Testimony of
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Good morning, Chairman Wu and members of the subcommittee. My name is Robert E. Skinner, Jr. I am the Executive Director of the Transportation Research Board (TRB) of the National Academies. I am pleased to be invited to testify before you again. TRB is one of the five divisions of the National Research Council (NRC), which, in turn, is the operating arm of the National Academy of Sciences, National Academy of Engineering, and the Institute of Medicine. This complex of organizations is collectively referred to as the National Academies. The institution operates under the charter given to the National Academy of Sciences by Congress in 1863 to advise the government on matters of science and technology.

I was invited to testify about the kinds of research that the U.S. Department of Transportation (USDOT) should be conducting to meet its strategic goals and on what USDOT could do to facilitate the implementation of research and adoption of the results. I would like to preface my remarks by noting that I'll be limiting my comments about research priorities to previous recommendations made by committees of experts who were appointed by the National Academies to provide advice to the government. The committees were balanced in terms of expertise and perspective, were free of conflicts of interest, and the members served without compensation. Although I am pulling together the recommendations from many reports, my testimony does not represent a comprehensive assessment of what the USDOT's research portfolio should contain; we have not been asked to assemble a committee to make such an assessment. Although I am able to draw upon pertinent reports of committees convened to address specific topics of science and technology, my testimony is incomplete on important R&D topics for USDOT such as safety, aviation, intelligent transportation systems, and environmental topics (other than climate change). This is not because these topics are unimportant; rather, it is because TRB has not been asked to conduct major projects in these areas in recent years. Moreover, some of the committee reports I draw upon were primarily tasked to address a policy issue and made supplemental recommendations about research, but did not provide recommendations about individual projects or estimates of research costs. In addition, my testimony will be more focused on highway R&T topics than others because the Federal Highway Administration has asked us to review its highway R&T activities more regularly than have other modes. FHWA's program is also the largest of the surface modes and accounts for about half of the R&D funds authorized in the research titles of existing surface transportation authorizing legislation.

PRIORITY RESEARCH TOPICS

As per your invitation, this section is organized according to the four USDOT strategic goals: safety, livable communities, economic competitiveness, and environmentally sustainable transportation.

Safety

TRB has not conducted a comprehensive assessment of safety research for many years, so my advice in this area will be limited to a few key topics. Importantly, missing entirely is any discussion about vehicle crashworthiness and design of highway appurtenances to absorb crash energy; these occupant protection measures have surely been major contributors to the long-term trend of improved highway safety.

Driver behavior

In 1998 Congress asked TRB to convene a committee of experts to determine whether a second Strategic Highway Research Program (SHRP) should be conducted.[1] The first SHRP was a time-limited, large-scale research initiative designed to find breakthroughs in highway materials, paving, and maintenance practices.[2] It resulted in, among other things, major innovations in asphalt paving and winter maintenance practices that have been widely adopted by states, counties, and many other nations. In response to the 1998 request, the committee that prepared TRB Special Report 260 gathered extensive input from stakeholders about major problem areas in highway transportation and recommended a broad-scaled research program addressing four major concerns: safety, travel time reliability, more rapid and efficient renewal of infrastructure, and capacity additions in accord with environmental and social values. The recommended safety research area would address the lack of insight about driver behavior in pre-crash or near-miss situations that has hampered vehicle design and evaluation of safety countermeasures.

In response to Special Report 260, Congress authorized the second Strategic Highway Research Program in SAFETEA-LU. SHRP 2 is being managed by TRB. The program is about to embark on the largest and most sophisticated naturalistic driving study ever conducted. It will gather extensive information about driving behavior from 3,000 volunteer drivers over a 2-year period, which will include collecting pre-crash, crash, and normal driving information about the driver, as well as vehicle and roadway conditions. The vehicles of volunteer drivers will be extensively instrumented with cameras and sensors that will measure a wide array of driver behaviors, vehicle responses, and road conditions.

The aim of the naturalistic driving experiment is to gain fundamental knowledge about driver behavior. However, SHRP 2's immediate mission is narrower—to successfully conduct the experiment; create a comprehensive and accessible database;

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[1] Special Report 260 *Strategic Highway Research: Saving Lives, Reducing Congestion, Improving Quality of Life*. Transportation Research Board of the National Academies. Washington, D.C. 2000.

[2] Special Report 202 *America's Highways: Accelerating the Search for Innovation.* Transportation Research Board, National Research Council. Washington, D.C. 1984.

and develop analysis tools for that database. After SHRP 2 is complete, extensive research using the database will be required to obtain the knowledge necessary to design more effective crash countermeasures. More specifically, safety research funding will be required in a number of promising areas: for example, to:

- Probe and understand the complex conjunction of events and conditional circumstances that lead to crashes and near-crashes in order to identify and prioritize road safety countermeasures;
- Study how drivers react to different roadway and environmental features and how their reactions affect crash risk in order to evaluate specific potential road design, lighting, signage, and delineation safety countermeasures; and
- Determine the role and causes of driver distraction to inform both vehicle design and driver regulatory safety measures.

Additionally, some behavioral work planned for SHRP 2 but dropped due to funding—a site-based video data collection to observe driver behavior at intersections—should be funded. And finally, because of the scale and complexity of the databases that will be collected through this experiment, support will also be required to house and maintain those data, make them accessible to researchers, and provide tutorials and training on how to use them, which will be unlike anything in scale and complexity that the highway safety research community has had to work with before.

Large Truck Safety

Many TRB committee reports over the years have pointed out the potential efficiency gains of permitting longer and heavier trucks to operate on a limited number of Interstate highways.[3] Progress in this area has been stymied for years, in large part because of concern about the potential risks to safety of permitting larger vehicles to operate. Large truck safety is an important area of risk. Although the number of large trucks involved in fatal crashes is declining, between 4 and 5 thousand people are killed each year in crashes involving large trucks.[4]

Promising techniques are available for enhancing the safety of heavier trucks and longer combination vehicles (LCVs). These techniques include vehicle designs for better control and stability, information technology applications for control and stability and collision avoidance, technology applications designed to improve enforcement, improvements in operator certification and training, and changes in highway design. However, little is known about the effectiveness of the majority of such measures once integrated onto LCVs and in actual use. Because of this knowledge gap, as well as a lack of scientific understanding about the relation of safety to truck design, road features, and other factors influencing risk, it is likely that important opportunities to reduce accidents are being missed, while resources are being wasted on ineffective actions. The

[3] These recommendations are summarized in Special Report 267 *Regulation of Weights, Lengths, and Widths of Commercial Motor Vehicles*. Transportation Research Board of the National Academies, Washington, D.C. 2002.

[4] *Traffic Safety Facts: 2008 Data—Large Trucks*. National Highway Traffic Safety Administration, U.S. Department of Transportation. http://www-nrd.nhtsa.dot.gov/Pubs/811158.PDF

committee that prepared TRB Special Report 267 recommended the conduct of carefully controlled, independently-conducted trials to test the efficacy of improvements in technology and changes in vehicle dimensions to determine whether LCVs could operate safely on a limited set of Interstates.

Enforcement

The National Highway Traffic Safety Administration (NHTSA) estimates that speeding is a contributing factor in 31 percent of fatal crashes resulting in more than 1,000 people being killed each month in speed-related crashes.[5] A TRB committee last examined this issue in a 1998 report, and some of the research it recommended at that time has been conducted by NHTSA, FHWA, and the National Cooperative Highway Research Program (NCHRP).[6] Issues that have not been resolved include the safety consequences of differential speed limits for cars and trucks, variable speed limits that would be adjusted based on traffic, weather, or lighting conditions, and the potential of automated enforcement to limit speeding in high-risk areas.

Although safety is important in all modes, 95 percent of the deaths and injuries associated with transportation occur on roads and highways. Unfortunately, the United States is no longer the world leader in highway traffic safety. Countries such as Australia, Germany, Great Britain, and Sweden have lower fatality rates than we do.[7] Such nations have been much more aggressive in enforcing speed limits and safety belt use, controlling drug and alcohol-impaired driving, and publicizing the importance of safe driving. We have a study under way that will be completed in a few months that will identify the measures these nations are using that might be applied in the United States and the research that may be needed to apply these measures in the United States.

Incremental High-Speed Rail

The Obama administration has renewed interest in intercity passenger rail by committing $8 billion for high-speed and intercity passenger rail in the American Recovery and Reinvestment Act of 2009, which is also raising the profile of passenger rail research. For many years the Federal Railroad Administration (FRA) has funded a TRB committee to provide a peer review of the agency's research, development, and demonstration programs. This committee has consistently recommended research on positive train control (PTC) as a priority for FRA, which the agency has embraced.[8] Outside of the Northeast Corridor, most passenger rail travel occurs on track that is shared with freight trains, which poses a safety risk given the different operating speeds of passenger and freight trains. FRA regulation restricts the speed of passenger rail to 79 mph on shared

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[5] *Traffic Safety Facts: 2007 Data—Speeding*. National Highway Traffic Safety Administration, U.S. Department of Transportation.

[6] Special Report 254 *Managing Speed: Review of Current Practice for Setting and Enforcing Speed Limits*. Transportation Research Board of the National Academies. Washington, D.C. 1998.

[7] In the last year for which comparable statistics are available (2005), the U.S. rate per million kilometers traveled was 9.0, compared with 5.9 in Sweden, 6.4 in Great Britain,7.8 in Germany and 7.9 in Australia. *Critical Issues in Transportation, 2009 Update*. Transportation Research Board of the National Academies, http://www.trb.org/Publications/PubsCriticalIssuesinTransportation.aspx

[8] See, for example, the committee's most recent letter report of April 2009 http://144.171.11.107/Main/Public/Blurbs/161603.aspx

track because of this risk. For the foreseeable future, higher-speed intercity rail passenger transportation will continue to rely on shared track; FRA regulation would permit speeds over 79 mph on shared track only if proven PTC were implemented.[9] With passage of the Rail Safety Improvement Act (RSIA) and the Passenger Rail Investment and Improvement Act in 2008, development and deployment of PTC has become a priority for FRA. RISA requires implementation of PTC by 2015. The committee has also consistently recommended support for the nationwide differential GPS system, which is an enabling technology for PTC.[10] Other research priorities recommended by the committee include performance-based standards and risk-based analysis; highway-rail grade crossing safety; and network capacity analysis.

Livable Communities

The term "livable communities" is a bit difficult to define, but is usually intended to refer to development patterns that foster non-automobile modes of transportation. Our main report in this area that makes recommendations for research was requested in the Energy Policy Act of 2005 regarding the effects that smart growth, or transit-oriented development, might have on vehicle miles traveled (VMT) and energy consumption.[11] In estimating how much compact, mixed-use development might reduce passenger vehicle miles of travel, the committee that prepared TRB Special Report 298 found substantial gaps in knowledge about how to best design transit-oriented development to reduce auto trips. The research recommendations from this report are incorporated into our report recommending greenhouse gas (GHG) emissions mitigation strategies discussed under the sustainability goal, so I won't repeat them all here, but one key recommendation stands out in terms of advising metropolitan areas responding to national climate change and energy conservation goals: we need a much better understanding of the density thresholds necessary to support different levels of transit (bus, trolley, bus rapid transit, light rail, heavy rail) and how they would vary across metropolitan areas of different size, employment concentration, and mixes of land use (employment, residential, and commercial areas that are intermixed rather than separated as is the norm in local zoning regulations). Also needed are better data on where jobs are located within metro areas at a fine enough level of detail such that they can be linked with transit plans and travel forecasts and better before-and-after studies of the effects of attempts to foster compact, mixed-use development. Portland, Oregon is one of the great successes in managing land use and investing in transit, but we do not understand whether communities need to replicate all the things that Portland and the state of Oregon have done to foster the urban form that Portland has achieved. The list includes the state's growth management policies; creation of Portland Metro, which has an almost unique level of control over land use and transportation investments at the metropolitan level; Portland's long-term and extensive support of data collection and modeling capability; the building of political

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[9] The higher speed allowed depends on the class of track. Currently 125 mph is the highest speed that non-electric propulsion technologies can attain.

[10] Funded in past years through FRA's R&D budget, this budget item is now the responsibility of the Research and Innovative Technology Administration.

[11] Special Report 298 *Driving and the Built Environment: The Effects of Compact Development on Motorized Travel, Energy Use, and CO_2 Emissions*, Transportation Research Board of the National Academies. 2009.

cohesion over decades to support growth management and transit investment policies; and others. We also do not have good insight about the successes or failures of efforts to replicate elements of Portland's strategy in other regions.

Economic Competitiveness

Competitiveness is another somewhat difficult term to define. For the purpose of this testimony I rely on an economic definition – the minimum level of investment required and the appropriate regulatory approaches to achieve the efficient movement of people and goods. Of particular interest is how to help the freight system support the competitiveness of U.S. products in world markets. (The conundrum of this policy, however, is that almost everything we do to facilitate the export of U.S. goods also facilitates import of foreign goods.) Also of particular interest is how to make the construction and operation of transportation facilities more cost effective and how to raise the funds necessary in the most efficient way to pay for public infrastructure.

Infrastructure

The construction, operation, and maintenance of infrastructure represent the largest share of public infrastructure expenditures on transportation assets. State and local officials are constantly searching for ways to make limited public funds stretch farther. The RD&T programs of the Federal Highway Administration (FHWA) have a long history of supporting innovations in design, materials, practices, and policies of state and local highway agencies. TRB's Research and Technology Coordinating Committee (RTCC) provides a program-level peer review of the FHWA program. The RTCC's 2008 report recommends restoring the funding for FHWA's RD&T programs that were reduced in SAFETEA-LU because of the designation and earmarking of more funds than were authorized.[12] Particularly hard hit were FHWA's R&D programs in policy and operations, but FHWA's safety and planning and environmental RD&T programs were also reduced. The committee also encouraged support for infrastructure programs strongly endorsed by stakeholders, such as the Long-Term Bridge and Long-Term Pavement Performance Programs.[13] To ensure that FHWA's infrastructure programs are addressing the right questions in the right ways, the RTCC recommends that Congress provide funding for extensive expert and stakeholder involvement in RD&T activities as FHWA has committed to in its *Corporate Master Plan for Research and Deployment of Technology and Innovation.*[14]

The states each have highway research programs that are mainly funded through the state planning and research (SP&R) provisions of Title I of SAFETEA-LU. These programs fund investigation of state-specific research topics, provide much of the local match for the University Transportation Centers Program, fund the collaborative, pooled-

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[12] Special Report 295 *The Federal Investment in Highway Research 2006-2009: Strengths and Weaknesses.* Transportation Research Board of the National Academies. Washington, D.C. 2008.

[13] See also the report of the TRB committee that provides an ongoing program review of the Long Term Pavement Performance Program, *Preserving and Maximizing the Utility of the Pavement Performance Database.* Transportation Research Board of the National Academies. Washington, D.C. 2009.

[14] http://www.fhwa.dot.gov/legsregs/directives/policy/cmp/03077.htm

fund National Cooperative Highway Research Program, and support technology transfer and adoption of innovation. The RTCC urged that the SP&R provisions be continued.

Public Investment in Freight Facilities

The efficiency of the U.S. freight system is an important contributor to the international competitiveness of the United States. This system is largely private, but truck, barge, and ship operators depend upon public infrastructure and are subject to public safety and environmental regulation. In addition, there is a growing public role in investing in intermodal freight facilities to encourage more efficient intermodal transportation. A recent TRB committee report on funding options for freight transportation projects recommends that USDOT develop the ability to monitor the performance of the freight system to identify sources of inefficiency.[15] This function would depend upon the collection of more extensive data about system performance, and research would be required to develop the components of such a monitoring system. An earlier committee recommended the development of a system of measuring the performance for the national Maritime Transportation System, which would also require research to develop and implement such a program.[16]

TRB Special Report 297 and previous reports by TRB committees have recommended that USDOT assist transportation departments at all levels of government in developing the capacity to rigorously analyze public-private investments in transportation projects in order to protect the public interest.[17] This would include developing standardized methods of evaluation, including accounting for external costs to improve benefit-cost analysis, and guidance about how the public and private shares of benefits and costs should affect the public share of co-funded projects.

Substitute for the Fuel Tax

The federal fuel tax raises most of the user fee revenues for the federal highway and transit programs, about $28 billion annually, but the federal tax has not been raised since 1993. The buying power of federal tax revenues has declined 33% since the tax was last raised, even as demand on the system has increased 31%. In SAFETEA-LU, Congress created two commissions to examine alternative mechanisms for charging users.[18] Both of these commissions recommended carrying out an accelerated development and testing program to determine the feasibility of charging users on a per-mile-traveled basis, also referred to as a VMT fee or mileage tax. In 2006 a TRB committee charged with evaluating the long-term viability of the fuel tax concluded that transitioning from a fuel-

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[15] Special Report 297 *Funding Options for Freight Transportation Projects*. Transportation Research Board of the National Academies, Washington, D.C. 2009.

[16] Special Report 279 *The Marine Transportation System and the Federal Role: Measuring Performance, Targeting Improvement*. Transportation Research Board of the National Academies. Washington, D.C. 2004.

[17] See Special Report 297, Special Report 271 *Freight Capacity for the 21st Century*, Transportation Research Board of the National Academies, Washington, D.C. 2002, and Special Report 252 *Policy Options for Intermodal Freight Transportation*. Transportation Research Board of the National Academies, Washington, D.C. 1998.

[18] The National Transportation Policy and Revenue Study Commission and the National Surface Transportation Infrastructure Finance Commission.

tax based user fee to one based on mileage traveled would be good public policy, and it made the same recommendation to test the feasibility of this approach through demonstrations.[19] There are important questions about the political and technical feasibility and cost of a VMT fee system that could be resolved through a large-scale demonstration program. This concept is also linked to energy conservation and climate change mitigation strategies, because a VMT fee could be easily adjusted to charge a premium for fuel-inefficient vehicles. The committee that prepared TRB Special Report 299 (discussed in more detail in the next section) commissioned a paper by the architects of Oregon's previous 6-year pilot program in this area, which was completed in 2007.[20] Based on their analysis, the committee estimates that a 10-12 year demonstration program would probably cost $70 to $100 million.[21] TRB's National Cooperative Highway Research Program recently published an analysis by RAND researchers on the feasibility of implementing simplified VMT charging systems on a more rapid timescale; these researchers concluded that it would be premature to move toward implementation of these systems without carrying out a demonstration and test program.[22]

Environmentally Sustainable Transportation

Addressing climate change and our nation's reliance on energy are high priorities for the administration and Congress. Transportation accounts for 28 percent of U.S. GHG emissions and is almost totally dependent on petroleum for fuels. Transportation consumes about twice as much petroleum annually as the United States produces, which results in our dependence on foreign sources. Just three weeks ago TRB released a committee's report that recommends the authorization of research programs to help mitigate transportation's contribution to climate change and adapt transportation infrastructure to climate change.[23] These topics have received relatively little attention in USDOT's R&D programs in the past, so the gaps are considerable. Mitigation topics, in particular, will become much more important if climate change legislation is enacted that contains provisions in Waxman-Markey and Kerry-Boxer bills that require additional measures for the transportation sector. These measures include having EPA set targets for GHG emissions reductions and would require states and metropolitan areas to analyze options, plan for, and implement GHG emissions reduction strategies, with federal oversight of these activities.

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[19] Special Report 285 *The Fuel Tax and Alternatives for Transportation Funding*. Transportation Research Board of the National Academies. Washington, D.C. 2006.

[20] Special Report 299 *A Transportation Research Program for Mitigating and Adapting to Climate Change and Conserving Energy*. Transportation Research Board of the National Academies. Washington, D. C. October 2009.

[21] See Appendix A of Special Report 299.

[22] Sorenson, et. Al. 2009. Implementable Strategies for Shifting to Direct Useage-Based Charges for Transportation Funding. NCHRP Web-Only Document 143. http://trb.org/Publications/Blurbs/Implementable_Strategies_for_Shifting_to_Direct_Us_162252.aspx

[23] Special Report 299 *A Transportation Research Program for Mitigating and Adapting to Climate Change and Conserving Energy*. Transportation Research Board of the National Academies. Washington, D. C. October 2009.

TRB Special Report 299 recommends a mitigation research program that would total $190 million over six years. This report does not address research on vehicles and fuels that the Department of Energy might fund. Rather, it makes recommendations for USDOT research. The committee's report identifies both key topics of research and initial projects to undertake.[24] The latter would focus on providing policy and technical guidance based on available information and expert judgment to the tens of thousands of federal, state, and local officials who make decisions about infrastructure and land use. This area of policy and technical guidance is estimated to cost $60 million of the recommended $190 million mitigation research program. To highlight just some of the mitigation topics identified in that report, I'll mention (a) the importance of providing state and local officials with better guidance about the benefits, costs, and cost-effectiveness, of different mitigation strategies that they might employ, and (b) improving the technical tools that states and metropolitan areas will rely upon to evaluate alternative policies and infrastructure investments. A previous TRB committee identified key shortcomings of the travel forecasting models that are central to this analysis process and recommended both research and technology transfer to improve the state of the practice.[25] In addition, a report TRB released in August of this year identifies the potential benefits of combined land use and transit investment strategies in terms of reduced travel and CO_2 emissions.[26] The research recommendations from these reports are incorporated into the recommendations made in Special Report 299.

The committee that prepared this report proposes that the initial emphasis be on guidance to officials, but, because of uncertainties in a number of areas, it also recommends a fundamental research program that would be modeled on the processes followed by the National Science Foundation. The committee's report identifies major areas of uncertainty that the program should address, including: the total GHG emissions associated with the construction, operation, and maintenance of infrastructure for different modes over their full life-cycle; improved quantification of external costs; research on travel behavior to improve model design and calibration; improvements to the state of the practice in travel models; incorporation of full social cost and benefits estimates in the evaluation of alternatives; infrastructure system management and operations; and others. This $130 million component of the recommended mitigation program would convene scholars and experts to identify the most promising areas of research, issue Broad Agency Announcements inviting proposals, and engage scholars and experts in merit review of proposals and peer review.

Special Report 299 also recommends an adaptation research program that would total $90 million over 6 years and identifies specific research topics to pursue that would provide guidance on identifying vulnerable assets and develop decision tools to help public officials weigh the risks and benefits of different strategies.[27] The research

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[24] See chapter 3 of Special Report 299.

[25] Special Report 288 *Metropolitan Travel Forecasting: Current Practice and Future Direction*, Transportation Research Board of the National Academies. Washington, D.C. 2007.

[26] Special Report 298 *Driving and the Built Environment: The Effects of Compact Development on Motorized Travel, Energy Use, and CO_2 Emissions*. Transportation Research Board of the National Academies. Washington, D.C. 2009.

[27] See Chapter 4 of Special Report 299.

recommendations of Special Report 299 build upon the recommendations of a 2008 TRB committee report that argued for the importance of beginning to adapt vulnerable assets to protect people and infrastructure against floods, storm surges, and heavy precipitation.[28] Roughly half of the U.S. population resides in coastal counties, so a substantial share of the population and transportation infrastructure is at risk. The priorities for adaptation research are to develop a process to help states and counties identify at-risk infrastructure and to develop decision tools to help officials weigh the uncertainties of climate impacts and the costs and benefits of taking protective measures.

Although the committee that prepared Special Report 299 includes many specific research topics in its report, it also stresses the importance of engaging officials, experts, and practitioners in the prioritization of the individual projects that should be pursued, in merit review of proposals to conduct the research, and in peer review of the completed research. If Congress decides to authorize the recommended research program, it should also require that these processes be incorporated in the program.

Data Collection

Data collection is necessary to support research in all the goals listed above. Data collection is among the activities supported through USDOT R&D budgets, but many of our committees have found major gaps and problems with available data. These problems will become more acute if, as expected, the next surface transportation authorization requires performance-based reporting on the results of expenditures of federal funds. In addition, if climate change legislation provisions were to be enacted such as those in the Waxman-Markey bill or the proposal of Chairman Boxer and Senator Kerry, then states and metropolitan areas would be required to conduct analyses of mitigation strategies that would demand much more extensive information about travel and land use at the neighborhood level.[29] States and every metropolitan area would require much more accurate and extensive measures of vehicle miles of travel (VMT) by road and vehicle type -- including average speeds and speed distributions by time of day -- to establish baselines from which to subsequently monitor the effects of different mitigation strategies on greenhouse gas (GHG) emissions.

TRB committees have consistently recommended support for and enhancement of two critically important surveys of USDOT: the National Household Travel Survey (NHTS) and the Commodity Flow Survey (CFS).[30] The committees that prepared Special Reports 299 and 277 also recommended research on ways to improve data collection through reliance on new and emerging technologies. Given the cost of surveys and problems with response rates to surveys that rely on compilation of travel diaries, development of these alternatives is becoming a necessity. We are just embarking on a

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[28] Special Report 290 *Potential Impacts of Climate Change on U.S. Transportation.* Transportation Research Board of the National Academies. Washington, D.C. 2008.

[29] See Special Report 299, Appendix B.

[30] Special Report 295 and Special Report 277 *Measuring Personal Travel and Goods Movement: A Review of the Bureau of Transportation Statistics' Survey Programs*. National Research Council of the National Academies. Washington, D.C.

study to identify key passenger and freight travel data and to recommend data collection and funding strategies to obtain these data. As important as they are, the NHTS and CFS are not the only important surveys, nor would funding them adequately cover all the gaps, especially if Congress requires extensive reporting on performance measures as part of reauthorization.

Conclusion

In principle, a comprehensive surface transportation research agenda should exist that, for a particular moment in time, relates research initiatives to specific goals and details those initiatives in terms of projects and project budgets. In practice, such a comprehensive, U.S.-wide agenda is almost never available because of the scale and difficulty of the task, the multiplicity of institutions and stakeholders involved, and the constantly shifting set of research needs, opportunities, and priorities. TRB's experience with managing two strategic highway research programs has been that moving from the level of defining the goals that research should achieve to the level of specifying which projects should be carried out to meet these goals requires concerted intellectual and planning effort by experts and stakeholders. Following both of the TRB special reports that led to SHRP 1 and SHRP 2, AASHTO, USDOT, and industry invested thousands of person-hours of effort by federal, state, and private officials and researchers and invested millions of dollars to develop detailed research program plans and scopes of work for individual projects. Similar effort has gone into FHWA research road maps developed by FHWA's safety, operations, infrastructure, and RD&T offices, as well as in the development of FTA's research program plans to implement its R&D strategic plan and the development of FRA's R&D agenda. The next section describes the processes that need to be put in place so that when Congress authorizes funding to meet certain goals it can be assured that the capability exists to execute a program to meet those goals.

HOW RESEARCH SHOULD BE CARRIED OUT

Although the *content* of USDOT's research program is of great interest to our committees and other stakeholders, we should equally emphasize the importance of the *process* of strategic R&D planning, agenda setting, merit review by peers of competitively solicited proposals, peer review of completed research, and extensive involvement of stakeholders in all of these steps. If the processes are right, we can have higher confidence that the research will address the right questions, produce results that are useful, and have greater probability of being implemented.

In transportation infrastructure and regulatory matters, which often involve multiple levels of government in the development and delivery of public infrastructure, the process matters just as much as the content. Requiring such processes may be the best mechanism available through legislation to ensure that the research is relevant, meets the highest standards of science, and maximizes the success of technology transfer programs. In this regard, I encourage you to consider requiring the organization of USDOT research programs according to the principles for research that were articulated in the preamble of

Title V of SAFETEA-LU, as slightly reorganized by the RTCC.[31] In a nutshell, these principles are:

1. Federal support of the full innovation cycle from agenda setting through to implementation and evaluation;
2. Limiting federal support to research activities of national significance, public benefit and inadequate private investment, or as the best means to further federal goals;
3. Content of the federal program should include fundamental research, filling significant gaps, and policy and planning;
4. Extensive stakeholder involvement in the development and execution of R&D plans and technology transfer;
5. Most awards made on the basis of competition and merit review;
6. Program-level evaluation; and
7. Consistency with the USDOT R&D strategic plan.

If I'm not mistaken, these principles resulted from the contributions of this subcommittee to Title V of SAFETEA-LU and have affected USDOT programs. FHWA, for instance, has committed itself to these principles in its *Corporate Master Plan for Research and Deployment of Technology and Innovation* and is organizing its activities accordingly.

Full Innovation Cycle

Much, if not most, of the R&D supported by USDOT is for activities almost wholly within the public sector. This is why support for the full innovation cycle is so important. It is not as if USDOT can simply conduct precompetitive research and then expect the private sector to turn this into products. In most cases, public owners of highway, transit, and intercity rail are the customers of the research, which requires support for activities to help ensure that useful products are implemented, as described in more detail in the next section on the innovation deployment process.

Federal Support

Private R&D funding is typically minimal in the transportation infrastructure sector because of the lack of incentives and opportunities for profit (see "barriers to innovation" discussion in the next section). Moreover, federal investment in research is often the best way to advance public understanding about potentially important topics that may not be understood or accepted by the public. For example, the authorization of pilot programs for congestion pricing over previous surface transportation bills, as recommended by one of our study committees,[32] has led to the adoption of High-Occupancy Toll Lanes in several metropolitan areas. Federal support for investigating the potential for VMT fees could lead to an acceptable alternative method for taxing road and highway use.

[31] See Special Report 295, pg 87.

[32] Special Report 242. *Curbing Gridlock: Peak Period Fees to Relieve Traffic Congestion*. Transportation Research Board, National Research Council, Washington, D.C. 1994.

Content

The RTCC has consistently recommended that FHWA allocate a larger share of its research to higher-risk, longer-term research.[33] The federal government is the only source of such research in surface transportation – it is usually not being done in state programs or in the private sector and is too applied for NSF. Such investment is necessary to bridge the gap between basic and applied research. In TRB Special Report 261, the RTCC suggested that at least 25 percent of FHWA's portfolio be allocated to higher-risk, longer-term research; 50 percent should be allocated to fill gaps in research not being covered by other programs and on emerging issues of importance, and 25 percent for mission-oriented research on policy and regulation, technology transfer, and training. These proportions may differ over time and across agencies depending on the agency's mission and stakeholders, but this portfolio approach is a useful way to analyze the strengths and weaknesses of USDOT R&D programs.

Stakeholder Involvement

In many cases, the processes for carrying out research are inseparable from the content and the customers of the research. Stakeholder involvement is particularly critical in FHWA's RD&T because much of what FHWA does is produce technology, tools, and products that will be implemented by the states and local governments that own, operate, and maintain the nation's roads and highways. Thus, the topics that FHWA pursues and the products that are developed need to be closely aligned with its state and local partners. Although FRA's and FTA's research programs have somewhat different orientations, TRB committees that review these programs have consistently commented on the importance of ensuring that there is a customer for the results of their projects and that these stakeholders have been consulted in the selection of projects to be pursued.[34]

The committee that prepared Special Report 299 recommends different kinds of stakeholder processes appropriate for the applied and fundamental research programs it recommends.[35] The more applied mitigation and adaptation research topics should be steered by the concerns and needs of policy makers and practitioners, while the fundamental research topics should be organized along the NSF model in which scholars and experts are guiding the decisions about which projects are likely to be most promising. Within FHWA's program, the RTCC recommends a different kind of stakeholder involvement for the Exploratory Advanced Research Program than for FHWA's applied RD&T.[36] The former requires strategic direction on priorities by policy makers and technical guidance on promising research to meet those priorities by experts, who should also be involved in merit and peer review. The latter requires stakeholder and expert involvement in problem identification, merit review, and peer review.

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[33] Special Report 295 and Special Report 261 *The Federal Role in Highway Research and Technology*, Transportation Research Board of the National Academies, Washington, D.C.

[34] Committee for the Review of the FRA R&D Program, Letter Report of April 29, 2008. http://onlinepubs.trb.org/onlinepubs/reports/frar&d_April_2008.pdf and Transit Research Analysis Committee, Letter Report of May 4, 2007 http://onlinepubs.trb.org/onlinepubs/reports/trac_may_2007.pdf

[35] See Chapter 5 of Special Report 299.

[36] Special Report 295, pg 90.

As you may know, one of TRB's main services to the transportation community is to manage research programs for others. TRB currently manages cooperative research programs for state departments of transportation (DOTs), transit agencies, airport operators, programs in the fields of freight transportation and hazardous materials for diverse constituencies, and we also manage the special purpose, limited-duration Strategic Highway Research Program (SHRP) 2. SHRP 2 was requested by state DOTs, authorized by Congress in SAFETEA-LU, and is funded as a take-down on state capital programs in Title I. We believe that the processes of stakeholder involvement we follow have been critical for the successes of these programs. The National Cooperative Highway Research Program is a pooled-fund program of the states that has been in existence for more than 45 years and has had virtually 100% participation by the states over that period. This voluntary program, which depends on annual contributions by the states, would not have survived for so long had the states not found it of value.

Competition and Merit Review

TRB committees reviewing federal programs and recommending research programs have consistently supported the principles that proposals be solicited through open competition and that decisions about awards be based on merit review by peers.[37] Research earmarking is a serious threat to the efficacy of transportation research, as it is in other fields of science and engineering. The more that your committee can do to assure that the programs are competitive, the more likely they are to be successful.

Program-level Evaluation

USDOT does support healthy program-level review of its RD&T activities. TRB is currently convening independent committees of experts to review FHWA's overall program (the RTCC) as well as particular FHWA R&D initiatives (the Long-Term Pavement Performance Program and the agency's pavement research and deployment activities), and additional reviews are under discussion. Committees are also reviewing the R&D programs of FRA and FTA. From time to time in the past, Congress has asked for reviews of specific USDOT programs and special R&D initiatives.[38]

R&D Strategic Planning

Strategic planning for R&D can be a useful exercise if done right and with appropriate expectations. It is clearly beneficial to align R&D programs with strategic goals set by Congress and the administration, and some proportion of the federal program should be strictly focused on these priorities. However, many of the R&D activities of FHWA and, to a lesser extent, FTA are addressing RD&T topics in support of stakeholders in the highway and transit communities who have the responsibility to deliver technology to customers. Much of FRA's R&D supports FRA's safety regulatory mission and individual rulemakings that have often been years in the making. Hence, we should expect that a significant part of USDOT R&D will be driven as much by a "bottoms up"

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[37] See Special Reports 295 and 299 as examples.

[38] See, for examples, *Estimating Demand for the National Advanced Driving Simulator*, TRB, National Research Council, Washington, D.C. 1995 and Special Report 253: *National Automated Highway Research Program: A Review*. Transportation Research Board of the National Academies, Washington, D.C. 1998.

as by a "top down" perspective.[39] This is appropriate in my view because support of the innovation process by states, counties, and transit authorities through RD&T is an important way to further federal goals of efficient use of resources, safety, mobility, and environmental conservation. Research results are much more likely to be implemented if the people and organizations that will have to implement them are involved in the shaping of the research agenda and in oversight of the conduct of the research. In addition, it is very difficult for any one person or group to understand the nature and extent of the problems being faced by agencies delivering transportation to citizens or to know which potential solutions might work. For all these reasons, stakeholder involvement is critical to selecting the right research and ensuring adoption of research results.

DELIVERY OF INNOVATION

Impediments

Adoption of innovation is a challenge in the public sector generally, and there are particular impediments in transportation infrastructure. Brookings' scholar Anthony Downs observed decades ago that the public sector fails to reward success but severely punishes failure; hence administrators of public facilities have few incentives to take risks and many to avoid them.[40] Transportation infrastructure managers are also inherently conservative about change because (a) public safety is uppermost in their minds and (b) they are often making decisions about committing tens of millions of dollars to build and maintain assets that are expected to be very long-lived. This problem is compounded in the administration of highway and transit programs because almost all roads and transit facilities are publicly owned and operated and must abide by public procurement policies.[41] Although these policies have gone a long way toward promoting open competition and avoiding graft, they have a downside as well. Most goods and services must be purchased in a low-bid environment that tends to focus on initial costs rather than life-cycle costs. In an effort to ensure minimum levels of quality, procurements often include highly detailed specifications and require strict adherence to formally-adopted standards. These practices have important benefits, but also tend to stifle innovation. Moreover, public laws and regulations make it very difficult for public agencies to purchase innovative proprietary products, which discourages the private sector from investing in the R&D needed to develop innovations for the highway and transit goods and services markets. For these reasons and others, innovation in

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[39] Research and Technology Coordinating Committee, Letter Report of August 2, 2009. http://onlinepubs.trb.org/onlinepubs/reports/RTCC-_letterreport_usdotrd&t.pdf

[40] Anthony Downs. 1957. *An Economic Theory of Democracy*. Harper Books, NY.

[41] This discussion draws from *Building Momentum for Change: Creating a Strategic Forum for Innovation in Highway Infrastructure*. Transportation Research Board, National Research Council, 1996, pg. 14, Special Report 261 *The Federal Role in Highway Research and Technology*, Transportation Research Board of the National Academies, Washington, D.C. 2001, and Special Report 296 *Implementing the Results of the Second Strategic Highway Research Program: Saving Lives, Reducing Congestion, Improving Quality of Life*, Transportation Research Board of the National Academies, Washington, D.C. 2009, pp. 95-97.

transportation infrastructure can rarely rely on market incentives to encourage adoption of new products and services.

Elements of Successful Strategies

The committee that prepared TRB Special Report 296 recommends important principles and strategies for implementation of the expected products from the second Strategic Highway Research Program (SHRP 2). Several of these principles and strategies emerged from the experience with implementing the first SHRP and can provide a framework for implementation of transportation research in general. First, the committee acknowledged that implementation is resource intensive: it can cost at least as much, and perhaps several times more, to implement research results as to conduct the research itself. Moreover, in a large, complex, decentralized community such as highways or other transportation modes, it can take a long time for innovations to spread and become standard practice. Approaches recommended by the committee to foster the adoption of research findings include the following:

- Engage the full array of stakeholders throughout the process: different innovations have different user groups, as well as groups that may feel threatened by innovation; each needs to be engaged and their issues and needs addressed; ideally, this process should start when research objectives are being identified and continue through the conduct of research so that users are ready to implement the results they asked researchers to produce.
- Communicate ceaselessly: communication is not all there is to implementation, but the large number of potential users, the highly decentralized nature of the highway industry, and the time it can take for innovations to spread mean that it can never be taken for granted that everyone already knows about research results and how to implement them.
- Choose the right implementation strategies: there are many potentially effective implementation strategies, but not every strategy is appropriate for every product or user audience; research products and potential users should be carefully studied to determine which strategies are most likely to be effective in each case.
- Take advantage of implementation mechanisms that are proven to be effective: these include, from the first SHRP's implementation efforts, strategic packaging and branding of related products, technical assistance for users, follow-on research, testing, and evaluation, lead state programs, demonstration projects, training, curriculum development, use of Local Technical Assistance Programs (LTAP), and partnership with standards-setting organizations and entities that develop standard design guidelines, such as the *AASHTO Policy on Geometric Design of Highways and Streets* (the "Green Book"), the *Highway Safety Manual*, the *Manual of Uniform Traffic Control Devices*, and the *Highway Capacity Manual*.
- Develop new or special implementation mechanisms where needed: as more "non-traditional" research is performed (in environmental, economic, and human factors areas, for example) the stakeholder groups may differ and new implementation mechanisms may be needed to effectively reach these potential users and support their implementation of research results.

- Provide for long-term stewardship of products such as databases, software, and web tools: increasingly, research results are taking the form of or are accompanied by electronic products that require long-term maintenance, updating, quality control, and user support; these activities must be budgeted for and not be in competition with proposals for new research and implementation efforts.[42]

In addition to recommending very similar steps as those recommended above in Special Report 296, the RTCC has noted that overcoming the risk of some high-cost projects using new materials or processes may require incentives to help states overcome the risk of premature failure.[43] The RTCC also recommended monitoring and learning from efforts to implement research results. Our committees have observed elements of all these strategies at work in individual FHWA projects and programs, and many successful examples could be cited, such as the new *Safety Analyst* and *Interactive Highway Safety Design Module* projects developed by FHWA in conjunction with state DOTs and highway safety researchers. What has been lacking are the necessary resources to organize and carry out a program on the scale of that recommended in Special Report 296; the committee for that study estimated that a 6-year effort to support implementation of all the products expected to come out of SHRP 2 would cost $400 million.

The committee that prepared Special Report 296 also identified knowledge management as key to facilitating the translation of research results into successful implementation. It is a broad concept that encompasses access to and sharing of information, networking and collaboration, and stewardship and archiving of data and information. It is dynamic and responsive and includes repositories of written information, as well as the collective knowledge of individuals, together with methods for accessing the information. Knowledge management is supported by and carried out through an array of methods and technologies. Information technology can significantly increase the scope, scale, integration, and timeliness of these methods; such technologies include online searchable databases and libraries, use of the Internet to communicate with colleagues around the world, on-line conferencing tools, backboards, and wikis. In 2006 a TRB committee recommended the development of a transportation knowledge network to address declining transportation library and information resources at the state and federal level; its recommended program of activity could provide for much of the needed information technology and access to technical materials for the highway field.[44] The committee recommended federal funding to support this effort, through RITA's National Transportation Library, that would range between $3 and $5 million in the first three years and $5 to $8 million in subsequent years (with local matching funds the total effort would range from $7.5 to $13 million).

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[42] The committee that *prepared Preserving and Maximizing the Utility of the Pavement Performance Database* (TRB 2009) concluded that it is critical for FHWA to organize itself to sustain and make accessible the massive and complex LTPP database so that it can be mined for improved pavement designs and pavement design guidance.

[43] Special Report 256 *Managing Technology Transfer: A Strategy for the Federal Highway Administration.* Transportation Research Board, National Research Council, Washington, D.C. 1999.

[44] Special Report 284 *Transportation Knowledge Networks: A Management Strategy for the 21st Century*. Transportation Research Board of the National Academies. Washington, D.C. 2006.

As you may know, our precursor organization, the Highway Research Board, was created in the 1920s to serve as an intermediary between the federal government and states and among the states to share information about ongoing research, avoid duplication in research, and to encourage the implementation of research by bringing together researchers with practitioners. In 1974, the name of the Highway Research Board was formally changed to the Transportation Research Board to acknowledge the expansion of our activities into other modes and all disciplines engaged in the field of transportation. Today TRB's core programs support 200 standing committees involving more than 4,000 researchers, consultants, and practitioners from states, transit agencies, airports, seaports, metropolitan planning organizations, and private industry. In response to requests from sponsors, TRB hosts 40 to 50 specialty conferences and workshops annually, largely for the purpose of exchanging technical information. The TRB Annual Meeting draws 10,000 participants to participate in hundreds of sessions and review thousands of technical papers. These events draw the leading researchers and administrators in our field along with numerous practitioners seeking guidance. In addition to reviewing and presenting papers, the members and guests of standing committees participate in meetings devoted to sharing information and identifying research needs. With support from our federal, state, and private sponsors, we also provide a free online database of ongoing research projects (with 7,000 records) and, in collaboration with RITA, offer a free online bibliographic database with more than 735,000 records of completed research citations and abstracts. These databases are accessed millions of times annually. Through both formal and informal mechanisms, TRB provides a way for knowledge about new research findings to reach our sponsors, their staffs, and the public at large. It also provides opportunities for federal, state, and local agency staff to get to know each other and to collaborate on the ongoing process of innovation.