual survey of motor carriers that generated (among many other things) financial and operating statistics that were used by industry and government for benchmarking, research, and planning. For a number of reasons, funding for this program was eliminated; it is now an unenforced regulation. The trucking industry has developed an alternative Form M Program that should be able to replicate adequately the financial and operating data. The Vehicle Information and Use Survey (VIUS) is another program, formerly conducted by the Census Bureau, that is no longer being funded. Arguably, it was even more important for freight analysis and planning than Form M. It provided relatively detailed data on truck fleet sizes, truck operations, and vehicle configurations—all stratified by state-level and geographic regions. FHWA recently issued an IDIQ task order to inquire about how 2007 VIUS data might be replicated by using predictive formulas, but such replication would be a poor substitute for the survey data.

SAFETY RD&T

Assessment Based on SAFETEA-LU Principles

The safety RD&T activities funded under Title V conform to the SAFETEA-LU principles, with the exception of four major earmarks.

1. Full Innovation Cycle

The majority of FHWA's safety programs provide software tools, manuals, technical briefs, and other guidance for practitioners. This work, therefore, particularly the software tools, manuals, and guides, are highly supportive of the implementation end of the innovation cycle. An example is FHWA's role in researching and aiding in the implementation of modern roundabouts, which reduce intersection crashes. Because of its large-scale naturalistic driving experiment, SHRP 2 is funding fundamental research at the advanced end of the research continuum. Collectively,

these activities span the full innovation cycle. SHRP 2 includes agenda setting with stakeholders and the conduct of advanced safety research. The FHWA program includes applied research and development, demonstration programs, implementation, evaluation, and the development of guidance documents to assist in the implementation of safer approaches to intersection design.

2. Justification for Federal Investment

Highway safety has long been recognized as a public-sector responsibility. The research funded through Title V is clearly a national priority because of the large number of people killed and injured on the highway system each year. Because roads are owned and operated almost exclusively by the public sector, very little private infrastructure safety R&D is being conducted.

3. Content

FHWA's safety activities fill critical gaps and are highly applied. The ITS safety research on the Cooperative Intersection Collision Avoidance System includes elements of fundamental research in evaluating safety benefits and user acceptance of such technologies, along with traditional elements of technology development and deployment.[6] Much of the SHRP 2 safety research is advanced in nature, even though the bulk of the cost is for data collection. The SHRP 2 research may significantly improve understanding of the causes of driver error and lead to improved countermeasures.

4. Stakeholder Input

FHWA's safety research is closely coordinated with other major stakeholders in highway safety, including other federal agencies with a safety mission, such as NHTSA and the Federal Motor Carrier Safety Administration; associations representing the states, counties, police chiefs, and motor vehicle administrators; companies providing signs and markings;

[6] This research is funded through the ITS Program, housed in RITA since 2007, but portions of the work are conducted at TFHRC, and development and deployment of such technologies is an element of FHWA's safety program.

governors' highway safety representatives; and others. Each safety program develops a detailed strategic plan in collaboration with stakeholders.[7]

Coordination with local officials responsible for the rural roads where most fatalities occur is difficult because there are so many individual engineers to reach, and they are highly decentralized. Even where FHWA has good ties with stakeholders, greater involvement is desired. For example, a state DOT stakeholder presenting to RTCC urged FHWA to do even more to involve and inform state DOT safety engineers with regard to the priorities and results of FHWA's safety research and outreach programs.

FHWA is also managing and helping to fund research initiatives funded in part by state DOTs and is involved with AASHTO in the development and implementation of the AASHTO *Strategic Highway Safety Plan.* As a further example of responsiveness to stakeholder input, research and the development of design guidance on nontraditional intersections resulted from strong state and local interest in these alternative designs. In addition, individuals from stakeholder groups are involved in technical working groups, expert panels, and focus groups; serve as participants in conferences to set agendas for safety research; and are active in demonstration programs conducted with various states. FHWA's safety staff is also heavily engaged in the safety activities of TRB's standing technical committees, which serve to bring together practitioners and researchers.

As discussed earlier, SHRP 2 is stakeholder driven. Volunteers representing multiple stakeholder groups set the direction and provide oversight for the safety program, provide merit review in the selection of research contractors, and conduct the peer review of completed research.

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[7] The following are examples of stakeholder involvement:

- The Roadway Departure Team's active involvement with the AASHTO Technical Committee on Roadside Design and related TRB committees;
- The Intersection Team's support for the National Agenda for Intersection Safety, based on a 2001 workshop, with plans to hold a workshop to update the agenda;
- The Pedestrian Team's active engagement with state ped–bike coordinators and various ped–bike advocacy groups and its close work with NHTSA;
- The Speed Team's sponsorship of the National Speed Forum; and
- The Professional Capacity Building Team's sponsorship of a 2002 Highway Safety Workforce Planning Workshop and its active coordination with the Institute of Transportation Engineers, TRB, and AASHTO on a variety of related activities.

5. Awards Based on Competition and Merit Review

About 20 percent of funding for FHWA's safety programs, averaging roughly $3 million annually, is earmarked to four activities: the Center for Transportation Safety (Virginia Tech), the Center for Excellence in Rural Safety (University of Minnesota), the Motorcycle Crash Causation Study (Oklahoma Transportation Center), and the Transportation Injury Research Program (Calspan University of Buffalo Research Center). While the activities funded by these earmarked institutions are laudable, the earmark for the latter program would appear to be more appropriate for NHTSA's budget than FHWA's.

A portion of FHWA's research funding is provided through IDIQ contracts, which are awarded through full and open competition, with subsequent tasks being competed among contract holders. As noted earlier, there is concern about whether research projects should be competed in this fashion. Some of the IDIQ-funded work, however, is awarded to support the operation, equipment, and staffing of the laboratories at TFHRC that play an important role in FHWA's safety RD&T. The Geometric Design Laboratory, for example, is heavily involved in the development and testing of the Interactive Highway Safety Design Model. As discussed earlier, all of the SHRP 2 research funds are awarded in full and open competition. Both FHWA and SHRP 2 safety programs engage stakeholders in merit review of proposals.

6. Performance Review and Evaluation

FHWA employs various forms of program review, ranging from the normal managerial evaluation of contractor performance to the engagement of stakeholders in the review of completed projects. In the Evaluation of Low-Cost Safety Improvements Pooled-Fund Study, for example, stakeholders will be involved in peer review of the research results. Likewise, in the development of Safety Analyst, a software tool being funded in part by the states through a pooled funding arrangement, stakeholders and experts will take part in evaluating interim and final versions of the software. Stakeholders representing state DOTs, local agencies, and universities peer review the products resulting from FHWA's evaluation of nontraditional intersections and interchanges.

Performance review and evaluation for SHRP 2 was discussed above in the section on infrastructure RD&T.

Assessment Based on Additional Criteria

The main area of concern for Title V safety RD&T is funding. Under SAFETEA-LU, FHWA's safety programs are receiving about 30 percent less funding, in current dollars, than was received under the previous authorization, in part because of the constraints on Title V funds. Valuable research and evaluation projects endorsed by stakeholders simply cannot be funded. SHRP 2 has been similarly affected. Congress authorized about $50 million annually for the total SHRP 2 effort—considerably less than the $75 million called for in the program plan and endorsed by AASHTO. Moreover, actual SHRP 2 funding is even less than $50 million annually because of obligation limits and funding constraints. The safety research program was to be funded at $180 million over the life of SAFETEA-LU, but will instead receive $43 million. These levels of investment are small compared with the annual cost of the highway traffic safety problem, which is estimated to exceed $230 billion (Blincoe et al. 2002).

POLICY RESEARCH

Assessment Based on SAFETEA-LU Principles

1. Full Innovation Cycle

Unlike the research and technology transfer activities of other program areas, which often lead to the introduction of new technologies and products, policy research helps inform decisions about investment levels, taxes, and regulations. The work conducted in the policy area spans the range of data collection, applied research, and implementation.

2. Justification for Federal Investment

The databases, models, and reports produced through funding in this area are clearly on topics of national significance. Moreover, without FHWA's national-level policy research, there would be few or no other sources of such information.

3. Content

The content of the policy research program easily falls within the category of policy or planning. There are major gaps that could be filled if

FHWA had more resources to devote to this program. For example, one of the major policy issues facing the highway program and the next Congress is the future revenue stream expected from the fuel tax, which is the primary funding source for state and federal highway trust funds (TRB 2006). Critical to projecting future revenues are estimates of future vehicle miles traveled (VMT) and how these estimates will be affected by prices, economic activity, growing congestion, and demographic changes (the aging population, immigration). As the nation considers alternatives to fuel taxes for providing the majority of funding for highway and transit programs, there is a great need for large-scale demonstrations to test new concepts, such as charging fees based on VMT (TRB 2006). Critical policy questions must be addressed as to whether the technology envisioned for such systems will work and protect privacy. Demonstrations are needed so policy makers and the public will know whether they can rely on such novel programs. Important questions in other areas—such as how increased congestion will affect travel demand, whether aging baby boomers will show different travel behavior than earlier cohorts of senior citizens, and how changing household composition will influence total travel demand—are simply not being adequately examined (Polzin 2006). Also important is understanding how sensitive freight carriers are to fuel price increases and tolling and a potential shift of freight between trucks and rail. Almost no public research on these topics is being funded or conducted, and this represents a major knowledge gap on topics vital to policy makers.

Other important policy questions are being inadequately examined through research. As important as commercial motor vehicle transportation is to the nation's economy and to the design and operation of highways, for example, there are significant gaps in understanding of the nature and extent of commercial trucking, including the sizes and weights of trucks and the roads on which they travel, as well as where bottlenecks occur in intermodal transfers. Likewise, in the context of growing interest in tolling, it is important to know how truckers would respond to more widespread tolls on Interstates. Would they, for example, divert to roads that are less safe, thereby increasing crash rates?

The work of the National Surface Transportation Policy and Revenue Study Commission was hampered by a lack of understanding of these

and other key policy questions. Examples of such questions are how important megaregions are to future economic development and highway demand, whether and how to divide federal revenues between states and regions for maximum public benefit, what the potential is for intercity passenger rail to compete with congested intercity highways, and whether there is adequate redundancy in the freight and passenger systems to respond to natural and man-made disasters.

4. Stakeholder Input

The primary constituencies for FHWA's policy research are policy makers in the administration and Congress. States are also vitally interested in national highway policy. Presumably, FHWA receives direct feedback on the efficacy of its work from its primary customers—the administration and Congress. The Office of Policy and Governmental Affairs has been responsive to stakeholders. In 2000, for example, FHWA adjusted the models it developed for national estimates of cost allocation to make them useful to the states. In 2007, after BTS reported that it could not support the NHTS, stakeholders appealed directly to the Secretary of Transportation, and, as noted above, FHWA volunteered to undertake the management of and collection of revenues for this important national survey.

5. Awards Based on Competition and Merit Review

Without funding during this authorization cycle, there has been little contract activity on which to comment.

6. Performance Review and Evaluation

The primary reports of the Office of Policy and Governmental Affairs receive considerable scrutiny by FHWA, USDOT, and the Office of Management and Budget before being submitted to Congress, where they receive similar scrutiny.

Assessment Based on Additional Criteria

As indicated above, policy research was virtually eliminated in FY 2006 and 2007 as a result of SAFETEA-LU, with funding in the area declining from approximately $9.5 million annually to only $225,000. Restoring

the prior levels of funding would be adequate to revive FHWA's programmatic activities in this area but would still fall far short of the level needed to fund the research needed to fill the gaps identified above.

UNIVERSITY TRANSPORTATION CENTERS PROGRAM

Assessment Based on SAFETEA-LU Principles

Universities are valuable assets that should be relied on for highway research. The UTC Program as currently designed, however, does not make the best use of the assets universities have to conduct research, particularly advanced research.

1. Full Innovation Cycle

UTC funding covers the full innovation cycle, from advanced research through training and technology transfer. Technology transfer to local governments occurs at 13 UTCs that house a Local Technical Assistance Program center, but all UTCs are required to include technology transfer in their program plans. The strength of most universities is in basic and fundamental research; however, the current matching requirement of the UTC Program drives UTCs toward applied research. As noted earlier, when state DOTs provide the match, as is often the case, they typically are most interested in highly applied, problem-solving research.

2. Justification for Federal Investment

Federal investment in the UTC Program is justified by the national significance of innovation, while the program's educational mission reflects federal interest in developing a future nationwide skilled transportation workforce. It is difficult to know how well the output of the UTC Program is meeting market demand for these workers. Rates at which UTC graduates are placed in transportation agencies or firms that work for such agencies would be one indicator, but it is one the UTCs are not required to collect and report.

Justifying a federal investment in some other elements of the UTC Program is more difficult. As noted, the applied research to which the match requirement drives UTCs is already supported through State

Planning and Research (SP&R) funds and most FHWA-funded programs, though arguably at lesser amounts than could be justified. Moreover, although the UTC Program probably does not fund a great deal of duplicative research, it is supporting research in similar areas and of a similar nature to that being funded by FHWA and state programs in an uncoordinated fashion. The large number of UTCs funded under SAFETEA-LU also raises questions about whether so many programs are needed; this is especially true for institutions earmarked in TEA-21 and SAFETEA-LU that did not previously house transportation education and research activities. A fragmented approach to research, characterized by uncoordinated research across myriad topics and universities, arguably is not the "best means to support federal policy goals"—one of the criteria for justifying federal investment.

3. Content

A review of UTC research under way in FY 2008 reveals that UTCs are engaged in research on a wide variety of technical and policy topics, but the research is almost exclusively applied in nature. The lack of advanced or basic highway research within the university community suggests a significant flaw in the program. UTC research probably does fill gaps in applied research. About 30 percent of research projects in the UTC Program are identified by the source UTC as addressing policy or planning topics.[8] Because of cutbacks elsewhere, the UTC Program is the only source of policy research under SAFETEA-LU, but only about 5 percent of UTC research addresses policy topics.

4. Stakeholder Input

Stakeholder input in the UTC Program is addressed for some stakeholders through the program's matching requirements. RITA also requires UTCs to engage stakeholders and peers through merit review of their proposed research and through advisory boards for the centers. Centers have a variety of processes for engaging stakeholders, but those processes must be approved by RITA as part of program plans.

[8] The category of policy research encompasses legal topics.

5. Awards Based on Competition and Merit Review

Most UTCs (62 percent) and most funds for UTCs (58 percent) are earmarked with no competition and merit review.[9] As noted, all UTCs must award funds they receive through a merit review process, but competition for these funds is not required. There is competition and merit review in part (38 percent) of the overall program. The 10 regional centers are awarded competitively (4-year awards made in August 2006), while the 10 Tier I UTCs are competed every fourth year (the Tier I centers recompeted for FY 2007–2009 awards, which were announced in October 2006). The 10 national centers and 22 Tier II centers are not required to compete.

6. Performance Review and Evaluation

The Government Performance and Results Act requires all federal programs to establish quantifiable performance measures by which the programs' effectiveness in achieving desired outcomes can be evaluated. UTCs are required to report annually on the number, types, and cost of research projects funded through the program; the number and types of courses offered; the number and types of students enrolled; and the number of transportation seminars, symposia, distance learning classes, and the like conducted for transportation professionals. Centers are also required to have their research activities peer reviewed. The results of such reviews, however, are not shared beyond the center, so the judgment of peers about the quality of a center's research is not part of the public record. This makes it difficult to judge the quality and value of the research produced through UTC funding without examining a sample of the completed research. One measure that would help in this regard would be publication in peer-reviewed journals, but this is not a metric the UTCs are required to collect.

Assessment Based on Additional Criteria

One of the structural weaknesses of the UTC Program is the lack of opportunity USDOT's mission agencies have to influence the centers'

[9] There are several universities and research institutes earmarked in sections of SAFETEA-LU in addition to those earmarked in the UTC Program. The total percentage of UTCs in Titles III and V receiving earmarked funding in this authorization is 67 percent.

Scientific Earmarks

The American Association for the Advancement of Science (AAAS), the world's largest general scientific society, has been in the forefront of the debates about the harmful effects of earmarking on science. AAAS has long supported the awarding of research funds on the basis of merit review by peers.

AAAS Resolution:
Reaffirmation of Commitment to Scientific Peer Review

"*Whereas* the partnership between the government and the community of scientists is essential to the advancement of science, and

"*Whereas* without broadly based, consistent, critical, and professional evaluation of proposed expenditures for scientific work, there is a growing danger that the quality of research and education in science will be jeopardized,

"*Be it resolved* that the Council of the AAAS reaffirm its commitment to the principle and practice of scientific peer review as indispensable to the allocation of public funds for the scientific enterprise."

[*Adopted by the AAAS Council, May 30, 1985.*]

SOURCE: archives.aaas.org/docs/resolutions.php?doc_id=372. Accessed Sept. 3, 2008.

research activities. Clearly there is a benefit to giving universities independence in the selection of research topics, but the UTC Program does not work this way in practice. Because of the 50-50 match, the entities providing the match have the greatest influence in setting a UTC's research agenda. SAFETEA-LU itself prohibits using most federal funds for matching purposes; hence FHWA and other administrations have little leverage over the topics pursued.

Funding based on the multitiered structure of the program also appears to lack a rationale. Funding for the regional centers was understandably increased in SAFETEA-LU after having been fixed at $1 million per center since 1987. But there is no apparent research or educational justification for providing the national centers $3.5 million annually or the Tier II centers $500,000.

As discussed above, the state DOTs are a primary source of matching funds for UTC research. The states have varied perspectives on the UTC Program. Some states, such as California, are pleased with the program. Other states, particularly smaller ones with limited SP&R funding, do not wish to have most of their SP&R funding devoted to matching funds for UTCs that are not necessarily focused on serving the state DOT's interests. A roughly equal proportion of state research directors rate the program positively (48 percent) rather than negatively (44 percent), but this is the only highway research program that more research directors (44 percent) believe to be overfunded rather than underfunded (7 percent) (CTC and Associates 2007).

SUMMARY

Overall Assessment Based on SAFETEA-LU Principles

FHWA manages several highway RD&T programs and funds SHRP 2, which is managed by TRB. RITA manages two research and technology (R&T) programs—the UTC and ITS Programs—that have significant highway research components. FHWA's Corporate Master Plan for Research and Technology commits the agency to adhering to the principles for RD&T called for by Congress.

Full Innovation Cycle

As required in SAFETEA-LU, the above programs collectively cover the full innovation cycle, from agenda setting through deployment and evaluation. While most FHWA programs include deployment activities, however, it is questionable whether the scale of these activities is adequate to meet the need and whether FHWA is appropriately organized to carry out an effective effort in this area.

Justification for Federal Investment

The R&T activities discussed in this chapter are justified either by the national significance of the topics addressed; a lack of private investment in the area; or the importance of facilitating efficient use of federal aid by states, counties, cities, and municipalities.

Content

The program content comprises largely either applied research or deployment and technology transfer. The bulk of FHWA's activities are in areas that fill gaps in state programs. RTCC would prefer that a larger proportion of FHWA's RD&T funds be invested in advanced research, which is most suited to the federal role. Too much of the funding under the UTC Program is invested in the same applied research and deployment activities supported by other programs. This applied R&T bias in the UTC Program is driven by the dollar-for-dollar matching requirement.

The content principle calls for advanced, applied, and policy or planning research. The committee believes that far too little funding is invested in the latter research, at both the national and program levels. Many significant policy debates are underinformed on such important issues as the total level of demand for highway transportation and how it might change with sustained high fuel prices and the large-scale population and demographic shifts now under way. At the program level, such questions as how to optimize expenditures on capital assets are not being examined at a level commensurate with their importance to state and local policy makers. There are also significant data gaps involving passenger travel behavior, freight demand, and other important issues.

Stakeholder Involvement

In recent years, FHWA has adjusted its R&T programs to involve stakeholders increasingly in agenda setting, merit review, and product evaluation. A complete lack of discretion over its budget, however, provides FHWA limited opportunities to expand these activities more completely and systematically. The lack of discretion is a result of the constraints on Title V funds. SHRP 2 programs are models of stakeholder involvement,

as stakeholders make decisions about topics to be investigated, prepare RFPs, provide merit review, decide which projects will be approved, and perform peer review of projects and their products. RTCC endorses RITA's emphasis on the UTCs' creating advisory committees for improved stakeholder involvement and applauds FHWA's efforts to foster stakeholder involvement in significant earmarked activities at universities outside of the UTC Program.

Competition and Merit Review

Most FHWA programs distribute funds through competitive processes, but some funding is retained for intramural research and support for FHWA laboratories. Significant portions of FHWA's programs (18 to 38 percent[10]) and RITA's Title V UTC Program (62 percent) are earmarked, thus failing the test for competition and merit review. RTCC would prefer to see less reliance on IDIQ contracts for FHWA research projects, as the awarding of individual tasks limits opportunities for competition.

Performance Review and Evaluation

FHWA has systematic processes for internal and staff-level evaluation of its R&T programs. Stakeholders are involved in review of the output of many R&T initiatives. More systematic use of external stakeholders in peer review would be desirable but is infeasible on a broad scale given the lack of dedicated resources for the purpose. SHRP 2 projects and products are evaluated by stakeholders and peers, and the entire program will be evaluated by GAO. The UTC Program requires peer review of UTCs, but the results of these reviews are not made public, so there is no ready means of evaluating the quality of these individual programs. Information on the publication of UTC research in peer-reviewed journals would be a useful indicator of the quality of UTC research.

[10] The percentage of FHWA's share of the Surface Transportation Research, Development, and Deployment (STRDD) component of Title V and SHRP 2 funding that is earmarked depends on how one classifies SHRP 2 funding. If it is classified as an earmark, which RTCC does not consider it to be, then 38 percent of FHWA's share of STRDD is earmarked; if it is not, then 18 percent of FHWA's share is earmarked.

Program-Specific Findings

FHWA's new **Exploratory Advanced Research Program** is a very important initiative. The committee has long advocated for an effective program of this sort. The earmark of approximately $7.6 million annually for asphalt research that is advanced, however, eliminates the important quality control mechanism of competition and merit review that has been the hallmark of advances in American science and engineering over the past century. Also, the area of research earmarked is not as important as those addressed by other, underfunded programs. In principle, the universities funded through the UTC Program should be conducting much more advanced research; however, the dollar-for-dollar match diverts UTC research from its originally intended purpose. As noted, most matching funds are provided by state DOTs, which are interested in highly applied and developmental research. Elimination of the match requirement would end this distortion of purpose and allow UTCs to focus more of their research on the knowledge development that is the universities' greatest strength.

FHWA's **infrastructure program** covers many core topics of deep interest to state DOTs and adheres to the principles of SAFETEA-LU. Individual components of the program, however, such as the long-term pavement and bridge research efforts, cannot realize their potential because of cutbacks necessitated by the constraints on Title V funding.

FHWA **operations and safety** programs embody the SAFETEA-LU principles. However, both programs were subjected to substantial cuts in SAFETEA-LU (operations by 50 percent and safety by 27 percent) and appear to be underfunded relative to national needs.

FHWA's **planning and environmental program** was reduced by at least 13 percent between TEA-21 and SAFETEA-LU. The only substantial R&T activity remaining under this program is the STEP Program. FHWA makes considerable effort to reach out to stakeholders of the STEP Program but also must rely on it for program support and technical assistance, thereby limiting its use for addressing complex and contentious environmental and planning issues through research and evaluation. If funding for program support and technical assistance could be restored, the STEP Program could work more as was originally envisioned by stakeholders.

Beyond restoring the lost RD&T funds for planning, new initiatives are required. Given the legal and regulatory requirements imposed on regional planning agencies and their travel forecasting models, the federal government could do much more to improve travel forecasting models and modeling practice. The research, development, and deployment proposals set forth in *Metropolitan Travel Forecasting: Current Practice and Future Direction* (TRB 2007) provide sound guidance for such an effort.

Many important transportation **policy** questions are going uninvestigated because of a lack of funding for this purpose, forcing infrastructure owners to make decisions without the necessary information. The lack of policy-relevant research has significantly hampered the work of the two commissions created by Congress in SAFETEA-LU to advise it on, among other things, the future viability of motor fuel taxes for funding highway and transit infrastructure. For example, gaps in knowledge about how sensitive travelers are to rising fuel prices and increased congestion, or how freight traffic might switch modes for these same reasons, undermine confidence in projections of future revenue streams for the Highway Trust Fund—one of the key policy concerns in reauthorization of the highway program in 2009.

About 62 percent of Title V **UTC** funding is earmarked, causing this program to fail to meet the requirement for competition and merit review, and funding is dispersed across too many institutions. Universities are a key resource for highway research and education, but the 50-50 matching requirement hinders them from conducting the advanced research that is the strength of universities and is needed by the highway sector. The diffuse and uncoordinated research conducted through the UTC Program highlights the need for a communitywide consensus on research priorities at a level of specificity that could guide research. With such a prioritized agenda, it might be possible to steer UTCs more toward national priorities.

Finally, **SHRP 2** is a model in conforming to the SAFETEA-LU principles and promises significant contributions. However, the strategic nature of the program is compromised by the loss of 64 percent of its anticipated funding and 2 years of its originally planned duration.

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Abbreviations

FHWA	Federal Highway Administration
TRB	Transportation Research Board

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6

Summary Findings and Recommendations

Highway transportation is the principal circulatory system for the national economy. It has contributed to the past few decades of national economic growth but is under severe stress due to heavy demand, aging of a huge capital stock, environmental impacts, and shortages of funding to address these problems. Continued innovations to make highways perform better, last longer, and cost less are essential to sustaining the contributions made by highways to national prosperity. Current spikes in energy prices could have profound effects on highway transportation, including the funding of highway and transit programs, the consequences of which are poorly understood. Research on such issues is needed to guide national and state policy decisions. Public-sector highway research has been the primary source of innovation and insight to meet national needs for highway transportation, but the programs that support this research are also under stress because of funding and other constraints. This chapter summarizes the Research and Technology Coordinating Committee's (RTCC's) evaluation of the strengths and weaknesses of the federal investment in highway research during 2006–2009 and presents recommendations based on those findings.

SUMMARY FINDINGS

Principles for Research

This report has analyzed the conformance of highway research funded through the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU) to the principles for research articulated by Congress in the preamble to the research title (Title V),

and it has presented the committee's judgment about priority program areas. These findings are summarized below.

Full Innovation Cycle

The portfolio of highway research programs managed by the Federal Highway Administration (FHWA), the Research and Innovative Technology Administration (RITA), and the Strategic Highway Research Program (SHRP) 2 collectively covers the full innovation cycle, with activities in agenda setting, research conduct, technology transfer, and deployment. More effort is needed, however, to establish national priorities that would inform all highway research programs, and additional resources are required to ensure that successful research results are deployed to the field.

Highway research in the United States has a decentralized management structure: each state has a program, some private-sector companies and associations have programs, and there are complementary federal programs. This structure was established in 1936, shortly after the founding of the federal–state highway partnership, and continues to serve the nation well. The geographic scale of the United States results in wide variation across the states in population, development patterns, congestion, economies, climate, soil conditions, and sources of materials. Thus states, as the principal owners and operators of highways, require individual research programs to focus on their particular needs. The State Planning and Research (SP&R) Program is funded through Title I but linked to Title V through requirements under this principle that FHWA work with the states in research, development, and technology (RD&T). The SP&R program links federal and state programs, ensures cooperation, and avoids duplication; it is also an essential element in the deployment of innovations at the state and local levels. In principle, the federal role of coordinating across research programs, leading in advanced research, filling gaps not covered by state or private programs, and facilitating technology transfer provides coherence across this decentralized enterprise, avoids duplication, and facilitates innovation.

The considerable expansion of funding for University Transportation Centers (UTCs) in SAFETEA-LU and the lack of linkage between federal mission agencies and individual UTCs have made apparent the lack of a prioritized national research agenda for highways that reflects broad-based

stakeholder input and support. FHWA's Corporate Master Plan for Research, Deployment, and Innovation has committed the agency to processes for the conduct of its programs that are consistent with the SAFETEA-LU principles. The agency has mission-oriented research plans in each of its program areas that were developed with stakeholder input. The Corporate Master Plan and FHWA's research plans, however, define federal rather than national priorities. SAFETEA-LU directs UTCs to ensure that their research is consistent with the 2002 report *Highway Research and Technology: The Need for Greater Investment* (National Highway R&T Partnership 2002) or with the Federal Transit Administration's National Research and Technology Program. The former, however, presents a wide range of research topics to make the case for additional investment in highway research and development (R&D) but does not establish priorities. Because of the restrictions on use of most federal funds to match UTC funding, federal agencies have few incentives to offer to influence the direction of UTC research. An ongoing set of carefully developed national priorities would help focus the efforts of all highway research programs.

Justification for Federal Investment

The RD&T programs of FHWA, RITA, and SHRP 2 are easily justified by the criteria of national significance, suboptimal private investment, and the importance of encouraging more efficient use of federal aid. The education component of the UTC Program is justified by the national significance of having a skilled transportation workforce available in a national labor market. There is certainly a need for independent fundamental and advanced highway research of the sort that is typically performed at universities, but the UTC Program requirement of matching research funding on a dollar-for-dollar basis results in too heavy a bias toward highly applied research. Most of the matching funding is provided by states through SP&R funding, and most state departments of transportation (DOTs) want research to address specific short-term problems they confront.

Content

The federal highway research program does not cover all the content areas Congress expects, largely as an inevitable consequence of overdesignation

and earmarks. Because of the resulting required cuts in existing programs, very little planning research and virtually no policy research appears in FHWA's portfolio, creating significant gaps in the FHWA program. FHWA was also forced to make severe cuts in funding for support of its research and testing laboratories, as well as information dissemination and exchange between and among researchers and practitioners. The 2008 Technical Corrections legislation redressed some of these shortfalls, but not all.

Another concern is adequate resources for deployment activities. Much of FHWA's applied RD&T program is designed to foster and support the adoption of innovations by the states and local governments that own and operate roads. Fostering innovations requires more than simply convincing states and local governments about the merits of new ideas. It must encompass deliberate programs of technology transfer, which include development of manuals, guidebooks, and specifications, where appropriate, and may include pilot projects to prove that new concepts work in the field. Adoption of innovations may also require incentives that reduce the risk of trying something new.

Important progress has been made under SAFETEA-LU. The Exploratory Advanced Research Program is an important new initiative. Advanced research refers to research with the potential to result in breakthroughs in understanding that could substantially improve practice. No entity other than the federal government is capable of supporting this type of risky but vitally important research. Congress increased funding substantially for advanced research in SAFETEA-LU; such research currently represents about 15 percent of FHWA's and SHRP 2's total portfolios and about 8 percent of all of Title V and SHRP 2 funding.

Stakeholder Input

FHWA has significantly revised its RD&T programs to foster stakeholder input, as reflected in agencywide commitments made in the agency's Corporate Master Plan. FHWA's ability to deliver on the commitments made in this plan, however, which derive from the requirements placed on the agency by the research principles of SAFETEA-LU, is constrained by the lack of any authorized funding for this purpose.

The 50-50 matching requirement for the UTC Program provides for responsiveness to sponsors, ensuring the relevance that stakeholder

involvement is meant to achieve. However, because state DOTs provide most of the matching funds and their interests are usually highly applied, the program has drifted away from the original intent to fund fundamental or advanced transportation research at universities.

SHRP 2 is a good model of stakeholder involvement in research. Including the pre–SAFETEA-LU planning phases, the program has allowed stakeholders to set program goals, develop a research agenda, select projects, merit review proposals, and peer review projects and their products.

Competition and Merit Review

Most of FHWA's RD&T funding is awarded competitively, and merit review is used for the purpose. Use of external experts in merit review is part of the agency's plans, but its practice is limited by inadequate resources. Other important points related to this principle include the following:

- About 18–38 percent of Title V and SHRP 2 funding is earmarked by Congress, depending on how one defines an earmark; therefore, at least 18 percent of the funding fails to adhere to the competition and merit review criterion.[1] Moreover, some earmarked projects are not nationally significant.
- The committee has concerns about how much FHWA relies on indefinite delivery/indefinite quantity (IDIQ) contracts for awarding research funding because of the way in which this contracting procedure limits the pool of potential competitors.
- SHRP 2 programs are responsive to stakeholders, and 80 percent of SHRP 2 funds are awarded in full and open competition, with decisions made through merit review by external experts. The remaining

[1] If one includes all the earmarked research in Title V, which is mostly highway-related but includes a number of earmarked research programs administered by other modal administrations of the U.S. Department of Transportation, along with SHRP 2, the total reaches 24 percent. The share earmarked grows if SHRP 2 is considered an earmark, as it is by some. Because SHRP 2 research funds are all subject to full and open competition, however, RTCC does not consider SHRP 2 to be an earmark. For all of Title V, which also includes training and education, the UTC Program, and the Intelligent Transportation System (ITS) Program among others, along with all SHRP 2 funding, 35 percent is earmarked if SHRP 2 is included, and 24 percent if it is not. If the analysis is restricted to FHWA's share of Title V, then 18 percent of FHWA's budget is earmarked if SHRP 2 is not considered an earmark and 38 percent is earmarked if SHRP 2 is considered an earmark.

percentage of funds covers stakeholder involvement processes and administration.
- Because about 62 percent of Title V UTCs and 58 percent of Title V UTC funding are earmarked, a major portion of the UTC Program fails to meet the criterion of merit review and awarding of funds based on competition.

The practice of earmarking is often justified by the ability of elected representatives to best judge the needs of their constituencies. Selecting the most meritorious research ideas is arguably a more complex process. The best research proposals may come from institutions outside a representative's own jurisdiction, for example. The merit review process for the selection of research proposals by expert peers, along with peer review of completed research, has made the U.S. scientific enterprise the envy of the world. These standards prevail in the legislation governing the renowned programs of the National Science Foundation and National Institutes of Health, but not in the legislation governing the programs of the U.S. Department of Transportation.

Performance Review and Evaluation

The outputs of all highway RD&T projects funded by FHWA are evaluated by agency staff. End users are also invited and encouraged to review the results of major projects in many FHWA R&T programs. FHWA has established peer committees to review its Long-Term Pavement Performance (LTPP) Program and its pavement technology development and deployment programs. SHRP 2 projects and products are evaluated by staff, Expert Task Groups made up of stakeholders, and the SHRP 2 Technical Coordinating Committees. The Government Accountability Office will also evaluate SHRP 2. It is difficult to judge the research benefits of the UTC Program. Each program is required to undergo peer review, but the results of that review are not made public. Individually earmarked universities and research institutes outside of the UTC Program have no real accountability for the funds they receive.

Funding

The level of investment in highway R&D is far from adequate. Funding for highway R&D is only about one-quarter the level of industrial investment

in R&D: industrial R&D equals about 3.34 percent of revenues from sales, but highway R&D is only 0.88 percent of highway funding (a public-sector proxy for revenues from sales).

Congress designated and earmarked funding for specific research programs in SAFETEA-LU that exceeded the total amount authorized for Title V, and this resulted in significant unintended consequences. Formerly, FHWA supported many RD&T activities with authorized funding that was not specifically designated by Congress. In addition to having to scale back many programs to fund all the SAFETEA-LU designations and earmarks, FHWA lost all funding for specific activities. Some of this funding was restored 3 years after passage of SAFETEA-LU in the Technical Corrections legislation. Nonetheless, even after that legislation, requirements placed on FHWA by SAFETEA-LU are underfunded or not funded at all (see Table 6-1). Policy research was virtually eliminated. (The $1 million in annual funding restored in the Technical Corrections legislation is far short of the $9 million to $10 million FHWA previously had available for policy research.) No funding is available to meet some elements of the SAFETEA-LU principles for RD&T, including performance review and evaluation involving external experts and stakeholders. Major programs strongly supported by stakeholders, such as SHRP 2, planning and environmental cooperative research, the Long-Term Bridge Performance (LTBP) Program, and the LTPP Program, are significantly underfunded compared with their authorized levels, thereby compromising their integrity and intent. The request for SHRP 2, for example, was $75 million annually over 6 years; $50 million annually

TABLE 6-1 FHWA RD&T Programs Significantly Reduced or Zero Funded by SAFETEA-LU

Program	TEA-21, FY 2003 ($ millions)	SAFETEA-LU, FY 2008 ($ millions)	Difference (percent)
Operations	16.2	8.1	–50
Safety	19.4	14.1	–27
Planning and Environment	23.1	20.2	–13
Policy	9.5	1.2	–87
R&T Program Support	12.0	4.4	–63

NOTE: FY = fiscal year; TEA-21 = Transportation Equity Act for the 21st Century.

was authorized over 4 years, $42.3 million of which will actually be received. Thus the program received only 36 percent of the total requested amount of funding over 4 instead of 6 years.

RECOMMENDATIONS

Principles for Research

To the maximum extent practicable, that is, in almost all instances, FHWA and RITA should award funds for research in accordance with the principle of competition and merit review. To ensure application of the procedures for research quality control that have helped maintain U.S. leadership in science and technology, funding to universities through the UTC Program should be awarded only through the application of this principle. All universities should be allowed to compete for these funds regardless of prior levels of transportation research.

Research projects should be awarded through contracts, cooperative agreements, or grants rather than through IDIQs. IDIQs have an appropriate role in such areas as testing and development, technical assistance, and other support for federal research programs and laboratories, and in cases when research must be initiated on a fast track to meet national priorities. Sole-source funding should be allowed for in the relatively rare circumstances where it is appropriate, such as when only a single agency has the capability required.

Congress recognized the importance of advanced, policy, and planning research to the federal program by including them under the "content" principle for Title V. The Exploratory Advanced Research Program begun under SAFETEA-LU should be continued. To permit UTCs to devote more of their efforts to advanced research, the matching requirement for UTC research should be reduced to a 20 percent university match. Policy research funding should be increased above the levels that existed before SAFETEA-LU; the activities funded through this program need to be restored. In addition, many pressing questions can be addressed through research and demonstrations. For example, continued high gasoline prices will have profound consequences for how the nation funds highway and transit programs. Much work needs to be done to develop alternative funding mechanisms, with appropriate consideration

of the trade-offs involved. FHWA also needs to have resources to assist states, metropolitan planning organizations (MPOs), and nongovernmental organizations in carrying out federal planning and environmental requirements. Additional support for data collection and improvements to travel models are needed for MPOs and states to fulfill their obligations.

Finally, in accordance with the principle of federal support for research and technology transfer by the states, the SP&R Program should be reauthorized.

Funding

FHWA should be provided the resources it needs to deliver on the commitments made in its Corporate Master Plan to involve stakeholders more substantively in its RD&T program, specifically in agenda setting, merit review, and peer review.

FHWA should be provided more funding for mission-related activities, such as program support for regulations and oversight, technical assistance, information sharing, technical exchange, and other deployment activities.

Funding for many program areas significantly cut back in SAFETEA-LU, including operations, safety, and planning and environmental research, should be restored. Funding for policy research should be restored and expanded to meet pressing national needs. FHWA should be given resources for stakeholder technical assistance and deployment activities in the planning and environmental area that were formerly provided under the Transportation Equity Act for the 21st Century. Specific programs supported by stakeholders also require additional attention. RTCC recommends that

- Congress consider extending SHRP 2 for 2 years into the next authorization and funding it under Title 1, as the states have requested;[2]
- The LTPP Program be funded to complete the data collection required for the experiment, fund the analysis needed to realize the benefits of

[2] RTCC endorsed the funding of SHRP 2 in its 2001 report *The Federal Role in Highway Research and Technology*. The program was subsequently authorized in SAFETEA-LU, and TRB was asked to manage the program. The committee believes that the program meets all the principles of research laid out in SAFETEA-LU. The program received much less funding and time than was requested and therefore is a candidate for continued funding. Even so, the committee does not wish to be perceived to be recommending future work for TRB to manage. Thus the committee's recommendation urges Congress to consider funding of an extension of the program on its merits.

the investment, and preserve the massive database on road performance collected under the program (according to one estimate, these activities would cost $9 million annually through 2015);
- The LTBP Program and other programs with broad-based stakeholder support authorized in SAFETEA-LU be reauthorized;
- The surface transportation environment and planning research program supported by stakeholders be authorized as a cooperative research program as recommended in *Surface Transportation Environmental Research: A Long-Term Strategy* (TRB 2002); and
- Funding for research programs to improve travel forecasting models and practice be authorized as recommended in *Metropolitan Travel Forecasting: Current Practice and Future Direction* (TRB 2007).

Data Collection

Much greater emphasis on data collection is necessary. The ability to answer many of the most important policy questions in highway transportation requires much better data. Research and better data are also needed in the planning area to develop the advanced modeling tools needed to meet federal and local planning and environmental mandates. States and MPOs rely heavily on the National Household Transportation Survey; that survey was dropped by the Bureau of Transportation Statistics (BTS), whose funding was also sharply reduced in SAFETEA-LU. Similarly, better and more timely data on freight movements are essential for improved planning. The Commodity Flow Survey, which is still part of BTS's portfolio, should be sustained and enhanced to meet user requirements.

Agenda Setting

Aside from the specific set of vital initiatives undertaken through SHRP 2, the lack of a national prioritized research agenda for highways has been made apparent by the wide variety of research topics being pursued by FHWA, the states, and the UTCs. To some extent, this variety is desirable. Mission agencies have a responsibility for RD&T to support meeting their legal responsibilities. States have their own priorities that they should be encouraged to pursue. Part of the rationale for creating the UTC Program was to encourage and allow discretion for academic researchers to pursue novel ideas that had not been recognized by

FHWA or the states. Even so, the UTC Program has grown to represent 16 percent of all SAFETEA-LU–funded research, and it is important to maximize the return on this investment. Although the mission agencies have some influence over the priorities in their own programs, they are not able to match UTC funds to influence the centers to focus on national priorities. Establishment of communitywide consensus on national highway research priorities would help focus all highway research programs on the most important areas. FHWA should be given the resources to take the lead in establishing an ongoing process whereby the highway community can set these priorities.

CONCLUDING OBSERVATIONS

Even within current constraints, the federal investment in highway research is a sound one. Publicly funded highway research programs have developed innovations that have resulted in longer-lived assets at lower costs, reduced environmental impacts, saved lives, and improved economic efficiency. Additional innovation will be needed to improve safety, reduce congestion, address environmental and energy concerns, and provide the quality highway system the nation's citizens expect. Adoption of the above recommendations would provide the nation with an improved program that would yield even greater dividends. These additional payoffs from research are urgently needed to meet the demands being placed on the highway system today and into the future.

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Abbreviation

TRB Transportation Research Board

National Highway R&T Partnership. 2002. *Highway Research and Technology: The Need for Greater Investment.* onlinepubs.trb.org/Onlinepubs/rtforum/HwyRandT.pdf. Accessed Aug. 29, 2008.

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APPENDIX A

Presentations and Discussions on Highway Research Programs That Informed This Report

UNIVERSITY TRANSPORTATION RESEARCH PROGRAM

Wednesday, June 14, 2006

Panel Discussion: Engaging the University Transportation Centers in Highway R&T

Dennis Judycki, *Federal Highway Administration (FHWA)*
Thomas Marchessault, *Research and Innovative Technology Administration*
John Mason, *Pennsylvania State University*
Dennis Christiansen, *Texas Transportation Institute*
Melissa Tooley, *University of Arkansas*
Gene Griffin, *North Dakota State University*

INFRASTRUCTURE RD&T

November 16, 2006

FHWA Overview

Gary Henderson, FHWA

Bridge RD&T

Presentations
Myint Lwin and Ian Friedland, FHWA, on FHWA bridge and structures RD&T programs; and Neil Hawks, Transportation Research Board, on the Strategic Highway Research Program (SHRP) 2 Renewal Program

Stakeholder Panel
John Sullivan, Portland Cement Association; Mal Kerley, Virginia Department of Transportation and Chair of the American Association of State Highway and Transportation Officials' Bridge Committee; Mary Lou Ralls, Ralls Newman, LLC; and Alexander Wilson, Mittal Steel

Pavement RD&T

Presentation on FHWA Pavement Research Programs
John Bukowski and Cheryl Richter, FHWA

Panel Discussion with Pavement Research Stakeholders
Harold "Skip" Paul, Louisiana Department of Transportation; Michael Ayers, American Concrete Pavement Association; and David Newcomb, National Asphalt Pavement Association

OPERATIONS RD&T

June 13, 2007

FHWA Operations RD&T

Presentation
Jeff Paniati, FHWA

Discussion
Committee

SHRP 2 Reliability Program

Presentation
Walter Diewald, SHRP 2

Discussion
Committee

Stakeholder Panel
John Conrad, Washington State Department of Transportation; Steve Lockwood, PB Consult; Connie Sorrell, Virginia Department of Transportation

PLANNING, ENVIRONMENT, AND REALTY RD&T

November 5, 2007

FHWA Planning, Environment, and Realty R&T

Presentation
Gloria Shepherd, FHWA

SHRP 2 Environmental R&T

Presentation
Neil Hawks, SHRP 2

Stakeholder Panel
Charles Howard, Puget Sound Regional Council; Joan Sollenberger, California Department of Transportation; Les Sterman, East–West Gateway Council, St. Louis

Safety R&T

November 6, 2007

FHWA Safety RD&T

Presentation
Jeff Lindley, FHWA

SHRP 2 Safety R&T

Presentation
Ann Brach, SHRP 2

Stakeholder Panel
Tom Welch, Iowa Department of Transportation; Peter Sweatman, University of Michigan Transportation Research Institute; Lowell Porter, Governor's Highway Safety Representative, Washington; Tim Neuman, CH2M Hill

POLICY RESEARCH

March 11, 2008

FHWA Program

Presentation
Susan Binder, FHWA

Discussion
Committee

FHWA RD&T PROCUREMENT POLICIES

March 10, 2008

Willie Smith, FHWA, Director of Acquisition Management

APPENDIX B

Research Projects Under the Strategic Highway Research Program 2 as of July 3, 2008

Project Number	Project Title	Stage
SHRP 2 Safety Projects		
SHRP 2 S01 (A)	Development of Analysis Methods Using Recent Data	Active
SHRP 2 S01 (B)	Development of Analysis Methods Using Recent Data	Active
SHRP 2 S01 (C)	Development of Analysis Methods Using Recent Data	Active
SHRP 2 S01 (D)	Development of Analysis Methods Using Recent Data	Active
SHRP 2 S01 (E)	Development of Analysis Methods Using Recent Data	Active
SHRP 2 S02	Integrate Methods and Develop Analysis Plan	Active
SHRP 2 S03	Roadway Measurement System Evaluation	Active
SHRP 2 S04	Acquisition of Roadway Information	Anticipated
SHRP 2 S05	Design of the In-Vehicle Driving Behavior and Crash Risk Study	Active
SHRP 2 S06	Technical Coordination and Independent Quality Assurance for Field Study	Anticipated
SHRP 2 S07	In-Vehicle Driving Behavior Field Study	Anticipated
SHRP 2 S08	Analysis of In-Vehicle Field Study Data and Countermeasure Implications	Anticipated
SHRP 2 S09	Site-Based Video System Design and Development	Active
SHRP 2 S10	Design and Conduct of the Site-Based Field Study	Anticipated
SHRP 2 S11	Analysis of Site-Based Field Study Data and Countermeasure Implications	Anticipated
SHRP 2 Renewal Projects		
SHRP 2 R01	Encouraging Innovation in Locating and Characterizing Underground Utilities	Active
SHRP 2 R02	Geotechnical Solutions for Soil Improvement, Rapid Embankment Construction, and Stabilization of the Pavement Working Platform	Active
SHRP 2 R04	Innovative Bridge Designs for Rapid Renewal	Active
SHRP 2 R05	Modular Pavement Technology	Active
SHRP 2 R06	A Plan for Developing High Speed, Nondestructive Testing Procedures for Both Design Evaluation and Construction Inspection	Active

(continued)

Project Number	Project Title	Stage
SHRP 2 R07	Performance Specifications for Rapid Renewal	Active
SHRP 2 R09	Guide for the Process of Managing Risk on Rapid Renewal Contracts	Active
SHRP 2 R15	Strategies for Integrating Utility and Transportation Agency Priorities in Highway Renewal Projects	Active
SHRP 2 R16	Railroad-DOT Institutional Mitigation Strategies	Active
SHRP 2 R19 (A)	Bridges for Service Life Beyond 100 Years: Innovative Systems, Subsystems, and Components	Active
SHRP 2 R19 (B)	Bridges for Service Life Beyond 100 Years: Service Limit State Design	RFP
SHRP 2 R21	Composite Pavement Systems	Active
SHRP 2 R23	Using Existing Pavement in Place and Achieving Long Life	Active
SHRP 2 R26	Preservation Approaches for High Traffic Volume Roadways	Active
SHRP 2 Reliability Projects		
SHRP 2 L01	Identification and Analysis of Best Practices	Active[a]
SHRP 2 L02	Establishing Monitoring Programs for Mobility and Travel Time Reliability	Anticipated
SHRP 2 L03	Analytic Procedures for Determining the Impacts of Reliability Mitigation Strategies	Active
SHRP 2 L04	Incorporating Reliability Performance Measures in Planning and Operations Modeling Tools	Anticipated
SHRP 2 L05	Incorporating Reliability Performance Measures into the Transportation Planning and Programming Processes	Anticipated
SHRP 2 L06	Institutional Architectures to Advance Operational Strategies	Active
SHRP 2 L07	Evaluation of Cost-Effectiveness of Highway Design Features	Active
SHRP 2 L08	Incorporation of Non-Recurrent Congestion Factors into the Highway Capacity Manual Methods	Anticipated
SHRP 2 L09	Incorporation of Non-Recurrent Congestion Factors into the AASHTO Policy on Geometric Design	Anticipated
SHRP 2 L10	Feasibility of Using In-Vehicle Video Data to Explore How to Modify Driver Behavior That Causes Non-Recurring Congestion	RFP
SHRP 2 L11	Evaluating Alternative Operations Strategies to Improve Travel Time Reliability	RFP
SHRP 2 L12	Training and Certification for Traffic Incident Responders	Pending
SHRP 2 L13	Requirements and Feasibility of a System for Archiving and Disseminating Data from SHRP 2 Reliability and Related Studies	RFP
SHRP 2 L14	Effectiveness of Different Approaches to Disseminating Traveler Information on Travel Time Reliability	Anticipated
SHRP 2 L15	Reliability Innovations Deserving Exploratory Analysis (IDEA)	Anticipated

(continued on next page)

Research Projects Under the Strategic Highway Research Program 2 as of July 3, 2008 *(continued)*

Project Number	Project Title	Stage
SHRP 2 Capacity Projects		
SHRP 2 C01	A Framework for Collaborative Decision Making on Additions to Highway Capacity	Active
SHRP 2 C02	A Systems-Based Performance Measurement Framework for Highway Capacity Decision Making	Active
SHRP 2 C03	Interactions Between Transportation Capacity, Economic Systems, and Land Use Merged with Integrating Economic Considerations Project Development	Active
SHRP 2 C04	Improving Our Understanding of How Highway Congestion and Pricing Affect Travel Demand	Active
SHRP 2 C05	Understanding the Contribution of Operations, Technology, and Design to Meeting Highway Capacity Needs	Active
SHRP 2 C06 (A)	Integration of Conservation, Highway Planning, and Environmental Permitting Using an Outcome-Based Ecosystem Approach	RFP
SHRP 2 C06 (B)	Development of an Ecological Assessment Process and Credits System for Enhancements to Highway Capacity	RFP
SHRP 2 C07	Integrating SHRP 2 Products into the Collaborative Decision Making Process (1)	Anticipated
SHRP 2 C08	Linking Community Visions and Highway Capacity Planning	Anticipated
SHRP 2 C09	Incorporating Greenhouse Gas Emissions into the Collaborative Decision-Making Process	Anticipated
SHRP 2 C10	Partnership to Develop an Integrated, Advanced Travel Demand Model and a Fine-Grained, Time-Sensitive Network	Anticipated
SHRP 2 C11	Development of Improved Economic Analysis Tools Based on Recommendations from Project C03 (2)	Anticipated
SHRP 2 C12	The Effect of Public-Private Partnerships and Non-Traditional Procurement Processes on Highway Planning, Environmental Review, and Collaborative Decision Making	Anticipated
SHRP 2 C13	Integrating Full Cost Analysis and Fiscal Impact Analysis into Collaborative Decision Making	Anticipated
SHRP 2 C14	Developing a Multiagency Change Management Framework	Anticipated
SHRP 2 C15	Integrating Freight Considerations into Collaborative Decision Making for Additions to Highway Capacity	Anticipated
SHRP 2 C16	The Effect of Smart Growth Policies on Travel Demand	Anticipated

[a]This request for proposals (RFP) was originally issued in July 2007; no proposal received was deemed responsive, so no contract award was made. A preproposal conference is planned before a revised RFP is issued by July 2008.

APPENDIX C

Conformity of Individual FHWA Infrastructure Research, Development, and Technology Programs with SAFETEA-LU Principles

Innovative Pavement Research and Deployment (IPRD) Program

Funding level: About $18.6 million annually, fiscal years (FY) 2006–2009.

Principle No. 1: Full innovation cycle: The IPRD Program goals include research, development, deployment, and evaluation of new, cost-effective designs, materials, practices, and technologies to extend pavement life and performance, to increase safety and to reduce construction time. Although the program includes applied research, the majority of the program goals are focused on deployment and evaluation.

Principle No. 2: Justification for federal investment: This program focuses on innovative pavement technologies, specifications, and test methods, issues that are inherently public-sector and would not attract investment by the private sector. By aiming to extend pavement service life and performance and enhance safety, the goal of the research serves efficient use of federal funds by state and local governments.

Principle No. 3: Content: This program fills significant gaps. Some of the most important issues to be addressed in the research program extend beyond consideration of asphalt, concrete, or aggregate in isolation to how these pavement types and materials work together.

Principle No. 4: Stakeholder input: The pavement program has an internal and an external component. The internal component consists of a Pavement Forum (FHWA experts in pavements at the senior level) and a Roadmap (which prioritizes the work that needs to be done

and where scarce resources need to be spent). FHWA is currently conducting outreach to state departments of transportation (DOTs), industry, and academia to obtain their input and participation by forming Expert Task Groups (ETGs) that will provide technical input in the areas of concrete and asphalt. TRB's recently formed Pavement Technology Committee, which draws from state DOTs, industry, and academia, also provides overall strategic direction for the program.

Principle No. 5: Competition and merit review: Some of the work is done in-house at FHWA facilities by FHWA and contract staff, and some is awarded competitively via formal requests for proposals (RFPs). For FY 2007, approximately 30 percent of funds cover the Turner–Fairbank Highway Research Center (TFHRC) on-site contractor, equipment, materials and supplies, mobile laboratories, and program-related staff travel. Approximately 70 percent goes to outside contractors. Merit review is normally conducted by FHWA staff. Occasionally, FHWA brings in an external expert, usually from a state DOT.

Principle No. 6: Performance review and evaluation: This program is subject to normal FHWA RD&T evaluation. TRB's Pavement Technology and Evaluation Committee meets once a year to review FHWA's overall pavement program and provide programmatic input. As the program is ongoing, ETGs, which include end users, meet semiannually to review programs, and members evaluate completed products.

Other comments: IPRD, which receives the bulk of FHWA's discretionary funds, is funded at about $16.4 million per year and it has some directed areas. Within IPRD, however, a relatively large portion is designated for specific materials; the balance that remains to cover research topics such as surface characteristics or composite pavements may not allow FHWA to allocate the resources available optimally.

Long-Term Pavement Performance (LTPP) Program

Funding level: About $8.3 million annually, FY 2006–2009.

Principle No. 1: Full innovation cycle: LTPP is a product-focused research program that, because of significant budget cuts, is focused on data collection on 2,513 pavement test sections throughout the country.

Principle No. 2: Justification for federal investment: The LTPP experiment is designed to yield fundamental improvements in knowledge about how loadings and environmental conditions affect pavement performance, and it may lead to substantially improved designs. The study has national significance and can lead to more efficient use of federal funding by states and local governments.

Principle No. 3: Content: The LTPP Program gathers and processes data describing the structure, service conditions, and performance of pavement test sections. The near-term work is primarily data collection, but improvements in understanding that could occur as a result of the experiment are fundamental.

Principle No. 4: Stakeholder input: The LTPP Program involves substantial stakeholder input; state DOTs, industry, and academia have been polled repeatedly to identify needs, and national pavement needs were identified by chief engineers during site visits. The program is being conducted in partnership with the state highway agencies that own the LTPP test sections. Since 1992 FHWA has convened a panel of state DOT engineers, industry experts, and academicians to give guidance and review the program on an ongoing basis. Other stakeholders include the TRB Pavement Technology Committee, the Asphalt ETGs, and the Concrete Pavement Roadmap Executive Advisory Committee.

Principle No. 5: Competition and merit review: Some of the work (about 5 percent) is done in house at FHWA facilities by FHWA and contract staff, and the remainder is awarded competitively via formal RFPs.

Principle No. 6: Performance review and evaluation: In addition to normal FHWA evaluation, ETGs advise and comment on the product development and delivery process, ensure dissemination of product information to the states, review research products to ensure that they are focused on national pavement needs, and evaluate the effectiveness of products.

Other comments: Begun in 1987, LTPP is a 20-year program of data collection and database development for the LTPP test sections originally established as part of the Strategic Highway Research Program (SHRP). Annual funding for LTPP declined from $14.5 million under the Intermodal Surface Transportation Efficiency Act (ISTEA), to

$12.6 million in FY 1998–2003, to $9.3 million in FY 2004–2005, to just $7.2 million under SAFETEA-LU. FHWA estimated that $20 million per year was needed after FY 2003 to recover from previous underfunding and complete necessary work. With annual funding of only $7.2 million, FHWA has had to identify the most critical work that needs to be done and defer all else. The first priority in the program is to ensure that the database is as complete and the data as accurate as possible. Within the LTPP budget allocation, FHWA lacks the resources needed to carry out the extended analysis, product development, and implementation activities FHWA and the TRB LTPP committee believe should be done. The other main issue facing the program is that funding is expected to expire in FY 2009, but the benefits of the data collection will not have been realized by then because of the lack of funding for analysis.

Alkali–Silica Reactivity (ASR) Program

Funding level: An average of about $2 million annually, FY 2006–2009.

Principle No. 1: Full innovation cycle: The ASR Program is focused on the development and deployment of new technologies to address concrete failures due to alkali–silica reactivity.

Principle No. 2: Justification for federal investment: Legislation calls for the development and deployment of technologies to prevent and mitigate ASR in highway structures, pavements, and bridges; the legislation specifically mentions the use of lithium, but the program is not limited to this. The development of products to assist states in inventorying existing structures for ASR may improve the efficiency of use of federal funds by state and local governments.

Principle No. 3: Content: The ASR Program provides for further development and deployment of techniques to prevent and mitigate ASR, including lithium-based techniques. Program content is applied research, deployment, and technology transfer.

Principle No. 4: Stakeholder input: The ASR Program was initiated with a stakeholder workshop, which provided the foundation for FHWA's program plan. The plan was subsequently discussed with a representative group of stakeholders selected for the ASR Technical

Working Group (TWG). The TWG will review the program on an ongoing basis.

Principle No. 5: Competition and merit review: Most funding (97 percent) is awarded competitively via formal RFPs. Some work was awarded and monitored under SHRP 2. Merit review normally is performed by FHWA staff.

Principle No. 6: Performance review and evaluation: Usual FHWA procedures apply. The TWG will review end products.

Other Comments: Unlike the other designated programs, the ASR Program is applicable to both pavements and bridges. Technology transfer and deployment are managed within the pavement program. R&D is managed jointly by pavements and structures staff.

Fundamental Properties of Asphalts and Modified Asphalts Program

Funding level: About $3.4 million annually, FY 2006–2009.

Principle No. 1: Full innovation cycle: The mission of this earmarked program is to improve the Superpave® asphalt purchase specification so that asphalts are classified accurately by how they will perform over time regardless of the crude oil source. This program is focused on the conduct of fundamental research.

Principle No. 2: Justification for federal investment: This program is not a national priority.

Principle No. 3: Content: The purpose of this program is to identify how variations in asphalt properties affect roadway performance and to develop and validate practical tests for performance variables that are missing from the current purchase specification. The program allows the Western Research Institute (WRI) to continue its fundamental research on the effects of asphalt composition on long-term pavement performance. It is hoped that this research will improve methods used to characterize asphalts and modified asphalts, which in turn will support improved materials selection processes and reduced risk of early pavement failure.

Principle No. 4: Stakeholder input: This program has stakeholder input only because FHWA is asking its Asphalt ETG to review and comment.

Principle No. 5: Competition and merit review: The program does not comply with this principle.

Principle No. 6: Performance review and evaluation: The program does not comply with this principle.

Other comments: None.

Asphalt Research Consortium

Funding level: About $6.8 million annually, FY 2006–2009.

Principle No. 1: Full innovation cycle: This consortium is led by WRI. Other members include the University of Nevada, Reno; the Texas Transportation Institute; the University of Wisconsin, Madison; and Applied Asphalt Technologies. The mission of the consortium is to conduct research on flexible pavements and means of extending the life cycle of asphalts; the focus is on fundamental research, and FHWA estimates that about 60 percent of the funding is for advanced research.

Principle No. 2: Justification for federal investment: Federal investment in the consortium could be justified by the lack of private investment in this type of research.

Principle No. 3: Content: This research fills gaps in knowledge. Its purpose is the validation and calibration of findings concerning the performance impact of fundamental properties of asphalt; the identification of advanced technological capabilities to increase pavement durability and performance and reduce life-cycle costs; and the identification of the mechanism of action of polyphosphoric acid as an asphalt binder modifier, as well as its potential beneficial and deleterious effects.

Principle No. 4: Stakeholder input: This program has stakeholder input only because FHWA is asking its Asphalt ETG to review and comment.

Principle No. 5: Competition and merit review: The program does not comply with this principle.

Principle No. 6: Performance review and evaluation: The program does not comply with this principle.

Other comments: None.

Long-Term Bridge Performance (LTBP) Program

Funding level: An average of $8.3 million, FY 2006–2009.

Principle No. 1: Full innovation cycle: The LTBP Program includes the type of applied research, deployment, and technology that FHWA should pursue. The focus is on bridge performance (system and component), maintenance and repair effectiveness, and improved knowledge for design and management decision making. The program is intended to provide high-quality, quantitative performance data for highway bridges that will support improved predictive models and better bridge management systems.

Principle No. 2: Justification for federal investment: This program meets the criteria for federal investment because it addresses a public-sector responsibility that would not attract private investment; there is a clear public benefit; and it encourages stewardship of infrastructure funded in part by the federal government.

Principle No. 3: Content: The data collected through this program will fill significant gaps in the understanding of how similar bridges perform under different loading and environmental conditions.

Principle No. 4: Stakeholder input: The initial framework for the program was developed with American Association of State Highway and Transportation Officials (AASHTO) support and in conjunction with university and industry partners. Stakeholder workshops occurred in 2007.

Principle No. 5: Competition and merit review: A fully competitive process will be undertaken to select the lead contractor.

Principle No. 6: Performance review and evaluation: All FHWA RD&T programs are subject to process and performance review. Normally, the results of FHWA RD&T projects are also subjected to independent review, usually by representatives of end-user groups (e.g., the various Technical Committees of the AASHTO Highway Subcommittee on Bridges and Structures). Peer review will be conducted on a continuing basis by the various oversight and advisory committees to be empaneled.

Other comments: The LTBP Program is intended to be a 20-year program but is currently authorized through FY 2009. Because this program is funded at only about $9.5 million per year instead of the $20 million requested by FHWA, its achievements will be severely affected.

The low funding levels are attributable to the overdesignation and earmarking of research funds in Title V.

Innovative Bridge Research and Deployment (IBRD) Program

Funding level: About $5.7 million annually, FY 2006–2007 (not including funding for High-Performance Concrete Program).

Principle No. 1: Full innovation cycle: The IBRD Program includes agenda setting (identification of national needs and priorities), applied research, technology transfer (from research to practice), and application of new technologies (via construction projects). The integration of program elements and stakeholder involvement should facilitate deployment.

Principle No. 2: Justification for federal investment: IBRD addresses national needs and priorities and encourages efficient use of federal funds by state and local governments by leading change and supporting the adoption of new technology.

Principle No. 3: Content: The RD&T element of the program directly addresses significant highway research gaps and emerging issues with national implications by focusing on problems that require a national approach (e.g., resisting the effects of storm surge, similar to that experienced from Hurricanes Katrina and Rita, on bridges subject to coastal flooding). The program supports research, technology, and education in the areas of high-performance concrete, geotechnical engineering, aerodynamics and wind engineering, and hydrology and hydrodynamic engineering. One part of the program supports innovative research on hydraulics, aerodynamics, and geotechnical engineering; another part supports the deployment of innovative approaches for bridges to be constructed.

Principle No. 4: Stakeholder input: Since criteria for the construction grant element of IBRD were spelled out in SAFETEA-LU, there is little room for stakeholder input. However, the RD&T element of the program has a high level of stakeholder input, as multiyear RD&T roadmaps were developed on the basis of input from a wide range of stakeholder communities, including states, industry, and academia.

Principle No. 5: Competition and merit review: The construction grant program is highly competitive. In FY 2006, grants were awarded (on the basis of criteria and technical merit) to only about 30 percent of

applicants. About 20 percent of the program funds (after funding of the grants) is for in-house research and program support.

Principle No. 6: Performance review and evaluation: All FHWA RD&T programs are subject to process and performance review. Normally, the results of FHWA RD&T projects are also subjected to independent review, usually by representatives of end-user groups (e.g., the various Technical Committees of the AASHTO Highway Subcommittee on Bridges and Structures).

Other comments: None.

High-Performance Concrete (HPC) Bridge Research and Deployment Program

Funding level: About $4 million annually, FY 2006–2007 (the HPC Bridge Research and Deployment Program is a subset of and funded via a takedown from the IBRD Program).

Principle No. 1: Full innovation cycle: The HPC Bridge Research and Development Program is intended to cover the full innovation cycle and includes formal components to develop, market, and deploy new knowledge and technologies resulting from the program.

Principle No. 2: Justification for federal investment: The HPC Bridge Research and Development Program addresses national needs and priorities and could lead to more efficient use of federal funds by states and local governments.

Principle No. 3: Content: The RD&T element of the program directly addresses significant highway research gaps and emerging issues with national implications by focusing on problems that require a national approach.

Principle No. 4: Stakeholder input: The overall multiyear RD&T roadmap was developed with significant stakeholder input and is being guided by a TWG comprising representatives of states, industry, and academia.

Principle No. 5: Competition and merit review: The RD&T element of the program is partially competitive: some of the work is done in-house at FHWA facilities by FHWA and contract staff (about 65 percent of funding), and some is awarded competitively via formal RFPs (about 35 percent).

Principle No. 6: Performance review and evaluation: All FHWA RD&T programs are subject to process and performance review. Normally, the results of FHWA RD&T projects are also subjected to independent review, usually by representatives of end-user groups (e.g., the various Technical Committees of the AASHTO Highway Subcommittee on Bridges and Structures).

Other comments: None.

Ultra-High-Performance Concrete (UHPC) Research Program

Funding level: About $0.5 million annually, FY 2006–2009.

Principle No. 1: Full innovation cycle: The UHPC Program is intended to cover the full innovation cycle and includes formal components to develop, market, and deploy new knowledge and technologies resulting from the program.

Principle No. 2: Justification for federal investment: The RD&T element of the program directly addresses significant highway research gaps and emerging issues with national implications by focusing on problems that require a national approach.

Principle No. 3: Content: The focus of the UHPC Program is on developing innovative practices, materials, components, and systems; improving knowledge and technology; accelerating fabrication and construction; improving durability and reducing long-term maintenance; and employing technology transfer to accelerate implementation.

Principle No. 4: Stakeholder input: The UHPC Program involves stakeholders in identifying the work to be done and reviewing the quality of the work.

Principle No. 5: Competition and merit review: There is no competition because all of the work will be conducted in-house. The TWG that was assembled for the HPC Program is also assisting with the UHPC Program. It is providing both guidance and review of technical content during the course of the program and will assist in championing the program's products.

Principle No. 6: Performance review and evaluation: All FHWA RD&T programs are subject to process and performance review. Normally, the results of FHWA RD&T projects are also subjected to independent

review, usually by representatives of end-user groups (e.g., the various Technical Committees of the AASHTO Highway Subcommittee on Bridges and Structures). The TWG will assist in providing performance review (peer review) and evaluation.

Other comments: FHWA has been actively engaged in R&D on the use of UHPC for a number of years. The work to date has focused on the fundamental properties of this material and potential applications in real-world situations (e.g., characterization of the material with respect to strength, durability, constructability). Emphasis in the SAFETEA-LU program is now on developing structural components and systems that optimize the application of UHPC, which is currently several times more expensive than the concrete typically used in highway construction.

Higher-Performing Steel (HPS) Bridge R&T Transfer Program

Funding level: About $3.4 million annually, FY 2006–2009.

Principle No. 1: Full innovation cycle: The HPS Program addresses the full innovation life cycle, from concept through deployment. The program includes agenda setting (identification of national needs and priorities), fundamental research, applied (gap-filling) research, and technology transfer and deployment. A multiyear RD&T roadmap addressing each of these areas has been developed and is being carried out. The projects in this program are very diverse—from research on basic steel chemistry to develop an economically viable corrosion-resistant steel (fundamental research); to the development of prefabricated steel bridge systems and details (highly applied research); to the development of design manuals and National Highway Institute training courses and the conduct of field showcases (deployment, education, and training).

Principle No. 2: Justification for federal investment: The HPS Program directly addresses nationally significant topics and encourages efficient use of federal funds by states and local governments. The focus of the program, as with the HPC and UHPC Programs, is on developing innovative practices, materials, components, and systems; improving knowledge and technology; accelerating fabrication and construction; improving durability and reducing long-term maintenance;

employing technology transfer to accelerate implementation; and forming TWGs.

Principle No. 3: Content: The HPS Program directly addresses fundamental research, significant highway research gaps, and emerging issues.

Principle No. 4: Stakeholder input: The overall multiyear RD&T roadmap was developed with significant stakeholder input and is being guided by a TWG comprising representatives of states, industry, and academia. The TWG is providing guidance and review of technical content during the course of the program and will assist in championing the program's products.

Principle No. 5: Competition and merit review: About half of the work is being done in-house at FHWA facilities by FHWA and contract staff, and half is being awarded competitively via formal RFPs. For example, the corrosion-resistant steel project was initiated via a Broad Agency Announcement, in which concept proposals for how to achieve the project objectives were solicited. Two organizations were selected and funded for preliminary proof-of-concept studies.

Principle No. 6: Performance review and evaluation: The HPS TWG is playing an ongoing role in process and performance reviews. The results of FHWA RD&T projects are also subjected to independent review, usually by representatives of end-user groups, as well as through review of papers submitted to peer-reviewed journals.

Other comments: None.

Steel Bridge Testing Program

Funding level: About $1 million annually, FY 2006–2009.

Principle No. 1: Full innovation cycle: The program is focused on developing improvements in existing steel nondestructive evaluation/testing (NDE) technologies, as well as soliciting innovative approaches and new technologies that may provide significantly more information for decision making. A major component of the program in FY 2008 and 2009 will be the development and deployment of manuals and demonstrations on the effective use of these technologies.

Principle No. 2: Justification for federal investment: This program directly supports the federal role in ensuring the safety of the nation's highway system by providing improved tools and knowledge to support the National Bridge Inspection Standards.

Principle No. 3: Content: The program directly addresses significant highway research needs, gaps, and emerging issues and encompasses research, development, and education and training.

Principle No. 4: Stakeholder input: Stakeholders have provided input into the program and are assisting in defining required NDE standards. Stakeholders will also be key contributors to deployment activities in the later years of the program.

Principle No. 5: Competition and merit review: The Steel Bridge Testing Program has two components: improving existing tools and technologies, and identifying and developing new approaches. Both components are being conducted through a full and open competitive process. The results of the program will be reviewed by stakeholder groups and technical experts.

Principle No. 6: Performance review and evaluation: As with other programs, FHWA is working closely with stakeholder groups, such as the AASHTO Bridge Committee, to review program results and help ensure that the NDE technologies being promoted through the program can be used immediately in the field.

Other comments: The Steel Bridge Testing Program was designated by Congress but would not have been considered a high priority by FHWA in comparison with other critical issues and end-user needs. The focus is on improving the technology used for identifying fatigue cracks in steel bridges through NDE techniques, but the current state of technology and practice at the state level, when applied correctly, is considered effective by FHWA. The United States does not build many steel bridges today, and the available funding will have little impact.

Seismic Research Program

Funding level: About $2 million annually, FY 2006–2009.

Principle No. 1: Full innovation cycle: The goal of the Seismic Research Program is to develop and implement cost-effective methods for reducing vulnerabilities and economic losses through the conduct of seismic research. Upgrades to earthquake simulation facilities will be made, as necessary, to carry out the program.

Principle No. 2: Justification for federal investment: The topic of seismic research is of national significance, but because there are no discretionary RD&E funds, FHWA is using this earmarked program

to address national needs and priorities that cannot otherwise be undertaken.

Principle No. 3: Content: The Seismic Research Program is focused on increasing the resilience of bridges and reducing earthquake-induced losses due to highway damage. The purpose of the program is to study the vulnerability of the federal-aid system and other surface transportation systems to seismic activity, to develop and implement cost-effective methods for reducing that vulnerability, and to upgrade earthquake simulation facilities as necessary to carry out the program.

Principle No. 4: Stakeholder input: The University of Nevada carries out seismic research in cooperation with the National Center for Earthquake Engineering Research at the University of Buffalo. They work with stakeholders to implement the developed methodologies and technologies. Both institutions are creating advisory groups to help guide the conduct of the program. These groups will comprise representatives from the federal and state governments, industry, and academia.

Principle No. 5: Competition and merit review: There is no competition for research conducted through earmarked programs, and thus the Seismic Research Program does not comply with this principle.

Principle No. 6: Performance review and evaluation: This earmarked program complies with the principle of performance review and evaluation through normal FHWA practice.

Other comments: None.

Polymer–Wood Composite Research Program

Funding level: About $750,000 annually, FY 2006–2007.

Principle No. 1: Full innovation cycle: The focus of the Polymer–Wood Composite Research Program is on basic research aimed at the development of a wood–fiber-reinforced polymer (FRP) composite material that can be used as structural lumber in bridges and other structures. The program is expected to result in the development of a tested and validated structural material, but limited technology transfer is included in the current work plan.

Principle No. 2: Justification for federal investment: Title V calls for $1 million annually to be made available for FY 2006 and 2007 for a demonstration project addressing this material. This project would not be

considered a high-priority need by the FHWA or stakeholder groups, perhaps other than those associated with FRP technology.

Principle No. 3: Content: The objective of this program is to conduct research aimed at the development of a composite material composed of the equivalent of sawdust and FRP.

Principle No. 4: Stakeholder input: There is no stakeholder input into the program, other than a limited advisory role by the Maine DOT and the FHWA contracting officer's technical representative.

Principle No. 5: Competition and merit review: This earmarked program does not comply with this principle.

Principle No. 6: Performance review and evaluation: This earmarked program does not comply with this principle.

Other comments: This earmarked program is being conducted by the University of Maine.

SHRP 2 Renewal Program

Funding level: A total of $28.9 million.

Principle No. 1: Full innovation cycle: The Renewal Program is applied research designed from a systems perspective to address persistent problems in the length of time required to plan, analyze, design, and finance the replacement of highway infrastructure.

Principle No. 2: Justification for federal investment: This program will help states and local governments use federal funding more efficiently. Because of the focus on helping states and local governments to deliver renewed infrastructure more quickly and efficiently and to install facilities with less disruption to users and with longer service lives, the research is inherently public-sector in nature and unlikely to be performed in the private sector.

Principle No. 3: Content: The research is aimed at filling gaps regarding how to renew aging infrastructure through rapid design and construction methods that cause minimal disruption and produce long-lived facilities.

Principle No. 4: Stakeholder input: SHRP 2 has three levels of stakeholder input. The program is governed by an Oversight Committee made up of senior state DOT officials, contractors, consultants, interest groups, and highway users. Each program area, such as renewal, has a Technical Coordinating Committee (TCC) made up of professionals from

DOTs, cities and counties, metropolitan planning organizations, contractors, consultants, users, and academicians. The RFP for each project is developed by relevant technical experts from diverse backgrounds. Moreover, the overall program design and the detailed research plans for each area were developed with extensive stakeholder input (the policy committee and five National Cooperative Highway Research Program panels, as well as the broader outreach efforts).

Principle No. 5: Competition and merit review: All SHRP 2 research is conducted through full and open competition, with selection based on recommendations made by the TCCs to the Oversight Committee.

Principle No. 6: Performance review and evaluation: Reports will be reviewed by the TCCs, possibly with the assistance of ETGs when reports are highly technical. SHRP 2 as a whole will be reviewed by the Government Accountability Office. The program as a whole is also constantly monitored by FHWA and AASHTO ex officio members.

Other comments: None.

APPENDIX D

SAFETEA-LU University Transportation Research Centers

Location	Theme
Regional Centers for Fiscal Years (FY) 2007–2009 (Authorized at $2.0 Million Each in FY 2006 Through 2008 and $2.25 Million in FY 2009)	
Massachusetts Institute of Technology (Region 1)	Strategic Management of Transportation Systems
City University of New York (Region 2)	Planning and Management of Regional Transportation Systems
Pennsylvania State University (Region 3)	Advanced Technologies in Transportation Operations and Management
University of Tennessee (Region 4)	Transportation Safety
Purdue University (Region 5)	Proposed theme: Integrated Solutions for Mobility, Safety, and Infrastructure Renewal
Texas A&M University (Region 6)	Transportation Solutions to Enhance Prosperity and the Quality of Life
University of Nebraska (Region 7)	Proposed theme: Improving Safety and Minimizing Risk Associated with Increasing Multimodal Freight Movement on the U.S. Surface Transportation System
North Dakota State University (Region 8)	Rural and Intermodal Transportation
University of California, Berkeley (Region 9)	Transportation Systems Analysis and Policy
University of Washington (Region 10)	Transportation Operations and Infrastructure Construction
Tier I Centers for FY 2006–2009 (Authorized at $1.0 Million Each Annually)	
Georgia Institute of Technology	Proposed theme: Investing in the National Transportation System: Economic Growth, System Productivity, and Finance
Iowa State University	Proposed theme: Improving Transportation Safety Through Improvements in Management Information Systems

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SAFETEA-LU University Transportation Research Centers *(continued)*

Location	Theme
Rutgers University	Proposed theme: Management and Operations of Multimodal Transportation Infrastructure Systems in High-Volume Intermodal Corridor Environments—Through Meaningful Research, Education, and Workforce Training
San Jose State University	Proposed theme: Transportation Systems Policy and Management
University of Central Florida	Proposed theme: Multimodal Solutions for Congestion Mitigation
University of Idaho	Advanced Technology for Sustainable Transportation
University of Maryland, College Park	Proposed theme: Integrated Transportation Systems Management
University of Michigan	Proposed theme: Safety and Mobility Across the Lifespan
University of South Florida	To Make Public Transportation and Alternative Forms of Transportation Safe, Effective, Efficient, Desirable, and Secure
University of Southern California/California State University, Long Beach	Metropolitan Transportation
National Centers for FY 2006–2009 (Authorized at $3.5 Million Annually Each in FY 2006–2009)	
Marshall University, West Virginia	Transportation and Economic Development in Mountain Regions
Western Transportation Institute at Montana State University, Bozeman	Integrated Approaches to Rural Travel and Transportation
Northwestern University	Improving the Technology and Expertise Available to Address the Problems of the Nation's Transportation Infrastructure
Oklahoma Transportation Center (at Oklahoma State University)	Economic Enhancement Through Infrastructure Stewardship
Portland State University (in partnership with the University of Oregon, Oregon State University, and the Oregon Institute of Technology)	Advanced Technology, Integration of Land Use and Transportation, and Healthy Communities
University of Alaska	Transportation Safety, Security, and Innovation in Cold Regions
University of Minnesota	Human-Centered Technology to Enhance Safety and Mobility
Missouri University of Science and Technology	Proposed theme: Advanced Materials, Transition-State Fuel Vehicle Infrastructure, and Nondestructive Evaluation Technologies and Methods
University of Vermont	Proposed theme: Sustainable Systems and Advanced Technologies for Northern Communities
University of Wisconsin	Sustainable Freight Transportation Infrastructure and Systems
Tier II Centers for FY 2006–2009 (Authorized at $500,000 Each Annually)	
California State University, San Bernardino	Decision-Making and Management of Transportation Systems

(continued)

Location	Theme
Cleveland State University, Work Zone Safety Institute	Highway Work Zone Safety and Efficiency
George Mason University	Proposed theme: Deployment of Intelligent Transportation Systems
Hampton University, Eastern Seaboard Intermodal Transportation Applications Center	Enhance Regional Intermodal Transportation Systems by Improving Safety and Efficiency While Minimizing Environmental Impacts
Kansas State University	Sustainability and Safety of Rural Transportation Systems and Infrastructure
Louisiana State University, Louisiana Transportation Research Center–Technology, Training, and Education Center	To be determined
Michigan Technological University	Materials in Sustainable Transportation Infrastructure
North Carolina State University, Center for Transportation and the Environment	Transportation and the Environment
Northwestern University	Commercialization or Implementation of Innovative Technologies for Multimodal Surface Transportation
University of Akron	Transportation Mobility and Infrastructure Management
University of Arkansas	Proposed theme: Rural Transportation
University of California, Davis	Sustainable Transportation
University of Connecticut	Transportation for Smart Growth
University of Delaware, Newark	Resiliency of Transportation Corridors
University of Detroit, Mercy	Alternate Energy and System Mobility to Stimulate Economic Development
University of Massachusetts, Amherst	Proposed theme: Improving Transportation Mobility and Safety with Innovative Technologies and Strategies
University of Memphis	Proposed theme: Freight, Transportation Safety, Logistics, and Policy Development
University of Nevada, Las Vegas	Development of Transportation Systems for Rapidly Growing Urban Areas
University of Rhode Island	Surface Intermodal Transportation Systems/Infrastructure in a Marine Environment
University of Toledo	Proposed theme: Transportation for Economic Security and Development: Alternate Energy, Infrastructure Utilization, and Supply Chains
Utah State University	Innovative Engineering Against Hazards
Youngstown State University	Transportation Mobility, Longevity, and Sustainability

Study Committee Biographical Information

E. Dean Carlson (NAE), *Chair,* an independent consultant, is retired Secretary of the Kansas Department of Transportation, a post he held for 8 years. Previously, he worked for the Federal Highway Administration (FHWA) for 36 years in various positions, retiring in 1994 from the position of Executive Director, the highest career position in that agency. As FHWA's Executive Director from 1990 to 1994, he helped guide the effort to establish a strategic vision for shaping the nation's highway and highway safety programs. He was centrally involved in developing the U.S. Department of Transportation's proposal for legislation to reauthorize federal highway programs in the period that preceded enactment of the landmark Intermodal Surface Transportation Efficiency Act of 1991. Mr. Carlson served as the 2002 Chair of the Transportation Research Board (TRB) Executive Committee and previously served as President of the American Association of State Highway and Transportation Officials (AASHTO). In 2001 he was elected to membership in the National Academy of Engineering for "outstanding leadership and dedication in developing national highway policy, systems management initiatives, and research programs." He holds a bachelor's degree in civil engineering from the University of Nebraska and did postgraduate work at the University of Texas.

Frances T. Banerjee has more than 30 years of experience in the public and private sectors. She assisted four mayors and numerous City Council members during her tenure in Los Angeles, where she served as General Manager of the Los Angeles Department of Transportation, Assistant Chief Legislative Analyst, and Transportation Director of the LA Redevelopment Agency. She managed the development and modernization of transportation systems that have become models nationwide, including

the city's software that is used for the award-winning Metropolitan Transportation Authority RapidBus Transit Program. She served on the city's Emergency Operations Board and directed execution of the successful transportation plan for the 2000 Democratic National Convention. She chaired the TRB Committee on Large U.S. Cities and the National Association of City Transportation Officials. Before joining the City of Los Angeles, she managed transportation planning programs at the Southern California Association of Governments. She also worked as a Research Associate at the Massachusetts Institute of Technology Urban Systems Laboratory. Ms. Banerjee received her MA from Boston College with an emphasis on transportation planning. Her BA from Boston College (Newton College Campus) was in political science.

John F. Conrad retired in 2008 from his position as Assistant Secretary for Engineering and Regional Operations for the Washington State Department of Transportation. In that position he oversaw the daily operations of the agency's engineering, environmental, maintenance, and planning programs. In his 23 years with the department, he served in the following positions: Assistant Secretary for Field Operations Support, Chief Maintenance Engineer, District Planning and Operations Engineer, Local Programs Operations Engineer, and Manager of the State Rail Program. He has also worked on highway program management for Parsons Brinckerhoff in the United Kingdom. He holds a bachelor's degree from the University of Nebraska and a master's degree from Kansas State University. He is a registered professional engineer in the states of Washington and Kansas. Currently he is Chair of the Strategic Highway Research Program (SHRP) 2 Technical Coordinating Committee for Reliability Research, and he is former Chair of the TRB Committee on Maintenance and Operations Management.

Arthur Dinitz is Chairman and Chief Executive Officer of Transpo Industries, Inc., a manufacturer and supplier of highway safety products and equipment. He has been a leader in promoting the development and use of new materials and technologies for more than 40 years. One of his primary areas of interest is how research results can be implemented more quickly. He serves on the Joint Committee of AASHTO–American General Contractors–American Road and Transportation Builders

Association and the AASHTO Technology Implementation Group. He holds several U.S. and foreign patents. Mr. Dinitz holds a bachelor of mechanical engineering degree from New York University.

Daniel C. Murray is Vice President of Research for the American Transportation Research Institute (ATRI), formerly known as the ATA Foundation. He has overall responsibility for directing ATRI's diverse portfolio of research initiatives. In addition, he has an extensive background in freight transportation planning and field testing of technology systems. Mr. Murray has served as a Project Manager on research initiatives sponsored by FHWA, the Federal Aviation Administration, the Federal Motor Carrier Safety Administration, the U.S. Department of Agriculture, Customs and Border Protection, and the Transportation Security Administration. Mr. Murray received his BA from Gustavus Adolphus College and his MS from Northwestern University.

Timothy R. Neuman is Vice President and Chief Highway Engineer at CH2M Hill, a national engineering consulting firm. He has more than 25 years of experience in the planning and design of major highways, freeways, and interchanges for more than 20 state departments of transportation. Mr. Neuman is a nationally recognized expert in highway safety and traffic operations related to geometric design. He is active in the field of context-sensitive design through both project work and research. He is recipient of the Past Presidents' Award of the Institute of Transportation Engineers and TRB's D. Grant Mickle Award. He is a member of the Task Force for the Development of a Highway Safety Manual and is a former member of the TRB Committee on Geometric Design of Highways. He received his bachelor's and master's degrees from the University of Michigan.

Lawrence H. Orcutt is a 21-year veteran of the California Department of Transportation. He currently is Research and Innovation Division Chief, and he has also been Maintenance Division Chief. Recently he served 18 months as Acting Deputy Director for Maintenance and Operations. Mr. Orcutt received the 2002 Governor's Safety Award for leadership and development of the Maintenance Safety Program. He is a member of TRB's SHRP 2 Safety Technical Coordinating Committee and Cochair of the Committee on Technology Transfer. Mr. Orcutt is a lifetime member of the American Indian Science and Engineering Society (AISES) and

past Vice Chair of the AISES Board of Directors. He graduated from California State University, Sacramento, with a BS in civil engineering in 1979. He earned an MS in transportation management in June 2008 from San Jose State University, Business School, Mineta Transportation Institute.

Leonard A. "Len" Sanderson is currently with Parsons Brinckerhoff. Previously, he was State Highway Administrator for the North Carolina Department of Transportation, where he was responsible for preconstruction, operations and maintenance, and safety and loss control functions. He was with the department for 36 years and served in a number of positions, including manager of the department's construction branch. He served on AASHTO's Standing Committee on Highways, its Highway Subcommittee on Construction, and its National Partnership for Highway Quality. Mr. Sanderson also served on the TRB Task Force on Accelerating Highway Innovation. He holds a bachelor of science degree from North Carolina State University and is a registered professional engineer.

Constance S. "Connie" Sorrell is Chief of System Operations for the Virginia Department of Transportation (VDOT). She is the first person in VDOT to fill this position, which was established in 2004. Ms. Sorrell is responsible for a $1 billion annual budget. She directs all systems operations and maintenance for the state highway system, including the planning and delivery of programs and projects to alleviate congestion at traffic choke points, development of innovative ways to manage highway incidents, and use of Smart Travel and traveler information systems. Highway maintenance and snow- and ice-removal operations are also within her purview. In her previous posts, Ms. Sorrell has been interim Hampton Roads District Administrator, Chief of Policy and Organizational Development, and Administrator for the Richmond District. She holds a BS in political science and economics from Radford University and has attended graduate school at the University of Amsterdam, Radford University, and the University of Richmond. Ms. Sorrell is a graduate of the AASHTO Executive Management Institute. She is a member of the Intelligent Transportation Society of America's Board of Directors and Vice Chair of AASHTO's Subcommittee on Operations, and she is former Chair of TRB's Strategic Management Committee.

Leslie "Les" Sterman is Executive Director of the East–West Gateway Coordinating Council, the metropolitan planning organization for the

St. Louis region. He joined the council in 1979 and attained his current position in 1983. Mr. Sterman is responsible for the council's largest and most visible projects, including conceiving and planning the MetroLink light rail system. He has been an active spokesman for metropolitan transportation, community development, and environmental issues at the state and federal levels, and he has testified before several congressional committees and spoken at many national conferences on these subjects. Mr. Sterman has been President of the Missouri Association of Councils of Government, Cochair and Founding Member of the National Association of Metropolitan Planning Organizations, member of the TRB Executive Committee, and a member of the Steering Committee of the Surface Transportation Policy Project. He served as Chair of the study committee that produced *Special Report 257: Making Transit Work: Insight from Western Europe, Canada, and the United States.* He earned his BSCE in civil engineering and MS in urban and environmental studies from Rensselaer Polytechnic Institute.

Joseph M. Sussman is J. R. East Professor in the Department of Civil and Environmental Engineering and the Engineering Systems Division at the Massachusetts Institute of Technology (MIT), where he has served as a faculty member for 32 years. Dr. Sussman specializes in planning, investment analysis, operations, management, design, and maintenance of complex systems, including transportation. He helped prepare the Strategic Plan for Intelligent Transportation System (ITS) Research, a 20-year plan that has shaped the U.S. ITS program. His current research focus is on integrating ideas from strategic management, scenario building, and technology architectures to develop a new methodology for regional strategic transportation planning. He currently serves as Chair of the ITS Advisory Committee. He is former Chair of the TRB Executive Committee and has chaired and served on numerous TRB study and standing committees. Dr. Sussman holds a BCE from the City College of New York, an MSCE from the University of New Hampshire, and a PhD in civil engineering systems from MIT.

Albert H. Teich is Director of Science and Policy Programs at the American Association for the Advancement of Science, the world's largest multidisciplinary scientific association. Previously, Dr. Teich served as Deputy Director of the Graduate Program in Science, Technology, and

Public Policy at the George Washington University; Visiting Research Professor of Public Affairs at the State University of New York at Albany; and Director of Research for the Institute for Public Policy Alternatives for the State University of New York. He serves on the boards of visitors for the School of Public Policy at the Georgia Institute of Technology and the Center for Science, Policy, and Outcomes at Columbia University. He is a member of the American Association for the Advancement of Science, the Technology Transfer Society, the Association for Public Policy Analysis and Management, the Society for Social Studies of Science, and Sigma Xi. Dr. Teich holds a bachelor of science degree in physics and a PhD in political science from MIT.

Paul T. Wells is retired from his position as Assistant Commissioner and Chief Engineer, New York State Department of Transportation. He previously served in a number of positions for the department, including Deputy Chief Engineer for Construction and Director of the Construction Division. He had more than 30 years of experience in planning, design, and construction in both regional and headquarters offices in the department before his retirement. Mr. Wells has served as Vice Chairman of the AASHTO Highway Subcommittee on Bridges and Structures. He is a Fellow of the American Society of Civil Engineers. He serves on a variety of study panels for the National Cooperative Highway Research Program and was a member of TRB's Task Force on Design–Build and Committee on Construction Management. Mr. Wells holds a bachelor's degree in civil engineering from the State University of New York at Buffalo.

Kevin C. Womack is Professor of Civil Engineering and Director of the Utah Transportation Center at Utah State University. His specialty is structural engineering. He served as a Congressional Fellow on the United States Senate Committee on Environment and Public Works in the period preceding the 2005 authorization of the Safe, Accountable, Flexible, Efficient Transportation Act: A Legacy for Users. The American Society of Civil Engineers sponsored the fellowship under the American Association for the Advancement of Science Fellows program. Since that time, Mr. Womack has served as Chair of the American Society of Civil Engineers' National Transportation Policy Committee. He has received several awards for exemplary teaching, research, and advising at Utah State University.