AN OVERVIEW OF TRANSPORTATION R&D

HEARINGS

BEFORE THE

SUBCOMMITTEE ON TECHNOLOGY AND INNOVATION

COMMITTEE ON SCIENCE AND TECHNOLOGY

ONE HUNDRED ELEVENTH CONGRESS

FIRST SESSION

FEBRUARY 12, 2009
and
MARCH 31, 2009

Serial No. 111–2
and
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AN OVERVIEW OF TRANSPORTATION R&D: PRIORITIES FOR REAUTHORIZATION

THURSDAY, FEBRUARY 12, 2009

HOUSE OF REPRESENTATIVES,
SUBCOMMITTEE ON TECHNOLOGY AND INNOVATION,
COMMITTEE ON SCIENCE AND TECHNOLOGY,
Washington, DC.

The Subcommittee met, pursuant to call, at 10:00 a.m., in Room 2318 of the Rayburn House Office Building, Hon. David Wu [Chair of the Subcommittee] presiding.

BART GORDON, TENNESSEE
CHAIRMAN

RALPH M. HALL, TEXAS
RANKING MEMBER

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Subcommittee on Technology and Innovation's

Hearing on

AN OVERVIEW OF TRANSPORTATION R&D: PRIORITIES FOR REAUTHORIZATION

Thursday, February 12, 2009
10:00a.m. – 12:00p.m.
2318 Rayburn House Office Building

Witness List

The Honorable Paul Brubaker
Former Administrator of the Research and Innovative Technology Administration of the U.S. Department of Transportation

Dr. Elizabeth Deakin
Director of the University of California Transportation Center at the University of California, Berkeley

Mr. Amadeo Saenz, Jr. PE
Executive Director of Texas Department of Transportation

Mr. Robert Skinner
Executive Director of the Transportation Research Board

Mr. David Wise
Acting Director of Physical Infrastructure Issues at the Government Accountability Office

HEARING CHARTER

SUBCOMMITTEE ON TECHNOLOGY AND INNOVATION
COMMITTEE ON SCIENCE AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES

An Overview of Transportation R&D: Priorities for Reauthorization

THURSDAY, FEBRUARY 12, 2009
10:00 A.M.—12:00 P.M.
2318 RAYBURN HOUSE OFFICE BUILDING

I. Purpose

On Thursday, February 12, 2009, the Subcommittee on Technology and Innovation will convene a hearing to review the research, development, and deployment activities of the Department of Transportation. The hearing will focus on issues related to the funding, planning, and execution of current research initiatives and how these efforts fulfill the strategic goals of both federal and State Departments of Transportation, metropolitan transportation organizations, and industry. With the expiration of SAFETEA–LU in FY 2009, this hearing will also examine possible ways to improve the current federal transportation effort.

II. Witnesses

The Honorable Paul Brubaker is a former Administrator of the Research and Innovative Technology Administration of the U.S. Department of Transportation.

Dr. Elizabeth Deakin is the Director of the University of California Transportation Center at the University of California, Berkeley.

Mr. Robert E. Skinner, Jr. is the Executive Director of the Transportation Research Board.

Mr. David Wise is the Acting Director of Physical Infrastructure Issues at the Government Accountability Office.

Mr. Amadeo Saenz, Jr. is the Executive Director of Texas Department of Transportation.

III. Overview

Signed in 2005, the *Safe, Accountable, Flexible, Efficient, Transportation Equity Act: A Legacy for Users* (SAFETEA–LU) (P.L. 109–59) authorized a total of $2.227 billion through FY 2009 for research and related programs under Title V of the bill. This Title authorizes surface transportation research by the Federal Highway Administration (FHWA), training and education programs, the Bureau of Transportation Statistics, the University Transportation Centers (UTCs), and Intelligent Transportation Systems (ITS) Research. The Science and Technology Committee's jurisdiction over surface transportation research and development is based on House rules which grant the Committee jurisdiction over, "Scientific research, development, and demonstration, and projects therefore" and legislative precedent. Jurisdiction over these programs is shared with the Transportation and Infrastructure Committee. The Science and Technology Committee has a long referral history regarding surface transportation research and development (R&D) bills, including H.R. 860 in the 105th Congress and H.R. 242, and H.R. 243 in the 109th Congress. Elements of each of these bills were incorporated in the highway reauthorization bills for the respective Congresses.

IV. Issues and Concerns

Planning, Coordination, and Evaluation of Research, Development, and Technology (RD&T)

Despite the creation of a specific RD&T coordinating agency within Department of Transportation (DOT) by the *Mineta Act of 2004* (P.L. 108–426), and requirements in the *Transportation Equity Act for the 21st Century* (TEA–21) (P.L. 105–178) and SAFETEA–LU that DOT evaluate and coordinate its research programs, efforts in this regard continue to fall short. In 2003, the Government Accountability Office (GAO) evaluated the coordination and review efforts by the Research and Special Programs Administration (RSPA).[1] RSPA had been created by the Secretary of Transportation to coordinate and review RD&T activity across the modal agencies. It was dissolved when the Mineta Act created the Research and Innovative Technology Administration (RITA) to fulfill largely the same functions. In the 2003 report, GAO found that efforts to locate duplicative programs and opportunities for cross-collaboration between the modal agencies were hampered by a lack of information on the RD&T activities being pursued across the modal agencies. GAO also found that DOT did not have a systematic method for measuring the results of federal transportation research activities, or a method to show how their research impacted the performance of surface transportation in the U.S. RSPA cited a lack of resources to perform these types of evaluations, and they also stated that each modal agency undertook its own evaluation of its research programs. GAO recommended that RSPA define metrics to evaluate the outcomes of its DOT-wide RD&T coordination efforts. In 2006, GAO did a follow-up evaluation of RD&T coordination and evaluation.[2] They again offered similar recommendations, noting the continuing lack of common performance measures for DOT RD&T activities. However, at the time of that evaluation, RITA had just recently been established. GAO commended the initiative in RITA's FY 2007 budget request to devote $2.5 million to RD&T coordinating activities (an increase of nearly $2 million over the $536,000 spent by RSPA in FY06 on coordination).

In November of 2006, RITA submitted the *Transportation Research, Development and Technology Strategic Plan for 2006–2010* to Congress. The Transportation Research Board (TRB), of the National Research Council, evaluated this plan and noted, "The strategic RD&T plan for 2006–2010 is a reasonable first effort. It offers useful descriptions of the many RD&T programs within the Department. At the same time, it is more a compendium of individual RD&T activities than a strategic plan that articulates department wide priorities and justifications for RD&T programs and budgets."[3] According to TRB, the plan lacked stakeholder input and also failed to identify how stakeholder input would be sought for strategic planning in research topic areas. It further failed to articulate the role and value of DOT's RD&T activities; describe the process used for selecting research topics to ensure their relevance, quality, or performance; describe the expected outcomes from RD&T; and describe the process for monitoring performance. In TRB's view, the plan, at a minimum should have explained the extent to which quantifiable goals, timetables, and performance measures would be part of RD&T programs.

The major surface transportation RD&T program of the FHWA has received similar criticisms regarding coordination and evaluation as DOT's overall RD&T program. The program is highly decentralized, with research activities taking place in five out of the thirteen offices within the agency. In 2002, GAO reviewed FHWA's R&D approach and urged that the agency "develop a systematic process for evaluating significant ongoing and completed research that incorporates peer-review or other best practices in use at Federal agencies that conduct research."[4] FHWA subsequently developed its *Corporate Master Plan for Research and Deployment of Technology and Innovation,* released in 2003. This document contains many overarching principles, such as measuring the performance of RD&T activities, but does not provide specific mechanisms through which FHWA will implement all of them. It is also unclear from FHWA's RD&T Performance Plan for 2006/2007 if the many research projects listed have been evaluated for their use by the transportation com-

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[1] GAO–03–500, *Transportation Research: Actions Needed to Improve Coordination and Evaluation of Research.*

[2] GAO–06–917, *Transportation Research: Opportunities for Improving the Oversight of DOT's Research Programs and User Satisfaction with Transportation Statistics.*

[3] RITA, *Transportation Research, Development and Technology Strategic Plan: 2006–2010,* Nov. 2006, Appendix A.

[4] GAO–02–573, *Highway Research: Systematic Selection and Evaluation Processes Needed for Research Program,* pg. 19.

munity. Without such analysis, the information portrayed in these documents establishes outputs, but does not offer any outcomes.

Tech-Transfer

There is general agreement that the transfer of technology and new ideas from the R&D stage to deployment and adoption is slow. In testimony before this committee in September of 2007, FHWA identified some of the contributing factors that slow the State and local adoption of new transportation technology, including insufficient information on the benefits versus the costs of new technologies; lack of confidence in new technologies or a lack of performance data; and a lack of incentive mechanisms to encourage the deployment of new technology.[5] TRB Special Report 295, *The Federal Investment in Highway Research, 2006–2009: Strengths and Weaknesses,* notes the important role FHWA plays in educating State DOTs about new technologies and encouraging their adoption, noting such efforts as FHWA's activities to identify, market, and track the deployment of market-ready technologies and incorporate a strategic plan for the deployment of pavement research activities. However, the funding for technology transfer activities at FHWA has suffered in recent years, falling from $100 million to $40 million after the passage of TEA–21. The report further notes, "The missing element among all of FHWA's deployment activities appears to be the resources within the agency with explicit expertise in technology transfer and deployment that could provide guidance to the various efforts agency wide [sic]."[6]

The Intelligent Transportation Systems program is a well studied example of transfer and deployment of R&D efforts. In 2005, GAO identified broad issues with DOT's deployment goals for traffic management ITS, finding that the goals did not take into account the level of ITS needed to accomplish local objectives and priorities; did not reflect whether localities were operating the ITS as intended; and did not adequately capture the cost-effectiveness of ITS.[7] Additional studies of ITS deployment have found that local officials are aware of ITS technologies but feel that the benefits are not adequately described.[8]

Recommendations from TRB

With support from FHWA, TRB's Research and Technology Coordinating Committee (RTCC) has periodically assessed the state of highway research and made recommendations to policy-makers. In its recent report, TRB Special Report 295, *The Federal Investment in Highway Research, 2006–2009: Strengths and Weaknesses,* the RTCC evaluated the investments in highway R&D made under SAFETEA–LU. According to the report, transportation R&D is significantly under funded when compared with the R&D investments made in other industrial sectors. Also, the report recommended that the matching requirement for UTCs be adjusted from 50 percent to 20 percent. According to the RTCC, if UTCs relied less on State DOTs and others for matching funds, they would be free to pursue longer-term advanced research topics and move away from applied research that could be handled elsewhere. The RTCC recommended that FHWA's Exploratory Advanced Research Program continue as well, and that a larger percentage of the agency's research budget go toward advanced research. Additionally, the report states that all research grants, including those to UTCs, should be made on a competitive, merit-reviewed basis. The RTCC recommended that FHWA be given more resources to engage stakeholders and carry out technology transfer activities. FHWA should be given the resources to take the lead in establishing an ongoing process whereby the highway community can set these priorities. Finally, the RTCC noted that the Strategic Highway Research Program 2 (SHRP 2) was funded significantly less than stakeholders had requested, and recommended that it continue to receive funding for another two years. TRB states many recommendations but does not provide specific mechanisms to accomplish them.

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[5] House Science and Technology Committee, *Bridge Safety: Next Steps to Protect the Nation's Critical Infrastructure,* September 19, 2007.

[6] TRB Special Report 295, page 68.

[7] GAO–05–943, *Highway Congestion: Intelligent Transportation Systems' Promise for Managing Congestion Falls Short, and DOT Could Better Facilitate Their Strategic Use.*

[8] Deakin, B. *Mainstreaming Intelligent Transportation Systems: Findings from a Survey of California Leaders,* 2004.

V. Background

Federal Highway Administration (FHWA)

The Federal Highway Administration oversees surface transportation infrastructure planning, construction, and maintenance; develops educational and training programs for transportation workers; and funds research efforts in surface transportation fields. Within FHWA, the Office of Research, Development, and Technology directs the Administration's transportation research efforts.

Office of Research, Development, and Technology

The Office of Research, Development, and Technology funds research into pavements, structures, safety initiatives, highway operations, and environmental interests. The Office of Research, Development, and Technology directs most of the research funds for DOT and operates the Turner-Fairbank Highway Research Center.

- **Turner-Fairbank Highway Research Center (TFHRC)**
  TFHRC operates as the hub for highway research by developing research plans in support of FHWA strategic goals; managing policy, budget, and administrative services for its research customers; and initiating strategic marketing plans to ensure the utilization of highway research.
- **Exploratory Advanced Research Program (EARP)**
  EARP manages longer-term, higher-risk research aimed at addressing mission-oriented technology and knowledge gaps as mandated in SAFETEA–LU. Intending to react to the call for more long-term research, this program seeks out projects not directed to solve specific current problems, but to enable approaches to future transportation questions.

Research and Innovative Technology Administration (RITA)

RITA is mandated to coordinate, facilitate and review the DOT's research and development activities, including those funded through FHWA.

- **Intelligent Transportation Systems Joint Program Office (ITS JPO)**
  ITS JPO was created in the *Mineta Act of 2004* to take over coordination of the Intelligent Transportation Systems program. ITS JPO focuses on developing transportation infrastructure and vehicles with integrated communication systems intended to deliver up-to-date information to both drivers and decision-makers. This information could be used to coordinate State department of transportation emergency efforts, relieve congestion through metropolitan signal coordination and enable on-the-go planning of efficient driving routes with up-to-date traffic information.
- **University Transportation Research**
  University Transportation Center (UTC) programs support almost 60 university-based centers that conduct transportation research in all disciplines and support educational activities for the next generation of transportation professionals. The centers are funded on a 50/50 matching funds agreement. Generally, the states provide the matching funds, and while the UTCs are intended to jointly operate as a multi-modal system focused on the DOT's strategic objectives, these matching funds often provide opportunities for State departments of transportation to channel efforts towards specific regional transportation issues.
- **Bureau of Transportation Statistics (BTS)**
  BTS is a component of the Research and Innovative Technology Administration (RITA) that collects, compiles, analyzes, and publishes transportation statistics in freight, travel and aviation; transportation economics; and geospatial issues. BTS is utilized by Federal, State, and local governments; universities; and the private sector. Data sets made available to customers can include air carrier traffic, border crossing, and national freight movement.
- **John A. Volpe National Transportation Systems Center**
  A fee-for-service organization, the Volpe Center is a center designed to respond to issues brought forth to them by Federal, State, and local governments; industry; and academia. The Center assists these clients in a number of areas including human factors research; system design, implementation, and assessment; environmental preservation; and organizational effectiveness. DOT makes up about two-thirds of the Volpe Center's contracted funding.

- **Transportation Safety Institute (TSI)**
  TSI is also a fee-for-service organization utilized by Federal, State, and local governments; industry; and the international community; that develops and conducts worldwide safety, security, and environmental training. TSI focuses on education programs developed in collaboration with the client organizations to meet specific situation needs. Training and educational information is disseminated through publications, websites, seminars, and classes.

The Transportation Research Board

TRB is one of five major divisions of the National Research Council; the principal operating agency of the National Research Council. TRB receives federal funding to manage cooperative research efforts and issue published analyses of transportation policy and research strategy. Two of the research efforts managed by TRB are the National Cooperative Highway Research Program and the Strategic Highway Research Program 2.

- **National Cooperative Highway Research Program (NCHRP)**
  NCHRP is a program aimed providing solutions to near-term problems in the transportation industry by tackling an annual list of research topics developed by State departments of transportation. NCHRO is administered by TRB and sponsored by the State departments of transportation in the American Association of State Highway and Transportation Officials.
- **Strategic Highway Research Program 2**
  SHRP 2 is a highway research program designed to advance highway performance and safety for the U.S. highway system. This program focuses on four areas of research that were identified by a TRB-established committee of leaders from the highway community: safety, infrastructure renewal, reliability, and transportation capacity. Funding is transferred through FHWA for execution by TRB with an expected program completion date of FY 2009.

Funding for Surface Transportation Research and Development ($ millions)

	FY2007	FY2008
Federal Highway Administration	*38731.0*	*41216.0*
Office of Research, Development, and Technology	**111.3**	**124.9**
Turner-Fairbank Highway Research Center	100.2	114.4
Exploratory Advanced Research Project	11.1	10.5
	FY2007	FY2008
Research and Innovative Technology Administration	**198.9**	**199.0**
Operating Costs	6.0	6.0
Intelligent Transportation Systems	101.3	101.6
University Transportation Research	64.1	64.4
Bureau of Transportation Statistics	27.5	27.0
	FY2007	FY2008
*Transportation Research Board***	-	-
National Cooperative Highway Research Program	*30.0*	*30.0*
Strategic Highway Research Program II	**40.5**	**38.5**

* - italicized lines are not under the House Subcommittee on Technology and Innovation's jurisdiction

** - historical numbers are not available, FY2009 funds are $89.5 million

Chair WU. Good morning. This hearing will come to order. Welcome to today's hearing entitled *An Overview of Transportation Research and Development: Priorities for Reauthorization.*

I want to welcome everyone to the Technology and Innovation Subcommittee's first hearing of the 111th Congress. This subcommittee was very productive in the 110th, moving the Small Business Innovative Research Program Reauthorization, Green Transportation Legislation, the 10,000 Trained by 2010, Health Information Technology Education Reauthorization—I am sorry—Legislation, and the U.S. Fire Administration Reauthorization and the National Institute of Standards and Technology portions of the COMPETES Act. I am certain that we can maintain this quick pace in the 111th Congress, and it is my intention to do so on a basis where both sides of the aisle will be participating vigorously in these processes.

And first up on our agenda and the subject of this first hearing is Surface Transportation Research and Development in preparation for the Surface Transportation Reauthorization Bill. I can think of a no more appropriate topic for this subcommittee to begin with as Congress concludes debate on an economic stimulus package that includes multi-billions of dollars for surface transportation projects.

As we start these and other major infrastructure initiatives, we all agree that we should deploy the most recent, efficient, proven surface transportation technologies to ensure that we are building the highways of the past—I am sorry—the highways of the future and not of the past. Today's hearing is an overview, an assessment of our current R&D investments, their coordination, and their focus. This will be the first in a series of hearings as this subcommittee develops a surface transportation title that will later be incorporated into the comprehensive Surface Transportation Bill.

In reviewing some of the Transportation Research Board's recent assessments of our surface transportation investments, I am somewhat concerned that the recommendations focus on increased funding as the sole means to overcome the challenges identified, including slow technology transfer and a lack of clear national priorities in DOT's (Department of Transportation's) R&D spending. More money is sometimes necessary. It is difficult in our current environment, and sometimes it is not a solution to a lack of coordination or a lack of focus.

What I hope to learn today, and in this series of hearings, is how to make our federal investments in surface transportation research and development as effective and as efficient as possible in overcoming the challenges of congestion mitigation and its impact on our lives and on the external environment.

I want to thank our panel of witnesses for taking the time from their busy schedules to be with us today.

Now I would like to recognize my colleague from Nebraska, Representative Smith, for his opening statement.

[The prepared statement of Chair Wu follows:]

PREPARED STATEMENT OF CHAIR DAVID WU

Welcome to today's hearing entitled *"An Overview of Transportation R&D: Priorities for Reauthorization."*

I want to welcome everyone to the Technology and Innovation Subcommittee's first hearing of the 111th Congress. This subcommittee was very productive in the 110th, moving the Small Business Innovation Research program reauthorization, green transportation legislation, the 10,000 Trained by 2010 health information technology education legislation, the U.S. Fire Administration reauthorization, and the National Institute of Standards and Technology portion of the COMPETES Act. I am certain we can maintain this pace in the 111th Congress.

Our first hearing focuses on surface transportation research and development programs, in preparation for the surface transportation reauthorization bill. I can think of no more appropriate topic for this subcommittee to begin with, as Congress debates an economic stimulus package that contains $30 billion for surface transportation projects. As we commence this major infrastructure initiative, we all agree that we should deploy the most recent and proven surface transportation technologies to ensure we're building the highways of the future, not the highways of the past.

Today's hearing is an overview and assessment of our current R&D investments. This will be the first in a series of hearings as the Subcommittee develops a surface transportation title that will later be incorporated into the comprehensive surface transportation bill.

In reviewing some of the Transportation Research Board's recent assessments of our surface transportation investments, I have been disappointed by their recommendations that focus on increased funding as the means to overcome the challenges they identify, including slow technology transfer and a lack of clear national priorities in DOT's R&D spending. I don't think more money is a practical or realistic recommendation in our current economic environment.

What I hope to learn today, and in this series of hearings, is how to make our federal investments in surface transportation R&D as effective and efficient as possible in overcoming the challenges of congestion mitigation and its impact on the environment.

I want to thank our panel of witnesses for taking the time from their busy schedules to appear for us today.

And now I would like to recognize Representative Smith for his opening statement.

Mr. SMITH. Thank you, Mr. Chair. It is a pleasure to return to business today, and I look forward to a productive and collaborative 111th Congress on this subcommittee.

The economic challenges facing our nation are of utmost importance to us all. We must ensure our nation's citizens have the opportunity to create and innovate. We must support entrepreneurship and see that businesses are allowed to become more nimble, more efficient, and more competitive. I believe the Subcommittee on Technology and Innovation will take an active role in shaping our economic recovery and certainly competitiveness.

I look forward to working closely with you, Mr. Chair, and the rest of my colleagues on the Subcommittee in accomplishing this task.

The agencies we oversee on this subcommittee are vital to the Nation's health and well-being. The National Institute of Standards and Technology performs cutting-edge research which supports the next generation of computers and electronics, the next generation of fuel-efficient vehicles, and the next generation of health care technologies. The Department of Homeland Security continues to perform lifesaving work to ensure our safety and security, and the Department of Transportation supports the highways and railways vital to our commerce and way of life.

Chair Wu, we have a lot of work ahead of us certainly, and all of these agencies may see funding increases due to a stimulus plan and all will need to have close oversight to ensure we are spending taxpayer dollars wisely. I am happy our first hearing of the year

addresses one of the major challenges facing our nation in Congress this year; infrastructure research and development.

We are currently contemplating spending billions of dollars on highway and railway infrastructure improvements. We will need to ask important questions in order to address the issues facing our nation's aging infrastructure. How will these projects incorporate science and technology to extend the life of and improve the quality of our transportation networks? How have our R&D programs performed over the past several years, and what can we do to improve them?

We expect most R&D to be relevant to the problems at hand and expect research agencies to focus on the real-world outcomes of such research. The witnesses before us today all have expertise in translating results from the lab to the road. I would like to thank you all for coming today and sharing your thoughts on how to improve our transportation networks and our research activities. I look forward to starting a dialogue with you during the question and answer portion of today's hearing and hope you will continue to work with us as we craft a new highway bill.

Thank you, Mr. Chair. Again, it is a pleasure to serve as Ranking Member of this subcommittee, and I look forward to continuing this bipartisan and productive relationship. I yield back.

[The prepared statement of Mr. Smith follows:]

PREPARED STATEMENT OF REPRESENTATIVE ADRIAN SMITH

It is a pleasure to return to business today and I look forward to a productive and collaborative 111th Congress on this subcommittee. The economic challenges facing our nation are of utmost importance to us all. We must ensure our nation's citizens have the opportunity to create and innovate. We must support entrepreneurship and help our businesses become more nimble, more efficient, and more competitive. I believe the Subcommittee on Technology and Innovation will take an active role in shaping our economic recovery and competitiveness. I look forward to working closely with you, Chairman Wu, and the rest of my colleagues on the Subcommittee in accomplishing this task.

The agencies we oversee on this subcommittee are vital to the Nation's health and well-being. The National Institute of Standards and Technology performs cutting edge research which supports the next generation of computers and electronics, the next generation of fuel-efficient cars, and the next generation of health care technologies. The Department of Homeland Security continues to perform life-saving work to ensure our safety and security. And the Department of Transportation supports the highways and railways vital to our commerce and way of life. Chairman Wu, we have a lot of work ahead of us. All of these agencies may see funding increases due to a stimulus plan and all will need close oversight to ensure we are spending taxpayer dollars wisely.

I am happy our first hearing of the year addresses one of the major challenges facing our nation and Congress this year—infrastructure research and development. We are currently contemplating spending billions of dollars on highway and railway infrastructure improvements. We will need to ask important questions in order to address the issues facing our nation's aging infrastructure. How will these projects incorporate science and technology to extend the life of and improve the quality of our transportation networks? How have our R&D programs performed over the past several years and what can we do to improve them? We expect most R&D to be relevant to the problems at hand and expect research agencies to focus on the real-world outcomes of such research.

The witnesses before us today all have expertise in translating results from the lab to the road. 1'd like to thank you all for coming today and sharing your thoughts on how to improve our transportation networks and our research activities. I look forward to starting a dialogue with you during the question and answer portion of today's hearing and hope you will continue to work with us as we craft a new highway bill.

Thank you Mr. Chairman. Again, it is a pleasure to serve as Ranking Member of this subcommittee and I look forward to continuing this bipartisan and productive relationship. I yield back the balance of my time.

Chair WU. Thank you very much, Mr. Smith. If there are other Members who wish to submit additional opening statements, your statements will be added to the record at this point.

[The prepared statement of Mr. Mitchell follows:]

PREPARED STATEMENT OF REPRESENTATIVE HARRY E. MITCHELL

Thank you, Mr. Chairman.

Today we will discuss surface transportation research and development funding, planning, and execution.

Surface transportation research and development is critical as the population continues to grow and congestion continues to increase.

Take Arizona, for example, which is one of the fastest growing states in the Nation. Since 1970, our population has more than tripled. The Phoenix metropolitan area, long the largest in our state, is now one of the largest in the Nation.

Not surprisingly, all this growth has created an urgent need for new transportation infrastructure and congestion mitigation efforts.

The Arizona Department of Transportation (ADOT) has been a leader in transportation research and technology and has engaged in several research efforts to improve infrastructure problems such as monitoring and managing congestion and experimenting with pavement materials.

I look forward to hearing from our witnesses about how we can encourage the development of new technologies and materials.

I yield back.

Chair WU. It is now my pleasure to introduce our witnesses. Mr. Paul Brubaker is the Former Administrator of the Research and Innovative Technology Administration of the U.S. Department of Transportation. Dr. Elizabeth Deakin is the Director of the University of California Transportation Center at the University of California, Berkeley. Mr. Amadeo Saenz is the Executive Director of the Texas Department of Transportation. Mr. Robert Skinner is the Executive Director of the Transportation Research Board. And our final witness is Mr. David Wise, the Acting Director of Physical Infrastructure Issues at the Government Accountability Office.

You will each have five minutes for your spoken testimony. Your written testimony will be included in the record for this hearing, and when you complete all of your testimony, we will begin with questions, and each Member will have five minutes to question the panel. We will go as many rounds as there are questions or we have time for, whichever arrives first.

Mr. Brubaker, please begin.

STATEMENT OF THE HONORABLE PAUL R. BRUBAKER, FORMER ADMINISTRATOR, RESEARCH AND INNOVATIVE TECHNOLOGY ADMINISTRATION, U.S. DEPARTMENT OF TRANSPORTATION

Mr. BRUBAKER. Thank you, Mr. Chair, Ranking Member Smith, Vice Chair Luján, distinguished Members of the Subcommittee. My name is Paul Brubaker, and I had the honor of serving as the Administrator of the Research and Innovative Technology Administration (RITA) at the U.S. Department of Transportation (DOT) from August, 2007, until January 20 of this year.

Oh, I am sorry.

I am pleased to be here today to testify on what I think is the real tipping point in the transportation infrastructure; how we le-

verage research going forward to transform our transportation infrastructure.

I have submitted written testimony as you know for the record, but I would like to highlight some key points in my oral testimony.

During my tenure at RITA we attempted to establish a process by which research funding decisions were made, executed, and evaluated, as well as develop a construct to actually manage research, in portfolios based on multi-modal communities of interest. We weren't entirely successful.

However, we did make significant progress in at least establishing a degree of transparency into the research spent which hadn't been reached before. The transparency is only the beginning. Decisions where to spend the 1.2 billion in research dollars must be based on strategic research objectives established in a holistic, multi-modal, and focused national transportation research agenda that covers all aspects of the transportation picture and drives innovation into the system.

For all research funded by the Department or through the Highway Trust Fund, outcome expectations and performance measures should be agreed upon in advance, progress should be monitored, and performance should be measured after the projects are complete. The Surface Transportation Authorization provides us an opportunity to redefine how we approach and conduct transportation research in a way that better serves our nation.

Before asking for additional transportation research dollars, I strongly believe we must ensure that current dollars are being spent wisely. As it stands right now nobody, and I mean nobody, can say with reasonable assurance or authority that funds are being spent wisely or in a manner that best reflects the overall national transportation priorities. We have an opportunity to fix this optimal situation by creating a new transportation research paradigm.

One good place to start is to ensure that RITA, and you might naturally expect me to say this, is both sufficiently resourced and allowed to perform its role that was created under the Mineta Act to coordinate the research spend for the Department, but more importantly, to develop that holistic process where the Secretary can select, control, and evaluate research in a strategic context based on a to-be-developed national transportation research agenda that reflects a broad group of stakeholders, ranging from states and localities to personal and commercial uses of our national transportation system, to accident victims, police and first responders, even economic development officials from states and localities.

I have made other recommendations including the establishment of the Transportation Advanced Research Projects Agency, the consolidation of research functions under RITA, and funds set aside for innovative research projects that can be carried out by a variety of institutions and individuals. Those are included in my written testimony.

I look forward to a constructive discussion today on ways to improve our transportation research to better leverage our existing investments and better serve the American public.

Thank you, Mr. Chair.

[The prepared statement of Mr. Brubaker follows:]

PREPARED STATEMENT OF PAUL R. BRUBAKER

Chairman Wu, Ranking Member Smith, Vice Chairman Luján, distinguished Members of the Subcommittee. My name is Paul Brubaker and I had the honor of serving as the Administrator of the Research and Innovative Technology Administration (RITA) at the U.S. Department of Transportation from August 2007 until January 20th of this year and I am pleased to be before you this morning to discuss lessons learned during my tenure; suggestions on how to improve transportation research; ways in which we can deploy the results of that research; and some thinking as it relates to the new surface transportation legislation.

Based on my recent experience, I believe we have a tremendous opportunity to shape a National Transportation Research program that has the potential to transform how we move people and goods across the Nation and indeed re-establish our global position as leaders of a new, innovative and efficient transportation paradigm. In order to achieve this lofty goal, we will need to rethink our approach to transportation research; build on a couple of innovations that I attempted to implement during my brief term; and establish structural improvements that can ensure the level of innovation that is often promised but rarely realized.

In your invitation you laid out a series of questions that I will attempt to answer in my testimony but with some additional information that I hope will provide a more complete narrative.

The current transportation research and development investment structure is improving—but what it really needs is a complete overhaul.

Early in my tenure it was clear that the fundamental legislative requirements of the Mineta Act, which created my office and called on RITA to coordinate the Department's transportation research, were not being met. While the Department established a Research Planning Council and a Research Planning Team—it could best be described as a loose governance process that was only meant to "rubber stamp" the Department's $1.2 billion in transportation research money was spent—with no enterprise level coordination as the law—as I read it—required.

After conducting a pretty quick assessment of the situation I asked RITA's RD&T staff to establish a framework by which we could prioritize transportation research investments to better reflect and align to the strategic goals of the Department and the Administration. I further requested that this framework be based on the Capital Planning and Investment Control (CPIC) processes mandated by OMB circular A–11 for the government's capital investments because there were a number of similarities and the GAO had established a nice corresponding maturity model for organizations to use in developing and using CPIC for technology investments.

The framework that was initially conceived, originally known as Research Planning and Investment Control (RPIC), cannot only prioritize investments, but was designed to monitor and track research outcomes over the life of the project and manage the research in portfolios. However, due to cultural resistance to change, the word "control" in RPIC was changed to "coordination," the investment prioritization activities, the research monitoring plans, and the concept of portfolio management were all scrapped. The RPIC project was relegated to a "pilot" program and today is essentially a data base of existing research programs that can be viewed by multimodal communities of interest (e.g., human factors; materials; safety systems) and across the modes. While this transparency is good and desirable, RPIC was originally conceived to do considerably more—it was to serve as a decision support, program management and program evaluation tool so that we could select, evaluate and control the underlying research spending in a manner consistent with research investment criteria.

The current incarnation of the RPIC process "buckets" existing spending to communities of interest but the actual decisions to invest in particular research activity are made almost exclusively by the modes. Consequently, the current spending of the Department's research resources is not subject to a systematic Department-wide prioritization. This spending is most often aligned with the wishes of a number of key stakeholders in each of the modes, or in some cases is the result of a Congressional earmark but the Department's portfolio of transportation research does not represent a comprehensive, holistic program that supports an overall National Transportation Research Agenda.

The University Transportation Centers represent approximately $70M of research spending each year. It is the one program where RITA has complete visibility over the research spending and reviews the strategic plans for consistency with the Department's overall strategic plan. Given the mission of the UTC program—to train the next generation of transportation leadership—there is strong evidence that the program is meeting that goal.

Clearly, we need to improve the current transportation R&D investment structure. My suggestion would be to start over. Begin with the development of a National Transportation Research Agenda. This agenda should take a comprehensive, holistic, multi-modal view of our transportation system and receive input from the Congress, Administration, transportation system user communities and all stakeholders—not just the ones with the deepest pockets—and establish and outline the key objectives and desired outcomes of our transportation system. It should then clearly map research programs and spending to the outcomes and goals outlined in the plan and clearly describe how these projects will help us achieve our goals and achieve our desired outcomes.

Once that agenda is established, a governance process—much like that originally conceived for the RPIC—explicitly supported by the Secretary and managed on behalf of the Secretary by RITA, should examine all of the research programs and proposals that receive any direct or indirect federal dollars, and only those that are consistent with the goals of the National Transportation Research Agenda should be funded. Those that are funded should be monitored and evaluated. A dedicated office of technology transfer, perhaps within RITA, could help ensure that the relevant, valuable knowledge (for both successful and unsuccessful projects) is shared and when appropriate, that successful innovations are commercialized and/or generate new levels of research.

The Department, through RITA, should also act as a facilitator of knowledge through the use of advanced collaboration capabilities that would allow researchers to self-organize around communities of interest. During my tenure, we attempted the creation of such an environment—think Facebook for the transportation research community—that would make knowledge sharing and technology transfer much more convenient and effective as collaboration and reporting could be accomplished virtually. Those not wishing to share results until the research projects are completed could create password protected work spaces that would restrict access only to those working on the project. While at RITA, we built the first generation of this collaborative capability at *www.transportationresearch.gov*. It is only the beginning of what could become an interesting new paradigm in research collaboration and ironically may bring the Internet back to its roots.

Our ability in the transportation research community to successfully transfer, commercialize and deploy new methods, innovations, and technology must be refocused. Currently, there is no systematic or focused program, process or set of activities that are driving innovations out of the laboratory and onto our Nation's roads, rails, runways or waterways. Most in the community believe that effective technology transfer only involves having researchers share their research by publishing peer reviewed articles in transportation research journals or presenting papers at conferences. Researchers communicating with other researchers is a valuable way to share knowledge—it is also a sure fire way to ensure that these advances or ideas rarely get commercialized.

We must focus on a new model and process to achieve technology transfer that leads to commercialization and deployment of new transportation-related technologies. Unfortunately, we may miss a prime opportunity to drive innovation into the transportation infrastructure through the stimulus spending but it may be an order too difficult to fill in short order.

Only a new approach to technology transfer and commercialization that is focused on transparency, openness, and a systematic way to communicate with a broader set of industry, entrepreneurs, investors and other interested parties will succeed in fostering innovation and ensuring wider-spread deployment of these innovations. For years, this has largely been an "inside game" managed by a relatively small group—an example of that President Eisenhower foresaw in his farewell speech in January, 1961—which virtually ensures that an innovator tinkering in the garage has no chance of getting his or her ideas vetted.

We need to look beyond the universe of traditional gatekeepers and work to facilitate the timely testing and standards development that would allow rapid prototyping, piloting and deployment of these new technologies. In short, we must move closer to technology development times versus industrial age development cycles. I have witnessed a great number of good ideas that are available today—but may not be deployed for decades to come because of a variety of cultural, structural and systemic obstacles—mostly related to intolerance of risk and processes that have the effect of stifling innovation. This can change. But it will require a collective commitment and leadership that is willing to deploy a systematic way of improving technology transfer and commercialization.

As the Congress begins drafting the next surface transportation legislation, it will have a unique opportunity to change the focus from strictly "highways" and direct spending and programs that better reflect the way we actually travel. While high-

ways are indeed an integral part of this equation, the view must be significantly expanded to include or at least accommodate alternative modes for people and freight to include rail, high speed passenger rail and transit, and water transportation. We even must integrate air as we consider this holistic picture.

The next surface transportation authorization must ensure that the transportation research budget and that of the Bureau of Transportation Statistics is directly aligned with the National Transportation Research Agenda which should be updated and published every two years by the Research and Innovative Technology Administration in coordination with the Administration, the Departmental leadership, the users of the systems and key stakeholders.

The budget should be aligned and adjusted based on changing priorities and the portfolio of projects should be balanced according to the priorities reflected in the agenda. This portfolio should be transparent both within and outside of the department and the final annual budget and program plan should be public. This way, citizens from anywhere in the county can examine the portfolio and its anticipated outcomes and compare actual results to anticipated results. Such increased transparency may actually improve achieve deployment of these technologies and methods as more people and entrepreneurs will have access to the new ideas being explored by the Department and its research community.

There is also a clear role for the Bureau of Transportation Statistics but it should be much focused and adequately resourced to monitor the performance of the Nation's transportation system. It must also expand its role and develop forecasting models and simulations that can help us drive research proposals as it will help us better understand the potential impact of alternative investments and research results as well as ensure that it has the capability to further our understanding of external events that impact our transportation system. For example, with this capability BTS could have been able to model the impact of fluctuating fuel prices on our national logistics system and passenger movement system.

Perhaps not surprisingly, I believe that RITA should remain the Department's focal point for transportation research—but it must be significantly strengthened—this will require a significant and substantial investment in people and money. RITA's first order of business should be to coordinate the formulation of the National Transportation Research Agenda—one that represents a cross-modal and holistic view of our national transportation system. This can only be developed with significant input from the user community and from stakeholders. The research agenda must also be multi- or intermodal in nature and not be primarily or disproportionately focused on highways to the exclusion of other modes—the only way to accomplish this is to provide direct funding.

Then, RITA should establish and manage a governance process that can align and direct transportation research resources in a manner that is consistent with the National Transportation Research Agenda. RITA could build on the RPIC process to achieve this goal but most importantly, the research portfolio should be managed and evaluated for its outcomes, results and effectiveness by developing transparent program and project evaluations and lessons learned that can be used to determine appropriate follow on research and serve as a basis for technology transfer and commercialization of the promising research.

RITA should also continue to play an active role in overseeing the University Transportation Research as well as house appropriate multi-modal research activity—such as the Intelligent Transportation System and Alternative Fuels program—and should expand its oversight role to include the approval and oversight of any Department or indirect federal dollars going to any University or not-for-profit research entity for transportation-related research. This includes the coordination, review and approval of any projects directly or indirectly receiving federal funds that are managed by the Transportation Research Board of the National Academies.

Although controversial, the Committee should examine the feasibility of consolidating all of the research laboratories within the Department. These could be centrally managed by RITA or at a minimum be subject to strict oversight by RITA to ensure that their activities are consistent with and achieving the objectives of the National Transportation Research agenda. Currently, a number of the modes have research labs dedicated toward performing transportation research. For example, the Turner-Fairbank Highway Research Center in Virginia currently performs a great deal of highway related materials and systems research. In many cases, similar if not identical research is also being conducted at a number of universities—some of which is funded by the Federal Highway Administration. While it may be appropriate in some cases to validate research results, I believe the resistance to visibility and oversight as well as the failure of the Department to drive toward better management of the research portfolio continues to encourage research redundancy and waste.

Finally, I would like to suggest that a certain portion of the Department's Transportation Research funding—at least half—go toward advanced systems research—and directed by RITA consistent with the National Transportation Research Agenda. I would propose that the majority of the funding be used to establish a Transportation Advanced Research Projects Agency. The balance of the funds should be used for worthy projects proposed by the Volpe National Transportation Systems Center, Turner-Fairbank, The Transportation Research Board, Universities and other potential worthy and qualified grantees including those who tinker in their garages.

Thank you for the opportunity to present the ideas to you this morning and I look forward to answering any questions you may have.

BIOGRAPHY FOR PAUL R. BRUBAKER

Paul Brubaker recently joined Cisco Systems, Inc. as leader of its North American public sector team in the Internet Business Solutions Group (IBSG).

Paul has an unusual blend of public and private sector experience. He has served in both the legislative and executive branches of the U.S. Federal Government. During his service in legislative branch, Paul worked for the General Accounting Office and eventually became Minority Staff Director of the Senate Subcommittee on Oversight of Government Management where he worked on a number of reform efforts including leading the effort that resulted in passage of the *Information Technology Management Reform Act* linking federal investment in technology to measurable improvements in mission performance and establishing CIO positions in major federal agencies.

In 1998, Paul was appointed by President Clinton to serve as Deputy Assistant Secretary of Defense and Deputy Chief Information Officer and in 2007 he was appointed by President Bush and confirmed by the Senate to serve as the Administrator for Research, Innovation and Technology at the U.S. Department of Transportation.

In the private sector, Paul founded two successful small businesses and has worked in a number of senior strategy positions with government contractors including: Litton PRC; Commerce One; and SI International. At SI international, he served as Executive Vice President and led the government and investor relations activities while serving as Chief Marketing Officer where he also re-engineered and automated a number of sales and proposal processes. While at Commerce One, Paul led a management buy-out of the firm's public sector professional services unit which he took private.

In his spare time, he has served as the Chairman of the Virginia Innovative Technology Authority, Chairman of the Technology Committee of the International Armed Forces Communications and Electronics Association, and as a board member of the Churchill Centre.

For his work in government Paul has received numerous awards including the Department of Defense Distinguished Public Service Medal (with palm device); The Gold Medal from the Department of Transportation; the Association for Federal Information Resource Management Federal Executive of the Year in 2000; and was a two-time winner of the Federal 100 Award from *Federal Computer Week.*

Chair WU. Thank you, Mr. Brubaker.

Next, Dr. Deakin, please proceed.

STATEMENT OF DR. ELIZABETH DEAKIN, PROFESSOR OF CITY AND REGIONAL PLANNING; DIRECTOR, UNIVERSITY OF CALIFORNIA TRANSPORTATION CENTER, UNIVERSITY OF CALIFORNIA, BERKELEY

Dr. DEAKIN. Thank you, Mr. Chair. I was asked today to speak about some research that we did at the University of California on Intelligent Transportation Systems (ITS), and let me start with——

Chair WU. Dr. Deakin, is your microphone on?

Dr. DEAKIN. It seems to be.

Chair WU. Okay. Pull it a little bit closer.

Dr. DEAKIN. Let me pull it closer.

Chair WU. There we go.

Dr. DEAKIN. Is that working?

Chair WU. Yes.

Dr. DEAKIN. Okay. I would like to talk to you about the research findings from our study of Intelligent Transportation Systems and how to get them into the mainstream in transportation. This is a study that was funded by CalTrans, who had spent a good deal of its own money, as well as federal funds, to invest in intelligent transportation and was concerned about whether they were getting their dollars' worth from the projects.

What we found in a series of interviews with decision-makers, as well as with technology experts and the decision-makers both in the public and in the private sector, was that while there were some valuable gains in such things as traffic signal timing, road tolling, better data collection, cheaper methods for gathering data and assembling it, monitoring the systems, and managing them, there also is a concern among the decision-makers that there really was a need for a tougher, more arms-length evaluation of the cost effectiveness of these investments, and there also was a need for a business plan for these investments that hadn't yet been developed.

And one of the reasons for that was a lack of real focus on institutions and business budgets and costs and effectiveness. This is social science research. There is a lot of interest in what kind of institutions it would take to implement these kinds of strategies.

One of the problems is that we have tried to include deployment in ITS projects, but it has been done by the technology experts, who are not necessarily the experts in institutions and planning and policy. And so we have concluded that we need to create a different framework and a different set of research foci that would compliment the technology development, really help it move into implementation. And that might extend to new kinds of partnerships and oversight that involves the private sector as well as government to really do a tough business plan for these technologies as they are being developed.

I was also asked to address the question of University Transportation Centers (UTCs), something that I have some experience with, having directed the center in Region Nine for ten years. University Transportation Centers do research, they do tech transfer, and they produce graduates. The graduates are a form of technology transfer in some ways because they go out into the agencies and the consulting firms and the private sector with the latest knowledge and learn on the job how to deploy that knowledge. So we look at them as an important product.

The Transportation Centers Program expanded greatly under the last Transportation Bill from the original ten to a total of 60 centers now, 20 of which competed for their funds and 40 of which were selected by Congress. My own view is the competition is a very good way to choose transportation centers because it assures that the best ideas are able to compete and win in a kind of marketplace. I also have to acknowledge, though, that some of the earmarked centers have used that opportunity as a chance to really show that they could develop and have developed and become successful.

A big issue on both the UTCs and ITS is measuring performance, and I think performance has to be measured on outcomes, not on

inputs, not just on the number of counts of papers produced or dollars spent, but actually what has been accomplished that has changed things, that has made the transportation system better, cheaper, faster, more equitable, and more environmentally sound. And we need to move in that direction quickly.

One way to do that is to increase coordination in research, which is the third topic I was asked to address. I think that can be, and is being, done much better than it was even a few years ago because of investments that the Transportation Research Board, that RITA, and that others have made in creating really good websites where we can coordinate the research and see what everybody else is doing. There really is no excuse for duplication with the kind of information that is now being made available.

On the other hand, I don't think that all projects that are doing the same thing are duplications. Sometimes we learn by doing multiple cases, and we really need to be able to do that. So replication has to be distinguished from duplication, and we will go ahead faster and gain better if we do that.

I do think that the strategic plan that Mr. Brubaker just described is a critical element in being able to manage research. We have to have a new strategic plan that really represents the new directions in policy that the country is pursuing under this Administration and under the changing information about science and technology that comes along. We need to keep that plan up to date and renew it, and I think the partnerships have to go beyond just DOT. They have to go to other agencies in a much stronger way than they have, to agriculture, to energy, to environmental agencies, and further, they have to go to the private sector in a stronger way than they have because we can't do this alone. And we need some new models on how to deliver our transportation systems so they will be cost effective.

And so I really think that plan has to be the starting point. It has to be outcome-focused. It has to be across the board integrating all the ideas and issues that we have to address in the next few years. We need to develop the plan quickly so that we will be able to have a framework for making decisions on what is a good investment in research and technology.

Thank you.

[The prepared statement of Dr. Deakin follows:]

PREPARED STATEMENT OF ELIZABETH DEAKIN

Millions of dollars are spent each year on transportation research. How can we be sure that these investments are effective and that the research findings are reflected in transportation decision-making? Here I briefly consider investments in Intelligent Transportation Systems, in University Transportation Centers, and in USDOT-led research, and recommend three strategies that could improve research and its utility: more emphasis on social science research to frame and complement technology-focused R&D; investing in long-term and exploratory research as well as in short-term, problem-solving studies, and framing research and investment in a strategic planning and evaluation context focused on outcomes rather than project categories.

A Bigger Role for Social Science Research: Evidence from Studies of the Implementation of Intelligent Transportation Systems

In a study conducted in 2003, researchers at the University of California investigated factors affecting ITS implementation as a "mainstream" transportation planning activity (Deakin et al., 2002; Deakin, 2006). We conducted a detailed literature

review, interviewed fifty-one leaders from a cross-section of California jurisdictions and agencies, surveyed 228 California transportation engineers, planners, and transit staff members, and had follow-up interviews with 52 of the staff members and 20 national transportation leaders with expertise in ITS.

ITS experts felt that ITS implementation has been slow, and attributed this to a lack of knowledge about ITS among elected officials and the public, as well as a lack of funding specifically for ITS. In contrast, our interviews with California leaders—elected officials and agency heads—revealed widespread familiarity with ITS concepts and applications (though many were irritated by ITS jargon and were unwilling to use it). Policy-makers cited freight applications, electronic toll tags, improved traffic signal systems, bus rapid transit projects, and traveler information signage as examples of ITS success. From the policy-makers' perspective, ITS elements that are not proceeding well suffer from institutional and political problems (e.g., efforts to route additional traffic on local arterials when the freeway is congested) or market weaknesses (e.g., efforts to sell traffic information to third party providers). Overall, most elected officials and senior policy staff members felt that ITS innovations are being implemented at a reasonable pace.

Elected officials were concerned, however, about a lack of good information on ITS benefits and costs, and some expressed concern that ITS evaluations have been less than arms-length. A number of leaders also commented that ITS proposals have focused too heavily on transportation system management benefits rather than traveler benefits. Some also argued that the private sector should be left to implement ITS applications such as traveler information systems.

Respondents suggested that the state DOT should lead by example, implementing ready-to-go technologies on its own facilities and within its own agency. Stronger partnerships with local government and other State agencies, developing mutually beneficial, multi-purpose applications, were recommended. Finally, respondents urged that future ITS work should pay more attention to legal and institutional issues and provide a clearer sense of "next steps."

Interviews with national experts identified additional issues. There was near-unanimous agreement that DOTs are having difficulty with ITS implementation because partnerships are needed to implement and partnerships necessitate a change in agency culture, including less hierarchical decision-making. In the experts' view, separate ITS units and ITS implementation plans can foster strategic thinking about ITS technology development but may hinder ITS incorporation into ongoing plans, programs, and funding streams. Earmarked funding for ITS was seen as appropriate for demonstration projects, to test concepts and provide examples, and when ideas are accepted but resources are low; traffic signal timing, which produces valuable cumulative benefits but is low-visibility and typically a low priority for local governments, was given as a case where earmarked funds may be needed to induce action.

Based on these findings, we recommended a refocusing of applied ITS research across a wider range of applications, as well as greater attention to research on implementation, including market studies and work on strategies to foster consensus building and partnerships for ITS.

A follow-up study currently underway suggests that many findings of our earlier work still hold true (Deakin, Frick, and Skabardonis, forthcoming). While efforts have been made to increase deployment of ITS, these efforts have continued to focus primarily on technology details rather than evaluating the broader questions of costs and benefits, markets and institutions that are also needed. Agencies have tried to address the latter issues and bring greater attention to implementation by requiring "technology transfer" elements in every project, but we find that this has been less successful than the agencies had hoped. One reason is that the assessments are often done as an add-on to a technology development or field test, often by the same staff members who developed the technology or test. But experts in science, engineering and technology are not necessarily expert in economics, policy design, planning, public support, and implementation, which are all social science fields of inquiry. We should not expect that our technical experts will excel at market studies, policy analyses, or social, economic, and environmental assessments any more than the marketing and public policy department of a technology firm would be expected to do engineering and technology development. Investments in social science research are what are needed, especially in the form of independent assessments conducted in consultation with technology developers. Such efforts could help us match technologies to markets, improve the research selection process, and speed up implementation of research findings when such implementation is warranted.

University Transportation Centers: Research and Human Resources

Since the late 1980s the Federal Government has devoted a portion of its funding for transportation to university transportation research centers. Originally the federal program funded ten centers, one per federal region, with center designation determined through a competitive process involving peer review of proposals. In the ensuing years, Congress has expanded the program several times, naming additional centers but also requiring that after an initial funding period, most centers must compete for continued designation. Currently there are sixty centers, with 20 selected through competitive reviews and 40 named in SAFETEA–LU. Centers fall under several classifications with differing funding levels. Most centers are required to secure a dollar-for-dollar "match" for federal funds, and state DOTs and other local transportation agencies are commonly called upon to provide this match. USDOT's Research and Innovative Technology Administration (RITA) manages the program with a small but highly effective staff.

All of the UTCs conduct research. The UTCs also support university transportation degree programs and offer continuing education, conferences, and symposia to help practitioners stay abreast of new methods and findings. However, the UTCs are a varied group, ranging from top-ranked research universities to smaller regional or local universities oriented principally toward education and training. The UTCs' emphases and work products likewise vary.

Most UTCs carry out a mixed portfolio of research projects, ranging from basic, exploratory research to highly applied projects. Each center has a strategic plan that outlines the areas in which it will concentrate. Most centers also refer researchers to the USDOT strategic plan and similar documents that identify research needs and project ideas. For most UTCs, however, the required "match" has a strong influence on the projects selected, since State and local agencies often will fund only those projects that they view as meeting their pressing, short-term information and training needs.

California UTCs have been somewhat of an exception. California UTCs have had the benefit of a generous match guarantee since the start of the UTC program, with Caltrans staff participating in peer review of research proposals but not directing research selection. Most other centers have had less flexible arrangements and as a result do a higher share of short-term, applied projects than the California UTCs.

California has had the ability to provide the UTCs this match and allow them this flexibility because of the size of its transportation program. However, with five UTCs now designated in the state and an increasingly constrained transportation budget, the UTCs have become a significant part of Caltrans' research expenditures and Caltrans is feeling the squeeze on its funding. Smaller states are even harder pressed for research funds and UTC match can eat up a large chunk of available funds. Under these circumstances, the states understandably want to see their funds used to meet their current need and are less interested in longer-term, riskier research. Some are also concerned that the growth of the UTC program amounts to de facto "earmarking" of State research funds that the they would otherwise use at their own discretion.

The pressure for UTCs to show short-term payoffs in ways that are relevant to current agency problems is substantial. Yet long-term, researcher-initiated studies can pay off immensely. Since the start of the UTC program, California UTC researchers have carried out investigations on such topics as strategies for greenhouse gas reduction, new fuels and new vehicle technologies, measurement and control of particulate emissions from trucks, freight logistics, management of traffic to and from ports, congestion pricing, parking pricing, land use-transportation coordination, outcome-oriented performance measures, and collaborative strategic planning processes (to name just a few of the topics studied). Much of this work was initiated well before there were federal or State transportation policies or research programs on such matters. One result of this investment in long-term, exploratory research—research that was NOT clearly tied to existing public policies and programs—is that the research itself has helped identify new ideas and directions. It has given California a strong evidentiary basis for action and has inspired new State legislation and new agency programs. As a result, California is now positioned to lead implementation efforts in key policy arenas that now are attracting national attention. The research might have been risky, but it has given us a distinct advantage in information and know-how.

At the same time, the UTC program has produced literally thousands of graduates in transportation, at least some of whom would not have entered the field had UTC-funded fellowships and research appointments not been available. Many of the graduates from early days are now in positions of leadership and are helping to reshape transportation policy and practice. This cadre of young transportation profes-

sionals is an important product of every UTC program and their accomplishments are a key measure of the program's productivity.

Indeed, a major way that UTCs disseminate research results—their own, and others'—is to train graduate students, who then enter the field armed with the latest methods and findings which they then introduce into their workplaces.

The consequences of the proposal to change the UTC match ratio from 50–50 to 80–20 will depend on the specifics of implementation. If the lowered match requirement is combined with a cap on federal funding for the UTC program at or near existing levels, and the number of UTCs stays the same or expands, both graduate student support and UTC research output is likely to decline. The UTC projects that do get funded are likely to be framed in longer-term, bigger picture terms, and while riskier, more of these projects may be of lasting consequence. In other words, less State funding may mean less pressure for short-term applications. However, there will of necessity be fewer projects, fewer graduate students supported, and as a result, a lower level of infusion of new knowledge into the profession. Not all UTCs will suffer, of course; the UTCs most successful at attracting funds from the private sector and foundations will refocus their efforts. Other UTCs will have to contract, and issues of public rather than private interest might receive less attention than they do today.

Of course, states could choose to continue a research program much as the one they are now funding through the UTCs, with consultants as well as universities able to compete for the available funds. Competing for these funds would allow UTCs to offset some of the reduced match "hit" on UTC funding levels.

If on the other hand Congress boosts the program funding to maintain or increase the funds available to the UTC program, while reducing non-federal match, a greater focus on national objectives and on longer-term innovation in research could be possible.

Congressional decisions on whether to designate more UTCs or endorse competition and peer review also will affect the quality and the scope of the UTC program. Research universities have concluded, based on the evidence, that competition and peer review are the best ways to produce quality results. However, in the UTC program it also is evident that earmarks have allowed some universities to develop transportation programs that have successfully competed for funds in later rounds. Building in an expectation of competition for all centers after an initial period of designated support appears to work reasonably well.

Finally, multiple year grants are important because they provide the predictability that enables graduate programs and research programs to mesh well. Sudden shifts in funding levels and expectations for match could cause significant disruptions to graduate programs, as could delays in reauthorization. Continuing the program as it stands for at least a year (rather than shorter periods that don't match grant cycles) is a preferable option to the difficult short-term continuations we experienced before SAFETEA–LU was enacted.

Coordination of Research Initiatives

Practitioners and policy-makers often ask how we coordinate research programs funded variously by the USDOT, other federal agencies, the states, foundations and other nonprofits, and the private sector. The USDOT's Research and Innovative Technology Administration (RITA) has provided leadership in this regard. The USDOT's strategic plan provides a framework for priority-setting in research, and USDOT and RITA help insure that there is a basic level of information on DOT activities both by making information on the department's research initiatives available on the web and by organizing and by reporting on collaborations with other departments of the Federal Government (*http://www.rita.dot.gov/about_rita/*). Online publication of research results and abstracts in journals and on university websites and academic/practitioner conferences such as the annual Transportation Research Board meeting are also important ways to share information.

However, there is more to be done. Compared to the EU and other economically advanced countries, the USDOT's strategic plan is narrowly framed; for example, there is no clear mention of global warming or many other environmental issues, and such matters as transportation's role in economic development, in social equity, and in quality of life are not given much attention. Further, the scope of the USDOT's collaborations with other federal agencies is quite limited and appears to be narrower in some cases than Congress apparently contemplated (e.g., in the Congressionally-requested Transportation Environmental Research Program, which was recommended as a collaboration with other agencies, states, and the private sector, but was instead instituted as a program within FHWA). U.S. research, development, and implementation practices also are narrower than those of other countries such as Canada, Australia, or the UK, where strong linkages have been forged among

transportation, housing, and economic development planning, and among water, waste disposal, communications and transportation infrastructure investments.

A big worry for many public agencies is that research will be duplicative. However, a distinction needs to be made between intentional replication and unintentional duplication. Research is often replicated intentionally, or conducted with a series of test conditions, to determine whether the results are robust and generalizable, and not just a fluke or limited to a specific case. Such replication is highly desirable because it reduces risk and builds confidence in research findings. On the other hand, research is published in journals so that other researchers can discover and evaluate what has been found in previous studies, and avoid unintentional duplication. If the latter occurs, the researcher has not done his or her job well—it is this sort of uninformed duplication that should be avoided.

University researchers are evaluated by their peers not only on the quantity they produce but also on the intellectual content of the products, asking what's new and innovative, what new insights were generated, what linkages were identified that were previously overlooked, what changed in research directions or in theory, method, policy, or practice as a result of the work. These are outcome measures.

In contrast, many transportation agencies evaluate the research they fund only on output measures (e.g., the main evaluation criteria are whether required products were produced on time and on budget, not whether the projects produced new knowledge, altered practice, or improved conditions). The same is true, of course, for most on-the-ground transportation projects: they are evaluated on design compliance and whether they are on time or on budget much more often than they are graded on whether they actually improved services, the economy, or quality of life. Changing evaluation expectations from output-focused to outcome-focused could significantly improve the results for all of us, in both spheres of activity.

One of the problems with evaluating based on outcomes is that if negative outcomes automatically mean failure, embarrassment, and potential job loss, no one will want to admit to a negative outcome. Yet we know that most new products never reach market and only a fraction of those that do are true successes. The private sector knows this, and so does academia: ideas that are proven wrong and proposals that fail are nevertheless valuable products for researchers. "Failed" research efforts can lay the foundation for future research, push it in new directions, suggest alternative applications for the failed product, and highlight challenges to innovation. These are valuable lessons, not embarrassments (Zhang and Sternberg, 2006).

Creating an environment where risks can be taken, failures assessed fairly, and rewards given when due has been hard for the public sector. This may be a reason to rely more on private sector organizations and to give academics more independence, and more responsibility, for R&D. Risks and responsibilities are also reasons to promote competition and peer review; it shares the risk and responsibility for both research initiation and research evaluation among a number of experts.

Implications: Improving Technology Transfer and Incorporating Research Findings into Transportation Investment Policy

Our research speaks to the need to complement technological R&D with research and development in the fields of economics and finance, markets and consumers, law and institutions, planning and policy-making. This is true with regard not only to the latest ITS technologies but more generally to all investments in transportation and other infrastructure.

A new USDOT strategic plan may be a way to organize these efforts. Work conducted last year as part of a study on how to respond more effectively to California's growth proposed the establishment of a new strategic planning process whose goals would be faster and more cost-effective delivery of infrastructure, better management of existing facilities and services, better value for money invested, greater accountability to customers, and the possibility of attracting private capital for infrastructure projects (Dowall and Reid, 2008). The strategic planning process would be focused on outcome-oriented measures such as quality of service and how they are valued by customers rather than on inputs, e.g., how to allocate categories of funds. The process would involve creating a vision of the future and the investments needed to attain that future; evaluating a broad set of alternatives including both capital projects and "soft" investments such as regulation or pricing in deciding what infrastructure is needed; determining the best way to deliver needed projects—direct public or private provision, contracting, partnerships; and providing technical assistance to State agencies and local governments ranging from opportunities for bundling demand to information on best practices. Linkages modes (air, rail, highway . . .) and across fields (transportation, energy, housing, agricultural lands, environmental quality . . .) would be made explicit and tradeoffs examined. Priorities for investment would be identified.

Such a process, which is being pioneered in several Canadian provinces as well as in a few U.S. states, could not only improve transportation investments but could help governments determine how to allocate scarce resources more effectively. State plans of similar scope are being developed and could greatly improve State and local priority setting, investment decision-making, and partnership opportunities.

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BIOGRAPHY FOR ELIZABETH DEAKIN

Elizabeth Deakin is Professor of City and Regional Planning at UC–Berkeley, where she also is an affiliated faculty member of the Energy and Resources Group and the Master of Urban Design group. She is completing her second five-year term as Director of the UC Transportation Center this spring. She formerly served as Co-Director of UC–Berkeley's new Global Metropolitan Studies Initiative, which involves nearly 70 faculty members from 12 departments. Before heading up UCTC, she was Acting Director of the UC Institute of Urban and Regional Development.

Deakin's research focuses on transportation and land use policy, the environmental impacts of transportation, and equity in transportation. She has published over 200 articles, book chapters, and reports on topics ranging from environmental justice to transportation pricing to development exactions and impact fees. She currently is carrying out research on sustainable development policy in China, Latin America, the EU, and the U.S., with funding from the China Energy Foundation, the World Bank, the World Resources Institute, the USDOT, and Caltrans.

Deakin has been appointed to a number of government posts including city and county commissions and State advisory boards. She has taught courses at universities in Australia, Germany, Sweden, France, and China and has served as an adviser to the Organization for Economic Cooperation and Development, the European Council of Ministers of Transport, the World Bank, and MISTRA (the Swedish sustainable development foundation). She chaired the NAS/TRB committee mandated by Congress on transportation environmental research.

Deakin holds degrees in political science and transportation systems analysis from MIT as well as a law degree from Boston College.

Chair WU. Thank you very much, Dr. Deakin.

Mr. Saenz, please proceed.

STATEMENT OF MR. AMADEO SAENZ, JR., EXECUTIVE DIRECTOR, TEXAS DEPARTMENT OF TRANSPORTATION

Mr. SAENZ. Good morning. Chair Wu, Members of the Science and Technology Committee, thank you very much for the opportunity to participate in this hearing. My name is Amadeo Saenz. I am the Executive Director of the Texas Department of Transportation (TxDOT). Today I would like to accomplish several things with my testimony.

First, I would like to give you a State perspective on federal research investment. I would also like to talk about the barriers that we face, some of the stakeholder involvement in transportation research and development, and finally, I would like to list some possible improvements that could make research and development more helpful.

Federal investment in transportation research and development is invaluable to the State DOTs. Because of the federal research we now have high-performance concrete, high-performance steel, and accelerated bridge construction methods. In Texas our highways are based on design criteria developed through the national—through national research.

We now use cable barrier systems developed through the National Cooperative Highway Research Program. These barriers have reduced crash severity in our highways, and this translates to countless lives saved. We installed, as part of a safety program, over 400 miles of cable barrier two years ago. We went back to evaluate those particular highways, and we saw that we were able to save 18 lives over that one year and 26 serious accidents from what it was prior. So measuring what you do and what you put in place is very important.

The Strategic Highway Research Program Concrete and Structures Initiative is another federal program we found to be very beneficial. The Texas Loretta Road Overpass in Houston was the first project in the country to use high-performance concrete throughout the bridge. The use of high-performance concrete has allowed us to realize tremendous savings and efficiency in the construction of our bridge structures across the state. So far we think we estimate and we save about $10 to $20 million a year in bridge construction.

In 2002, to demonstrate the impact of that research and development has on Texas, on the Texas transportation system safety and cost effectiveness, Texas DOT performed an analysis of 21 of over 200 improved technologies that had been developed through our research program. A benefit period of ten years was used to determine what kind of returns we were going to get, and the findings showed that the products provided a net return of our investment of over five to one. We currently have the Texas Transportation Institute updating our report because we now have more data on it, and preliminary indications are that the original five to one investment is still a good number.

These are just a few samples of the benefits that we have been able to realize from the transportation research and development, but like with every other government program there are some barriers. The competing challenges of relentless congestion, lack of adequate funds, and the need to move people and goods across towns, across the—and across the country with really—I am sorry. Excuse me. The competing challenges of relentless congestion, lack of adequate funds, and the need to move people and goods across town and across the country demand that we generate answers very quickly. We need to anticipate future needs and begin research today to address those needs.

One of the largest barriers to overcome in research and development is to overcome the institutional inertia and resistance to change. When we entered these new specifications, new standards, or construction techniques, we saw that there is contractor resistance, and there are also cost increases because of the unknown. There are implementing—therefore, implementing research becomes difficult due to staffing and funding shortages. And with the uncertain economy that we have today, the State resources are

stretched just by maintaining our existing systems, and sometimes research has to take a back seat.

At TxDOT all levels of employees are involved in the research and development program. For example, we have set in place research management committees. These committees are made up of key administrative and key lead people, district engineers, that work hand in hand with researchers who have the technical expertise in the different areas. This committee has established the priorities and selects the research that is to be conducted. We have more employees involved in each of the projects from within the Department to ensure that they work hand in hand with the researchers, to ensure that everything stays on track and will result in information that TxDOT can use as part of the research program.

In addition, the Department has also seen very important to set aside money to be able to implement some of the research findings that come out of our research program, and we put in place a $5 million a year budget amount to be able to address, to implement these new technologies that come out of our research program.

The Federal Government can help states, counties, and cities with the use of the newest technologies in several ways. One, first you need to understand what the needs of our states are and what the needs of our local communities are. Information, guidance requirements developed at the national level should be provided in a ready-to-use format and in an understandable language.

And we must also form partnerships between the federal, State—federal and State DOTs to maximize and share all of our information, our assets, and expertise. We need to all work together instead of all working separately and independently and reinventing the wheel every time.

Partnership is a major focus for us in Texas. We believe that only through partnership and coordination we will be able to meet our mission, and the same level of coordination and focus would be helpful in all federal research programs.

As Congress looks to reauthorize the Nation's Surface Transportation Program and the research that underpins it, there are some simple but important changes that would reenergize the research and would cost little or nothing, little or very little to put in place. Not since President Eisenhower have we had a national plan for infrastructure, and if I have to guess, Congress is starting to think that we need to have a new national plan. Our national plan should not only be for highways, it should also include all modes of transportation, whether it is mass transit, high-speed rail, freight rail, aviation, and ports. We have to measure how well we succeed or how much—by how much we have missed our goals. We will need to move into measuring real congestion relief, lasting cleaner impacts, safety improvements, and sustainable maintenance programs. That way we know whether we got what we expected from our research program.

If Congress is serious about making us perform, then a well-organized research program can get us there. Congress should set our goals and then the states and the Federal Government should work in partnership to define what and how we measure our success. We need to avoid developing systems independent of each other as I

mentioned because this leads to additional cost. A nationally-coordinated approach worked well for mapping the Genome Project, and it can certainly help us in advancing our research program and the development of transportation systems.

Mr. Chair, thank you for allowing me to provide this testimony. I look forward to your questions and will be happy to answer them.

[The prepared statement of Mr. Saenz follows:]

PREPARED STATEMENT OF AMADEO SAENZ, JR.

Introduction

This testimony will provide the Committee on Science and Technology with the State of Texas perspective on the federal research investment, barriers we face, and stakeholder involvement in transportation research and development. It will also address the impact to states and possible improvements that might make the entire R&D endeavor more useful.

At TxDOT we strive to be a progressive State transportation agency that provides safe, cost-effective, efficient, environmentally sensitive and aesthetically appealing transportation systems to the citizens of Texas.

Federal Investment

The federal investment in research and development has impacted transportation practices and investments in many positive ways. First, the federally funded national programs are the basis for the development of national, State and local operating processes, standards and specifications. These programs consolidate information and experience from around the United States and produce usable documentations for new methods. They also obtain results that might otherwise take individual states decades to complete. Federal research and development has brought the transportation industry high performance concrete, high performance steel and accelerated bridge construction, which have significantly improved the efficiency and the durability of bridges. These, of course, are not the only examples.

In Texas, the safety devices along all of our highways are based on design criteria developed through national research. For example, the National Cooperative Highway Research Program (NCHRP) Report 350, *"Recommended Procedures for the Safety Performance Evaluation of Highway Features,"* has been used for selecting cable barrier systems. The installation of these barriers on Texas highways has dramatically reduced crash severity and saved several lives. NCHRP projects have helped TxDOT in other programs as well, like the repair of prematurely failing modular joints on bridges. If these systems are poorly designed, specified or installed, which had happened previously due to a lack of national specifications, they can under-perform and result in costly bridge damage and premature replacement.

NCHRP has assisted Texas in many ways. It helps us provide secure highway and bridge infrastructure by presenting the results and findings that enable transportation professionals to deal with emergency preparedness functions. The NCHRP reports also help TxDOT identify and quantify environmental impacts in the earliest phases of project planning, making that complex process more effective and avoiding costly changes later. The research associated with new regulatory requirements can address lawsuit findings and help facilitate more efficient and effective environmental clearance and improve project delivery.

Another great federal program example is the Strategic Highway Research Program (SHRP) Concrete and Structures initiative, which promoted the interchange of ideas and information among representatives of Federal, State and local government agencies; the construction industry; and the academic community, an effort which provided High Performance Concrete (HPC). The Texas Louetta Road Overpass in Houston was underway and was the first highway bridge construction project in the United States to use HPC throughout the bridge.

Additional benefits from SHRP continue today. The current Superpave asphalt binder specifications that the Nation uses today were developed through the initial SHRP. For example, Expert Task Groups, or ETGs, for binders and mixtures that were originally organized for implementing Superpave still function to research changes needed in testing and specifications that were not adequately addressed during the original funding for SHRP. The FHWA formed a working group for the implementation of the Mechanistic Empirical Pavement Design Guide that is being developed to replace the existing American Association of State Highway and Transportation Officials (AASHTO) design guides. The end product should improve the ac-

curacy and reliability of pavement design in the United States. An ETG for pavement models was organized to evaluate prediction models including fundamental properties to predict pavement performance. This Long-Term Pavement Performance project was used to develop the new pavement design guide and provided several valuable lessons from the Special Pavement Sections. FHWA also uses ETGs to evaluate the measurement of pavement performance characteristics such as smoothness, rutting and cracking with goals to standardize the practices of calibration and data collection.

TxDOT has built a very robust research program funded through the federal State Planning and Research Program involving many of the Texas universities. We perform research in areas such as pavements, materials, construction, planning, environment, right of way, public transportation, operations, safety, hydraulics and structures. Some of our recently completed research projects are:

- **The Role of Preferential Treatment for Carpools in Managed Lane Facilities,** which involved a review of carpool preferences on managed and tolled lanes; a stated-preference survey of HOV lane users with respect to carpool preferences relative to price; development of a predictive demand model; and an assessment of mobility, revenue and environmental impacts.
- **Impacts of Current and Future Demographic Trends on Transportation Planning in Texas.** One of the deliverables from this project was a *One-Stop Demographic Data Analysis Tool,* which will provide a starting point for reporting and comparing demographic characteristics of selected areas for transportation professionals.
- **Synthesis Study of Programs Used to Reduce the Need for Inspection Personnel.** TxDOT is looking for more effective ways to manage the workload involved in construction project testing and inspection. This project identified strategies that could help TxDOT do this while maintaining quality.
- **Development of An Advanced Overlay Design System Incorporating Both Rutting and Reflection Cracking Requirements.** TxDOT spends millions of dollars each year designing and placing overlay on its existing highways. The tools developed in this study will assist TxDOT engineers in designing and implementing longer lasting overlays. The software can address issues such as where to use high-performance mixes and optimal thicknesses, particularly in the area of jointed concrete pavements where joints must be repaired prior to placing any overlay.

A January 2003 TxDOT report titled *"The Value of Texas Transportation Research"* stated the following:

> "To demonstrate the impact that research has on transportation system safety and cost effectiveness, 21 improved technologies and methods produced by TxDOT's research program were selected from a three-year period, 1999 through 2001. The selected products are considered to be among the best of over 200 beneficial initiatives implemented from those three years of the research program. A benefit period of ten years was used for determining the returns from the selected research program products. This is a conservative assumption, since many benefits never become truly obsolete as newer technology is layered on earlier innovation."
>
> "The estimated ten-year cost savings in department operations, stemming from these 21 research products, are more than $322 million. The research program budget total for fiscal years 1999, 2000, and 2001 was approximately $54 million (less than 0.4 percent of the department's budget). The total operational cost savings derived from these 21 products exceed the cost of the research program by approximately $268 million. This is a net return on investment ratio of 5:1, without considering the value of the numerous other products implemented from that three-year period of the research program."

This report is currently being updated by the Texas Transportation Institute. However, preliminary indications are that the original findings remain valid.

Research and Development Barriers

The competing challenges of relentless congestion, lack of adequate funds and the need to move people and goods across town and across the country demand that we generate answers quickly. In some instances, we need the answers today—so we cannot wait on a research question to be posed with answers to be presented two years down the road. The public expects the best transportation system at the lowest cost, and research facilitates this but we have to do a better job of anticipating

our questions and issues. We must begin research now so we have the answers available when tomorrow comes.

A key barrier we have to overcome is institutional inertia and resistance to change based on rational aversion to risk. Contractors in Texas, as in other states, are used to standards and consistency, so when we introduce new specifications, standards or construction techniques, resistance and cost increase is certain. Another barrier to implementing research is quite simply staffing and funding shortages. As you know, there is a cost to implementation and changeover to a new technology. With reduced budgets today and our uncertain economy, our resources are already stretched in our ability to just maintain our existing systems.

Some other barriers include failure to get useful information to decision-makers, reluctance by some to embrace advanced technologies (perhaps due to lack of understanding), lack of clarity or understanding of potential benefits, and unavailability of specifications. Some research outcomes may have to be validated by environmental regulatory agencies and go through rule making by multiple regulatory agencies before being implemented (for example, alternative mitigation strategies that research has shown to be superior to earlier practice). This barrier is exasperated by the chronic shortage of staff in the federal regulatory agencies.

Proprietary issues continue to hinder implementation. Frequently, successful research must be converted to hardware, software or new materials by vendors before it can actually be effectively used. Sometimes we must wait to implement a research result until we have enough vendors for competitive bidding. Manufacturers are often reluctant to add new features or applications that resulted from research. Another potential obstacle is that there must be agreement on the limits of the use of data available from the new technology (i.e., electronic tolling).

The Federal Government can help states, counties and cities use the newest available technologies in several ways. First, there must be an understanding at the federal level of State and local issues and needs. It's a long way from Washington, D.C. to Austin, Texas, and things can get lost in translation. Information, guidance and requirements developed at the national level should be based, where necessary, on sound research. This information should then be provided in clear, "ready to use" format and language. Distributing reports that are unread and put on the shelf or stored on the Internet is not the answer. Research results need to be communicated at all levels. Professionals and first-tier government decision-makers must share the details of research results and agree on standard processes and methods; i.e., safety related road design, clearance zones and access management. Transportation department regional and discipline specialist leaders must agree with local leaders on the value of, and the resources for, implementing research results; i.e., real-time monitoring at Traffic Management Centers. Senior transportation leaders and elected or appointed officials must ask for and then implement research on major requirements; i.e., alternative funding methods, linking planning with the *National Environmental Policy Act,* global warming and greenhouse gases. The Federal Government can assist in developing specifications and standards. Perhaps funding more demonstration projects highlighting technologies with potential big pay-off could also help.

At TxDOT, we have made some changes in policy to assist in overcoming some of these barriers. For example, deliverables required on some TxDOT research projects include a specification, standard, or "manual pages" in the proper format ready to insert into our documents. This makes it easier and quicker to implement the results. Some research project results are such that a formal implementation project is developed. An implementation project is typically triggered by the need for specific funding to help integrate a product, new method or process, or innovation into department operations. Examples include:

- The incremental cost for the first use of a product or innovation in construction or maintenance operations.
- The purchase of newly developed equipment for use in the field.
- Training of field personnel in the use of new equipment or methods.

Training is also a significant tool for ensuring that planning and construction use the newest available technologies. Universities must also maintain strong research programs to attract high quality students to continue graduate level study. Continuing research progress must be matched with money, resources and materials to understand and implement new technologies. Basic and continuing education and technical skills training at multiple levels is needed equitably across the country. In Texas, for example, over 300 department employees have been trained in the past 18 months on research project specific best practices and implementations. Topic areas include Wireline Communication Design, PASSER V Signal Optimization, Dy-

namic Message Signs, Managed Lanes, Measuring Access to Public Transportation, Procedures for Setting Curve Advisory Speeds and Spall Repair.

Recently, the research project on Transversely Varying Asphalt Rates has been added as a course that will be available to the department employees in March 2009. We have also partnered with the National Highway Institute and the Transportation Curriculum Coordinating Committee (TCCC) to place all new TCCC Web-based training on the department's Learning Content Management System. This allows immediate access to these new courses in a secure environment for department employees. We are involved with the Texas Pavement Preservation Center, a collaborative association with the department, Center for Transportation Research, the Texas Transportation Institute and private industry, and have developed a series of training courses that are delivered on an established schedule to department employees and private industry. Over 400 employees have been trained on best practices in asphalt preservation methodology and design in the past 15 months.

The department is a firm believer in the use of technology not only in application in the design, build and maintenance of roadways, but also in the delivery of training and access of the latest cutting-edge technologies for its employees. The department has an extensive video teleconferencing system that has been in place since 2002. In FY08 alone, TxDOT used over 8,700 hours of connectivity to delivery training. TxDOT's Learning Content Management System now hosts over 400 course titles and is used by every employee for a variety of courses and access to resources. The Local Technical Assistance Program (LTAP) is also a valuable program for assisting cities and counties with technical issues and training. Some of the specifics of the LTAP in Texas include:

- Distributing technology transfer materials (videos, CDs and publications) to local government officials upon request.
- Providing technical information, advice and guidance upon request of local agencies.
- Conducting or arranging seminars or training courses including Bridge Maintenance, Road Maintenance, Culverts and Drainage, Vegetation Control/Herbicide Use and Using a Motorgrader to Shape Gravel Roads.

Stakeholder Involvement

Lastly, we believe the current level of stakeholder involvement in determining DOT RD&T priorities at the federal level is sufficient but needs improvement. The stakeholders included at the federal level, for example, are FHWA, RITA, TRB, State DOTs, local agencies, highway industry and highway users. But sheer volume does not necessarily mean that the programs and priorities are well coordinated and focused. As a result, we have unnecessary duplication, significant research gaps and increased difficulty in sharing results that can be used across the country. The challenge is big. All 50 states are conducting their own research. In addition, RITA, TRB and the FHWA have numerous research programs (for example, NCHRP, SHRP 2, and STEP). Some possibilities for improvement include:

- Defining the roles and "boundaries" of the various programs more clearly. It should be much clearer at the federal level how the "pieces of the puzzle" fit together. For example, how does the research conducted by RITA relate to the research conducted by FHWA? Is there duplication? Are there gaps? How and where does one see how this "puzzle" fits together?
- The goals and focus areas of the multitude of research programs at the federal level should be clearly and succinctly outlined, put in the same format for easy comparison and kept current in one electronic document. In essence, "What is everyone doing and where do I find it?"
- Focus the coordination efforts so that the right stakeholders are involved in the right programs. More importantly, ensure that the "products" resulting from these stakeholder meetings and interactions are specific, meaningful and measurable. Too often, many groups at all levels meet to develop research agendas. The problem occurs when there is no accountability and no follow-up.

The National Vision and Transportation Research

As Congress looks to reauthorize the Nation's surface transportation program and the research that underpins it, some simple but important changes would not only re-energize that research but would cost little or nothing to do.

As we look forward to the 2009 authorization cycle, Congress should define a national strategy and provide the policy framework that empowers states and regions

to set goals, make decisions and deliver projects that implement the national strategy. Not since President Eisenhower have we had a national plan for infrastructure, and if I had to guess, Congress is starting to we think should have one, too.

Our national plan should not only be for highways. It must include all modes of transportation: mass transit, high-speed rail, freight rail, aviation and ports. Congress should enact consumer-focused legislation and recognize that Americans expect congestion relief, cleaner air, improved economic opportunity, well maintained roads and increased safety.

And we're going to have to measure how well we have succeeded, or occasionally, how spectacularly we have failed. In the stimulus legislation that's presently under consideration, a good portion of the discussion is on measuring results. Right now it tends to be about the number of jobs created, which is good, but we're going to need to move into measuring real congestion relief, lasting clean air impacts, safety improvements and sustainable maintenance programs. That way we can know if we get what we expected to get out of our transportation investments, a level of thinking that is absent these days.

The national research program to some degree mimics the transportation plan we have today. There's little central coordination or vision, everyone's off doing their own thing with inadequate funding and we generally do nothing more than follow processes. When we spend a federal dollar, the question we're asked isn't "Did you relieve congestion?" but rather "Did you follow all of the processes?" If we happened to actually accomplish something, then we got lucky.

If Congress is serious about making us perform (and I hope it is), then a well organized national research program can get us there. It can define what we measure and how to best measure it. I think it could also develop the software to do it so we we're not all developing systems independent of each other at a tremendous cost or buying it from different vendors at an equally high cost.

A nationally coordinated approach worked for mapping the human genome project, and it can work for mapping the next advances in our transportation system.

BIOGRAPHY FOR AMADEO SAENZ, JR.

Amadeo Saenz Jr., P.E., is Executive Director of the Texas Department of Transportation (TxDOT). Under Texas Transportation Commission direction, he manages, directs, and implements TxDOT policies, programs, and operating strategies. He represents TxDOT before the Texas Legislature, the United States Congress and other entities. He was appointed as Executive Director of TxDOT in 2007. Mr. Saenz is a trailblazer in transportation and was the first Hispanic to hold this position in the agency's 90-year history.

After earning a Bachelor of Science degree in civil engineering (with honors) at the University of Texas at Austin, Mr. Saenz joined TxDOT in 1978 in the Pharr District as an engineering laboratory assistant. As a TxDOT employee he succeeded through various positions to learn the agency and transportation from beginning to end.

He was named district engineer in the Pharr District in 1993 and held this position until 2001 when he was appointed as Assistant Executive Director for Engineering Operations in Austin. In this role, he implemented and managed TxDOT's engineering operations policies, programs and operating strategies according to federal and State laws and Texas Transportation Commission regulations and directives.

A native of Hebbronville, Texas, Saenz is a past member of the Rotary Club and was active with the Boy Scouts. He served on the Civil Engineering External Advisory Committee for the University of Texas at Austin. He owns and operates a small cattle ranch in South Texas, where he enjoys horseback riding and hunting. Mr. Saenz and his wife, Geraldine, have two children, Priscilla Marie and David Aaron.

Chair WU. Thank you very much, Mr. Saenz.

Mr. Skinner, please proceed.

STATEMENT OF MR. ROBERT E. SKINNER, JR., EXECUTIVE DIRECTOR, TRANSPORTATION RESEARCH BOARD OF THE NATIONAL ACADEMIES

Mr. SKINNER. Good morning, Mr. Chair and Members of the Committee. My name is Robert Skinner, and I am the Executive Director of the Transportation Research Board (TRB) of the Na-

tional Academies. My testimony this morning is based upon the work of expert committees appointed by the National Academies to carry out projects for the Federal Highway Administration's (FHWA) Research and Technology Programs and for the Research and Innovative Technology Administration (RITA). I emphasize highway research programs in my testimony, but most of the lessons drawn are applicable and transferable to research in other modes.

The administration of our highway system is incredibly decentralized with tens of thousands of states and local governments owning pieces of the system. Even though the Federal Government owns and operates relatively few highways, it plays a crucial role in research and the innovation process. The Federal Government funds about two-thirds of the total Highway Research and Technology Program, enables training and technology transfer activities, and is the sole source of funding for higher-risk, potentially higher-payoff research.

Now let me turn to the questions provided in advance and highlight some of the points that are made in my written testimony. The first question referred to R&D priorities, alignment with stakeholders, and changing priorities. The TRB committee that reviewed RITA's first five-year DOT-wide strategic plan identified several constraints on having a truly strategic plan.

The research title of SAFETEA–LU (*Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users*) contains numerous, narrowly-defined designations, and many R&D activities are earmarked to specific recipients. As a practical matter, most of the needed research identified by stakeholders is mode-specific in character. Finally, the ability for USDOT to direct or control research programs from a top-down perspective is in a natural tension with efforts of the modal administrations to be responsive with stakeholders.

Given the decentralized administration of the system, responsiveness to stakeholder needs and perspectives is crucial. FHWA may have the most extensive interactions with stakeholders of the modal administrations but even it could be doing more.

Regarding changing priorities, the research proposals for reauthorization that the TRB Executive Committee looked at last spring did not adequately recognize the growing importance of reducing transportation greenhouse gas emissions and energy consumption. TRB now has a study underway that will make recommendations before SAFETEA–LU expires regarding research on climate change mitigation and adaptation.

The second question concerns improvements to transportation R&D investment structure. In concept, the portfolio of programs funded through SAFETEA–LU is appropriate, but the program, as authorized, is far more detailed than necessary. Compare that to NSF (National Science Foundation), which has a budget that is 10 to 15 times greater with fewer line items.

Other weaknesses in the structure include: too small a share of the funding is devoted to advanced or longer-term, higher-risk research; policy research is neglected; there is too little emphasis on data collection; and inadequate attention to technology transfer.

The third question, in fact, addresses improvements to the technology transfer programs. FHWA provides extensive information about new technologies and practices, administers the Local Technical Assistance Program (LTAP), and offers training on new technologies and practices. These activities, however, are not sufficient to fully overcome the significant barriers to innovation that exist.

Our recently-released report on implementing the results from the Strategic Highway Research Program (SHRP) provides a model of what is required to assist the states in deploying new technologies and practices. For SHRP products the committee recommends a large-scale implementation effort totaling $400 million over six years. It would be guided by a formal stakeholder advisory committee and detailed, publicly-available implementation plans.

The final question asked about lessons learned from the last reauthorization, excuse me, the final question asked about lessons learned from the last reauthorization of Surface Transportation Programs. The principles for research articulated in the preamble to Title V are good ones, and I hope they will be retained, and more importantly, followed. They encourage stakeholder involvement, competitive award of funding based upon merit review, advanced research, and a federal program that spans the entire innovation process.

Along with fewer, more-broadly defined line items, adherence to these principles would restore funding to policy and other core missions, including enhanced technology transfer, and provide flexibility needed to respond to changing needs. Specific recommendations based on our assessment of SAFETEA–LU's Title V are included in my written testimony.

Thank you for this opportunity to appear before the Committee. I look forward to answering any questions you may have.

[The prepared statement of Mr. Skinner follows:]

PREPARED STATEMENT OF ROBERT E. SKINNER, JR.

INTRODUCTION

Good morning, Mr. Chairman and Members of the Committee. My name is Robert E. Skinner, Jr. I am the Executive Director of the Transportation Research Board (TRB) of the National Academies. 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.

From the 1920s until 1975, my organization was named the Highway Research Board. In 1975 the organization became multi-modal and was renamed the Transportation Research Board. TRB's mission is to promote innovation and progress in transportation through research. It is best known for its role in promoting innovation and information exchange by maintaining approximately 200 standing technical committees in all modes of transportation and hosting an Annual Meeting that attracts more than 10,000 participants from the United States and around the world. TRB also conducts policy studies for Congress and the executive branch, and is increasingly called upon to administer research programs for others that are stakeholder-directed and primarily award research funding based on competition and merit review by peers.

The testimony I will give today is based upon the work of expert committees, appointed by the NRC, and serving without compensation to carry out projects for the Federal Highway Administration's (FHWA) research and technology programs and the Research and Innovative Technology Administration (RITA). I have cited these

different reports throughout my testimony, and they are listed at the end of this document.

We also have committees at work reviewing the research programs of the Federal Railroad and Federal Transit Administrations, and TRB manages cooperative research programs for transit agencies and airports. I have not addressed these modes in my written testimony in any detail but will be happy to comment on these activities if requested. I emphasize highway research programs in my testimony, but most of the lessons drawn are applicable and transferable to research in other modes.

Importance of Highways

The American lifestyle is absolutely dependent on highway transportation. Americans use personal vehicles for 87 percent of daily trips and 90 percent of long distance trips. The decentralized U.S. economy would be unimaginable without the access that highways provide for motor carriers. Truck ton-miles represent about 30 percent of total ton-miles of freight; more importantly that tonnage accounts for nearly 75 percent of the value of freight shipped domestically.

With the fourth largest land area of any country, the United States is surely the most reliant upon roads and highways. The Nation has 8.4 million lane miles (3.2 million miles) of roads connecting metropolitan areas, towns, and counties across the country to serve its 300 million residents and seven million business establishments.

As valuable and important as highway transportation is, it also faces enormous challenges. For example, demand on the system increased sharply in recent years resulting in the congestion we have become all too familiar with. Total highway travel in personal vehicles, motorcycles, light and heavy trucks totals nearly three trillion miles annually. Total travel has leveled off in the last couple of years, but it increased 25 percent between 1997 and 2006. Not only is much of the highway system reaching or exceeding its expected service life, it is also carrying a much heavier burden than expected. The amount of traffic on rural Interstates more than doubled between 1970 and 2005, but the loadings placed on those highways, due largely to more trucks traveling more miles, increased six-fold during that period. The system is facing unprecedented challenges in overall demand, safety, the cost of paying for system preservation and operation, and environmental impact. Because there is not enough money to meet all these challenges, research and innovation is desperately needed. For example, we must learn how to reconstruct highways more efficiently at lower cost and do so while continuing to maintain service with minimal disruptions. We must also strive to meet ever-higher standards for providing capacity with minimal disruption to communities and the environment.

AN OVERVIEW OF U.S. HIGHWAY RESEARCH & TECHNOLOGY PROGRAMS

Decentralized Responsibilities

Highway research, like the management of the highway system itself, is highly decentralized, and appropriately so. 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, operation, and preservation of roads. Aside from the roads on federal lands, the Federal Government has little direct connection with the pressures of financing, building, maintaining, and operating roads. Doing so is a massive enterprise. Roughly $94 billion is spent every year on roads and highways.

Each state has its own highway research program, and states, in turn are providers of technology and innovation to cities, counties, and municipalities. States' R&T programs often provide the final step in implementing new technologies, and they must meet the particular needs of individual states' soil conditions, climate, and institutional arrangements. Pavement design itself, for example, is highly dependent upon local soil conditions, moisture levels, temperature ranges, and sources of local aggregate. Operational needs range widely between states with major metropolitan areas and states mostly made up of rural areas. State policy concerns about economic development, finance, environmental issues, and safety also vary considerably across states. State research programs support research initiatives in all these areas.

The existence of 52 programs might suggest that duplication would occur, but, in fact, states have a system of sharing resources in order to study topics of collective interest, and the states and federal transportation agencies, through TRB, maintain a database of completed research and research in progress, which states are required by FHWA to consult before initiating new projects. State highway research programs are mostly funded through federal aid. For decades, the federal aid title

of surface transportation authorization (Title I) has required states to spend a small percentage of federal aid on planning and research. (The State Planning and Research (SP&R) program currently sets aside two percent of selected highway program funding of which 25 percent must be spent on research.) States pool some of their resources in the National Cooperative Highway Research Program (NCHRP), which is managed by TRB on the states' behalf, as described in more detail below.

Federal Role

Even though the Federal Government has a minor role in owning and operating highways, it plays a virtually indispensable role in the research and innovation process. The Federal Government funds about two-thirds of total highway research and technology programs (Table 1), plays a critical role in training and technology transfer, and is the sole source of funding for higher-risk, potentially higher-pay off research.

The Federal Highway Administration (FHWA) is the principal agency managing highway research at USDOT. It has research activities in each of its mission-area responsibilities: infrastructure, operations, environment and planning, safety, and policy. Through its research and program office staff in these areas, FHWA interacts with experts and stakeholders in the public and private sectors to develop multi-year program plans for their research and development activities.

The Intelligent Transportation Systems (ITS) research program, initiated and formerly managed by FHWA, is now managed by the Research and Innovative Technology Administration (RITA). The ITS program is multi-modal, but most of the projects and funding are highway-related. In addition, the University Transportation Centers (UTCs) conduct highway research (generally with federal funding); this program is administered by RITA. The UTC program is multi-modal, but 69 percent of the projects in 2008 were focused on highway topics,[1] hence I have included it as part of the federal investment in highway research. Various private entities fund highway research, but their role is surprisingly small.[2] Because of the large public presence in roads and highways and the nature of public procurement of highway goods and services, there are relatively few opportunities for the private sector to capitalize on private research. Consequently, the share of private funding is small and the public responsibilities for encouraging innovation are large.

[1] *The Federal Investment in Highway Research 2006–2009: Strengths and Weaknesses,* Special Report 295, Transportation Research Board of the National Academies, Washington, D.C., 2008, p. 75.

[2] *Building Momentum for Change: Creating a Strategic Forum for Innovation in Highway Infrastructure,* Special Report 249, Transportation Research Board of the National Academies, Washington, D.C. 1996, p. 14–15. See also Chapter 6 of *Implementing the Results of the Second Strategic Highway Research Program: Saving Lives, Reducing Congestion, Improving Quality of Life,* Special Report 296, Transportation Research Board of the National Academies, Washington, D.C. 2009.

Table 1: National Highway Research, Development, and Technology Expenditures, 2006 ($000s)[3]

	Federal	State	Private	Total
FHWA				
Surface Transportation R&D	133,000			133,000
Training & Education	23,000			23,000
RITA				
University Transportation Centers	60,000			60,000
ITS program	96,400			96,400
States	165,800[a]	160,200		326,000
Strategic Highway Research Program 2	36,200[b]			36,200
Associations			25,000-50,000	25,000-50,000
Companies			50,000-100,000	50,000-100,000
Total	512,700	160,200	75,000-150,000[c]	747,700-822,700
Percentage	62-69%	19-21%	10-18%	100-100%

[a]State Planning & Research Funds, Title I of SAFETEA-LU.
[b]Funded from Title V 2005-2006 and Title I in 2008-2009.
[c]Estimated in 2001 in *The Federal Role in Highway Research* TRB Special Report 261, Transportation Research Board of the National Academies, Washington, D.C., 2001.

[3] *The Federal Investment in Highway Research 2006-2009: Strengths and Weaknesses*, Special Report 295, Transportation Research Board of the National Academies, Washington, D.C., 2008, Table 2-2, p. 21.

FHWA is closely connected to the states though its federal aid and RD&T programs and has offices in each state. RITA, in addition to administering the ITS and UTC programs, has a role in strategic RD&T planning for the department. Because of the extent of earmarked research and detailed designations of research programs in the *Safe, Accountable, Flexible, Efficient, Transportation Equity Act of 2005* (SAFETEA–LU), about which I will say more later, RITA has had limited opportunity to influence the scope and direction of highway research.[4]

A federal role of growing importance is the support for higher-risk, potentially higher pay-off research. TRB has been administering an NRC-appointed expert committee to provide guidance to the FHWA RD&T program since 1992. The Research and Technology Coordinating Committee (RTCC) has consistently encouraged FHWA to invest in this kind of research.[5] The vast majority of the highway research conducted in this country is highly applied, problem-solving research, as it should be. But no agency has been funding more exploratory research that is seeking new understanding that could lead to new breakthroughs. The Exploratory Advanced Research program authorized in SAFETEA–LU is an example of this kind of research and a welcome change. In principle, this kind of research should also be supported through UTC program, but the dollar-for-dollar matching requirement of the UTC program has driven this program to focus on applied research.

Special Initiatives

Over the years stakeholders in the highway community have requested special initiatives to meet special needs. Most of these initiatives have been governed by stakeholders and funded with federal aid and rely on competition and merit review to award contracts and grants.

AASHO Road Test and Long Term Pavement Performance Experiment.

In the late 1950s an extensive series of tests was conducted for the American Association of State Highway and Transportation Officials (AASHTO), then named the American Association of State Highway Officials (AASHO), on a pavement test track. These tests established the empirical relationships between pavement load-

[4] Committee for the Review of the USDOT Strategic Plan for R&D, Letter Report, August 2, 2006. *http://www.trb.org/news/blurb_detail.asp?id=6582*

[5] *The Federal Role in Highway Research and Technology,* Special Report 261, Transportation Research Board of the National Academies, Washington, D.C. 2001.

ings and distress that that became the basis of the first AASHTO pavement design guide issued in 1961, which subsequently determined pavement designs in the United States as well as influencing them around the world. TRB, then the Highway Research Board, administered these tests for AASHO.

The AASHO road test, however, did not adequately account for variations in soil conditions, materials, climate, and other factors that influence pavement deterioration in addition to loadings. The Long-Term Pavement Performance (LTPP) experiment, begun 20 years ago, and costing over $260 million in federal funding, will be nearly completed this year. FHWA has managed the experiment in collaboration with the states, which have invested at least double the federal share in constructed pavements and data collection. An NRC-appointed committee administered by TRB has advised FHWA and the states on the conduct of this experiment. The data collected to date have already been influential in implementing the new Mechanistic-Empirical Design Guide being implemented by the states and will likely be as influential in future pavement design as the AASHO road test.

Intelligent Transportation Systems (ITS) program

In the late 1980s a broad-based public-private stakeholder group known as Mobility 2000 began promoting the need to apply computer and electronic communications technologies to increase the capacity and safety of highways. The research and demonstration program that was initially funded in the *Intermodal Surface Transportation Efficiency Act of 1991,* has since invested more than $1.2 billion in developing, testing, and implementing ITS technologies. ITS America, an outgrowth of Mobility 2000, was originally designated as the formal advisory body for the program; RITA now has a designated ITS advisory committee for this purpose.

Strategic Highway Research Programs (SHRP) 1 and 2.

Originally conceived by an NRC-appointed committee administered by TRB, the first SHRP program was a fixed-duration $150 million research effort focused on materials and maintenance practices that produced significant breakthroughs in asphalt mix design procedures and winter maintenance practices. FHWA, AASHTO, and TRB collaborated in the development of detailed research plans. The program was authorized in the 1987 surface transportation reauthorization legislation. A special unit of the NRC was created to allow for stakeholders governance of the program and convene expert panels to produce requests for proposals (RFPs), provide merit review of the proposals, recommend selection of contractors, and manage the contractors.

In the *Transportation Equity Act for the 21st Century,* Congress requested that TRB convene another NRC-appointed committee to determine the need for a second SHRP. A committee made up of leaders from the highway community recommended an ambitious program to significantly improve safety, provide capacity in greater harmony with community values and the environment, improve travel time reliability, and renew highway capacity more efficiently and effectively while under traffic.[6] SAFETEA–LU authorized a six-year, $205 million program for this purpose. Under a three-way partnership with AASHTO, FHWA, and TRB, the program is governed by stakeholders and administered by TRB. Eighty-five percent of the research funds are awarded competitively based on merit review by peers.

National Cooperative Highway Research Program (NCHRP)

Since 1962, under a cooperative agreement among AASHTO, FHWA and TRB, TRB has administered the NCHRP program. In this cooperative program, the states select the topics to be studied through the Standing Committee on Research of AASHTO. TRB then forms panels of experts to issue RFPs, review proposals, select contractors, and oversee the research. TRB administers similar programs for transit agencies (Transit Cooperative Research Program, since 1991), and airports (Airport Cooperative Research Program, since 2005).

Other Cooperative Research Programs

SAFETEA–LU authorized two relatively small-scale cooperative programs that TRB administers for others. One program, recommended by AASHTO, addresses intermodal freight research issues. Another pilot program, recommended by an NRC-appointed committee convened at the request of USDOT, addresses hazardous

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

materials transportation.[7] As with other cooperative programs, stakeholders provide the governance and TRB provides the administration.

In 2002, an NRC-appointed committee also recommended the creation of a Surface Transportation Environment and Planning cooperative research program.[8] The committee that authored that report was chaired by Betty Deakin, who is also invited to testify today. A key concept behind this proposal was to bring the highway and environmental communities together to govern a research program that would use the best science and technology to address and resolve some of the contentious issues and questions that separate these two constituencies. SAFETEA–LU authorized such a program and left it to the discretion of USDOT whether to manage it directly or have TRB form a stakeholder committee to provide governance of the program. Partly due to the funding constraints SAFETEA–LU imposed on USDOT, FHWA chose to retain the program, which, nonetheless, does have an extensive outreach component.

The structure of the highway research program appears complicated, and it is. The genius of the design, however, is that the programs and initiatives are structured for the most part so that they are close to the various problems they are designed to address. In principle, the various programs provide a portfolio that ranges from highly applied to more exploratory research. In the view of many, the balance is not quite right, and, for the amount of money being spent, there appear to be far too many categories and far too little flexibility to shift program priorities in response to new opportunities, such as nanotechnology, or emerging needs, such as security and climate change.

FINDINGS AND RECOMMENDATIONS FROM RECENT NRC REPORTS

Two NRC-appointed committees have recently completed reports that address the questions posed by the committee. After summarizing the main findings and recommendations of these reports, I respond to the Committee's questions more directly.

Last November the NRC released the RTCC report entitled *The Federal Investment in Highway Research 2006–2009: Strengths and Weaknesses.* This report evaluates the federal highway RD&T programs in terms of the principles for research that are articulated by Congress in the introduction to Title V of SAFETEA–LU. Some of these principles are based on recommendations made by the RTCC in is 2001 report, *The Federal Role in Highway Research.* These principles address:

- the scope of the federal RD&T program;
- when federal investment is justified,
- the content of the program, including fundamental, long-term research; gap-filling research; and policy or planning research;
- stakeholder input;
- awarding R&D funds primarily through competition and peer, or merit, review; and
- evaluation of research.

The main findings of the RTCC are as follows:

- Despite the progress made in overall funding in SAFETEA–LU, highway research programs are significantly under funded compared with the level of R&D investment in private industry. Public and private highway research is funded at only 25 percent of the level of industrial R&D in the United States (0.9 percent of highway expenditures compared to 3.4 percent of industrial sales).
- The research programs funded in SAFETEA–LU meet the Title V principles with these main exceptions:
    - Extensive earmarking (62 percent) of the University Transportation (UTC) Program and additional earmarks scattered across FHWA programs (equal to at least 18 percent of total funding) violate the SAFETEA–LU principle of awarding research funds according to competition and merit review.

[7] *Cooperative Research for Hazardous Materials Transportation, Defining the Need, Converging on Solutions.* Special Report 283. Transportation Research Board of the National Academies, Washington, D.C., 2005.

[8] *Surface Transportation Environmental Research: A Long-term Strategy.* Special Report 268. Transportation Research Board of the National Academies, Washington, D.C., 2002.

- The programs funded in SAFETEA–LU do not include all the content areas Congress requested. Due to funding constraints in Title V caused by a considerable number of narrowly-designated programs and earmarking of more programs than were authorized, FHWA was forced to cut important areas of research in safety, operations, planning and environment, and policy. Funding for research and data gathering to support policy decisions was eliminated and funding for planning was greatly reduced. Other areas that are funded, such as deployment and technology transfer, are nonetheless inadequate to the task.[9]
- 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.
- Due to funding constraints, FHWA has inadequate funds to carry through on commitments it has made in its *Corporate Master Plan for Research, Deployment and Innovation* to engage stake holders more broadly in agenda setting, merit review, and program evaluation.
- The SHRP 2 program meets all the research principles, but is funded at only one-third the level and for two years less than stakeholders requested. The down-scaled program will not be able to meet all the original goals envisioned.

The committee also makes several important 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.
3. The Exploratory Advanced Research program should be continued.
4. The State Planning and Research (SP&R) program should be continued.
5. Cuts in policy, safety, operations, and planning and environmental research at FHWA should be restored. Funding for research and data gathering to inform policy decisions should be increased to meet pressing national needs. The surface transportation environmental and planning research program should be authorized as a cooperative research program in which the stakeholders are enabled to govern the program. In the planning area, additional funding for expanded data collection and improving regional travel forecasting models should be provided.
6. Congress should consider extending the SHRP 2 program for two years into the next authorization and funded 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 responsible for administering highways, such as the Long-Term Pavement Performance Program[10] and the Long-Term Bridge Performance Program should be continued.
8. Adequate resources should be provided to FHWA for a robust program for deployment 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 and improve the ability of all programs to focus efforts on the highest priorities.

A second NRC committee has recently recommended a deployment program that would implement the results of the SHRP 2 program in its report, *Implementing the*

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[9] SAFETEA–LU technical corrections legislation of 2008 restored some of FHWA's lost funding and gave the agency discretion over about an additional $14 million annually.

[10] The recently issued NRC report, *Preserving and Maximizing the Utility of the Pavement Performance Database,* Transportation Research Board of the National Academies, February 2009, recommends completing the data collection from the 500 or so highway sections of the LTPP experiment that will still be providing important information at the end of 2009 and establishing a permanent database to allow researchers to mine these data and complete the analysis originally envisioned for this experiment, which has not been conducted due to funding constraints.

Results of the Second Strategic Highway Research Program: Saving Lives, Reducing Congestion, Improving Quality of Life.

The committee recommends that a large-scale deployment effort totaling $400 million over six years be carried out by FHWA in partnership with AASHTO, the National Highway Traffic Safety Administration (NHTSA), and TRB. The committee also recommends that:

- this implementation effort be guided by advice from a formal advisory committee made up of key stakeholders who must implement the results from SHRP 2 and
- detailed, publicly-available implementation plans be developed with stakeholder input.

I include these recommendations of this report because the large-scale, organized deployment program envisioned provides a model for how FHWA should be organizing itself to support the delivery of innovation. The RTCC report calls for funding a "robust" program of deployment and this is certainly an example of a robust program. It has to be. Innovation in the highway sector is challenging. The largely public-sector highway field results in an extremely risk-averse environment. The barriers to innovation are high. The procurement of highway goods and services is highly detailed and specified as public procurements often must be. There are severe penalties for failures and few rewards for success. The key concepts of this committee's proposal are its guidance by stakeholders, its degree of organization and dedication, and the scale of funding necessary to deliver results to overcome the barriers to innovation.

RESPONSE TO QUESTIONS POSED BY THE COMMITTEE

1. *How are R&D priorities developed and coordinated within DOT and how are they aligned with the needs of the user community? What is your assessment of these priorities? Do we need to change any R&D priorities to address major challenges such as environmental impact and energy consumption?*

R&D Priorities

SAFETEA–LU charged RITA with preparing a multi-modal strategic five-year RD&T plan and required that the plan be reviewed by the National Research Council. The five-year plan was released in 2006.[11] An NRC committee reviewed this plan and found that it was best described as a summary of what research the various modal administrations were funding rather than a true strategic plan.[12] There are important reasons why this plan was not truly strategic from a top-down perspective. First, the research titles of SAFETEA–LU contain numerous narrowly-defined designations and many R&D activities are earmarked to specific recipients. These designations and earmarks exceed the amount authorized, which effectively removes agency discretion in shifting resources to respond to USDOT priorities. Second, as a practical matter, most of the needed research identified by stakeholders is truly modal in character. Pavements and structures, for example, are such a large share of highway agency responsibilities and expenditures that it is natural that FHWA would conduct extensive research in these areas with an interest and focus not shared by other modal administrations. Safety is another important area for FHWA, and its areas of highway safety responsibility are well delineated and distinct from those of NHTSA and the Federal Motor Carrier Safety Administration. Finally, the ability of USDOT to direct or control the research programs from a top-down perspective is in a natural tension with the efforts of the modal administrations to be responsive to the "bottoms up" needs for research identified by stakeholders. It is appropriate for USDOT to set broad goals and objectives for the RD&T program, allocate resources according to direction set by Congress, support advanced research, and conduct mission-critical research for federal regulation and oversight. FHWA should be taking more of a leadership role in developing research priorities in concert with the entire highway community. Because USDOT is so disconnected from responsibilities of actually delivering and operating infrastructure, however, the federal RD&T program should be largely driven by stakeholders.

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[11] Transportation Research, Development and Technology Strategic Plan, 2006–2010. U.S. Department of Transportation, Research and Innovative Technology Administration.

[12] Committee for the Review of the USDOT Strategic Plan for R&D, Letter Report, August 2, 2006. *http://www.trb.org/news/blurb_detail.asp?id=6582*

Alignment with needs of user community

The research programs of the modal administrations reach out to stakeholders to inform their selection of research priorities and projects. As mentioned previously, TRB has expert committees reviewing the research programs of FHWA, FTA, and FRA as well as committees of experts reviewing the FHWA's pavement research and deployment activities and the conduct of the Long-Term Pavement Performance experiment. TRB also manages the SHRP 2 research program, which was identified and is governed by stakeholders. The FAA has an extensive advisory committee structure for its aviation research program.

The FHWA probably has the most extensive interactions with stakeholders, as described in some detail in Chapter 5 of *The Federal Investment in Highway Research 2006–2009: Strengths and Weaknesses.* FHWA's different R&D offices for infrastructure, operations, safety, and planning and environment have varied outreach efforts to different constituencies, including AASHTO committees, Metropolitan Planning Organizations (MPOs), industry associations, public-private consortia, standing committees of TRB's Technical Activities Division, environmental and safety groups, and others. The program and research offices have developed multi-year R&D program drawing on stakeholder input. Moreover, FHWA has committed to working even more extensively with stakeholders in its *Corporate Master Plan for Research, Deployment and Innovation,* although the RTCC notes in its 2008 report that because of the constraints in Title V, FHWA has not had the discretionary resources to carry out the commitments it made. Despite FHWA's extensive and varied outreach to stakeholders, however, it is fair to say that FHWA could do more to make these activities more transparent to others. Many of the interactions between research and program offices and various stakeholder groups are carried out informally. FHWA should be communicating via its website the opportunities for stakeholders to participate in the shaping of its program, documenting the input it has received, and posting its multi-year research program roadmaps. FHWA is clearly listening to and working with stakeholder groups and most of its R&D programs and initiatives within these programs are aligned with stakeholder interests. Because the Federal Transit Administration's program is so heavily earmarked, it has relatively little discretion over what research it conducts, but its research office should be reaching out to the American Public Transportation Association and other transit industry stakeholders in the ongoing development of its strategic RD&T plan.[13] Much of the Federal Railroad Administration's R&D program is safety-oriented research driven by its safety regulatory mission, but it also could be more attuned to research the states and passenger and freight rail industries would benefit from.[14]

Changing Priorities

The TRB Executive Committee recognized in mid 2008 that the surface transportation research proposals for reauthorization being developed by various groups were deficient in not recognizing the growing importance of reducing transportation greenhouse gas (GHG) emissions and energy consumption. TRB has self-initiated studies under way that we anticipate will make recommendations to Congress before SAFETEA–LU expires regarding research in climate change mitigation and adaptation and will identify policy options for reducing transportation energy consumption and GHG emissions.

Despite what I anticipate will be recommendations for dedicated research in the areas of climate change and energy conservation, I hesitate to recommend cutting existing programs to shift funds to these areas. The RTCC report notes that highway research is significantly underfunded. The share of annual revenues devoted to highway research is only one quarter as large as industry generally and comparable to the lowest of the low-technology sectors of industry. But the challenges faced in the highway sector are among the most complex and important of society. We have a sunk investment in infrastructure worth well over a trillion dollars that has to be maintained. We lose more than 40,000 people each year in traffic crashes. The motor vehicles that use the highway system burn petroleum-based fuels almost exclusively and are a main source of our dependence on imported oil. We must find a funding mechanism to replace or supplement the gasoline tax as the mainstay for funding highway and transit programs. And highways are significant sources of neg-

[13] Transit Research Analysis Committee, Transportation Research Board of the National Academies, Letter report of May 4, 2007. Washington, D.C. *http://onlinepubs.trb.org/onlinepubs/reports/trac_may_2007.pdf*

[14] Committee for the Review of the Federal Railroad Administration Research and Development Program, Letter report of April 29, 2008. Transportation Research Board of the National Academies. *http://onlinepubs.trb.org/onlinepubs/reports/frar&d_April_2008.pdf*

ative environmental impact. Because we are also so heavily dependent on highways to serve our economy and society, the need for innovation to address these problems has never been greater.

2. How would we improve our transportation R&D investment structure?

R&D Investment Structure

In concept, the portfolio of programs funded through SAFETEA–LU is appropriate, but the program is far more detailed than necessary. In an ideal world, the programs would mirror FHWA's mission, goals, and operational areas (infrastructure, operations, safety, planning and environment, and policy) with flexibility for the agency to be responsive to new issues and stakeholder input. FHWA's share of Title V, Surface Transportation Research and Technology Deployment, has 42 line items to allocate $130 million, many of these line items are at the research project level. Compare that to NSF, which has a budget in excess of $6 billion and roughly the same number of line items.

There are several federally-managed programs funded through Title V that are clearly aligned with stakeholder interests; the State programs are supported through the State Planning and Research (SP&R) provisions in Title I; special initiatives such as the fixed-duration Strategic Highway Research Programs have been funded from time to time; and support for university-initiated research is provided through the University Transportation Centers Program.

A principal weakness in the portfolio is the scant funding for advanced, or longer-term, higher-risk research. The creation of the Exploratory Advanced Research Program (EARP) in SAFETA–LU is a step in the right direction. In its 2001 report, the RTCC recommended that 25 percent of the FHWA program be devoted to "longer-term, higher-risk" research. Applied research is the central element of the federal program, and it should be, but it is also incremental in nature. Such research is unlikely to result in breakthroughs that can transform practice. At present the EAR program represents about six percent of FHWA's overall program. It is a good start, but far from the goal the RTCC has suggested.[15]

The RTCC's 2008 report recognizes the role that the UTC program could be playing in advanced research. Universities are ideally suited for creating new knowledge and understanding, and the UTC program is one of the few surface transportation research programs that can fund investigator-initiated research. The RTCC finds, however, that the UTC program is mostly conducting applied research. A scan of highway research projects under way in the UTC program indicates that at least 80 percent are highly applied.[16] The RTCC concludes that the dollar-for-dollar matching requirement of the UTC program drives it toward applied research. Most of the providers of matching funds are state DOTs, which they typically provide from SP&R funds, and they tend to want their SP&R funds devoted to solving the many immediate problems they face. An important reform of the UTC program recommended by the RTCC is to change the matching requirement to a 20 percent university match. This would free up universities to devote more of their available funding to the kind of advanced research the program was created to conduct in the first place. At the same time, of course, the UTCs should be selected competitively, rather than having 62 percent earmarked.

Another weakness of the structure of the program is the relative neglect of policy research. Many important transportation policy questions are going uninvestigated because of lack of any funding for this purpose, forcing infrastructure owners to make decisions while ill informed. This is the kind of research that ought be conducted to guide decisions about intermodal investments, such as inter-city passenger rail, improved highway access to ports, short-sea shipping, and policies to enhance the effectiveness of transit. The lack of policy relevant research significantly hampered the work of the two commissions Congress created in SAFETEA–LU to advise it on, among other things, the future viability of motor fuels taxes to fund highway and transit infrastructure. 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, for example, undermine confidence in projecting future revenue streams for the highway trust fund, which is one of the key policy con-

[15] There are earmarked programs that are addressing, in part, advanced research in asphalt. The RTCC, however, recommends that advanced research conform to the principles Congress established in Title V—that funds be awarded based on competition and merit review of proposals by peers.

[16] *The Federal Investment in Highway Research 2006–2009: Strengths and Weaknesses,* Special Report 295, Transportation Research Board of the National Academies, Washington, D.C., 2008, p. 76.

cerns for reauthorization of the highway program in 2009. Policy funding was reduced to almost zero as a result of the over-designation and earmarking of funds in Title V. Funding that had been about $9-10 million annually was eliminated. Last year's technical corrections legislation helped, but restored but $1 million annually for the Office of Policy.

Much greater emphasis on data collection is also necessary. Being able to answer many of the most important policy questions in highway transportation requires much better data. Research in the planning area to develop the advanced modeling tools needed to meet federal and local planning and environmental mandates also require better data. States and MPOs rely heavily on the National Household Transportation Survey, which was dropped by the Bureau of Transportation Statistics (BTS), whose funding was also sharply reduced in S–LU. (Fortunately FHWA and other administrations within USDOT have stepped in to provide stop-gap funding to maintain this critical survey.) Similarly, improved, and more timely, data on freight movements is essential for improved planning; the Commodity Flow Survey, which is still part of BTS's portfolio but nonetheless underfunded, should be sustained and enhanced to meet user requirements.

Proposals already circulating that address reauthorization of the surface transportation program, including the reports of both SAFETEA–LU commissions, recommend that the federal-aid program become performance based. A true system of performance measures will create enormous new demand for better data on inventory condition and value, real-time system performance, safety, environmental protection, and other performance metrics.

Technology transfer is another area of weakness, as I explain in response to Question 3.

3. How can we improve the transfer of transportation technology from the R&D stage to deployment and adoption in the field? As we prepare for major investment in infrastructure, how do we ensure that the latest proven technologies are utilized?

Deployment of new technology and practice does not receive the attention it deserves. It is important to recognize, however, that FHWA does carry out considerable technology transfer activities. FHWA has extensive information on its program office web pages about new techniques, as well as technical briefings, manuals, and implementation guidance. These activities are partially funded with R&D funds. FHWA also administers the Local Technical Assistance Program (LTAP) and offers training on new technologies and practices through the National Highway Institute. FHWA's field offices in every state are also sources of information for State practitioners. These activities, however, are not sufficient.

FHWA formerly had resources explicitly devoted to technology transfer, which were lost in 1998 in TEA–21, and the office that had specialized in this activity was subsequently disbanded.[17] FHWA then allocated technology responsibilities to program offices in concert with the office of research and technology, but this responsibility was added to other responsibilities of FHWA's existing staff. The barriers to innovation, however, are high and the expertise required for successful technology transfer requires a strategic plan, dedicated and expert staff, and adequate resources to overcome these barriers.[18] The SHRP 2 implementation report provides a model of what is required to assist the states in deploying new technologies and practices. In addition, the RTCC's report indicates that adoption of innovations may require incentives that reduce the risk of trying something new. FHWA used to have resources, for example, that would allow 100 percent federal funding for implementing promising, but not quite fully proven, technologies or techniques.

4. What are some of the lessons learned from the last reauthorization of the highway bill (SAFETEA–LU)? What improvements can we make?

The principles for research articulated in the preamble to Title V of SAFETEA–LU are good ones and I hope they will be retained and followed. They encourage stakeholder involvement, competitive award of funding based upon merit review, advanced research, and a federal program that spans the entire innovation process. There are, however, too many designated programs and earmarks in SAFETEA–LU that constrain FHWA and RITA from carrying out a research programs consistent with these principles, reduces funding to core mission activities of FHWA, and deny the agencies flexibility in responding to emerging issues and the needs of stakeholders.

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

[18] *Implementing the Results of the Second Strategic Highway Research Program: Saving Lives, Reducing Congestion, Improving Quality of Life,* Chapters 6 and 7.

In terms of other improvements, I refer back to the committee recommendations from the two reports summarized in the previous section.

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All documents are available on TRB's website, *TRB.org.* Most are available as PDF files for download. Congressional staff can receive free paper copies upon request.

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BIOGRAPHY FOR ROBERT E. SKINNER, JR.

Robert Skinner has been the Executive Director of the Transportation Research Board (TRB) of the National Academies since 1994. TRB is a non-profit organization that promotes transportation innovation by sponsoring professional meetings and publications, administering applied research programs, and conducting policy studies. It serves as an independent adviser to the Federal Government and others on scientific and technical questions of national importance.

Prior to becoming Executive Director, Mr. Skinner directed TRB's policy study activities. Before joining TRB in 1983, Mr. Skinner was a Vice President of Alan M. Voorhees and Associates, a transportation consulting firm.

Mr. Skinner recently served on the Metrolink (Los Angeles) Commuter Rail Safety Review Panel and chaired the Special Advisory Panel for the Stem-to-Stern Safety Review of the Boston Central Artery/Tunnel Project. In addition it serves on a number of university and research advisory groups including the Board of Trustees for the School of Engineering and Applied Sciences at the University of Virginia, the Advisory Board for the Center for Urban Transportation Research at the University of South Florida, the External Review Committee for the MIT–Portugal Project, and the Advisory Board for the School of Public Policy at George Mason University.

Mr. Skinner earned his Bachelor's degree in civil engineering from the University of Virginia and received a Master's degree in civil engineering from the Massachusetts Institute of Technology. A registered professional engineer, Mr. Skinner received the James Laurie Prize from the American Society of Civil Engineers in 2003.

Chair WU. Thank you very much, Mr. Skinner.

Mr. Wise.

STATEMENT OF MR. DAVID J. WISE, ACTING DIRECTOR, PHYSICAL INFRASTRUCTURE ISSUES, U.S. GOVERNMENT ACCOUNTABILITY OFFICE

Mr. WISE. Chair Wu, Ranking Member Smith, and Members of the Subcommittee, thank you for the opportunity to discuss research and development and technology coordination and evaluation at the Department of Transportation. RD&T (Research, Development, and Technology) activities are vital to meeting DOT's transportation priorities such as increasing safety, enhancing mobility, and supporting the Nation's economic growth.

DOT's budget in this area totaled about $1.1 billion in fiscal year 2008, primarily for projects undertaken by the Federal Highway Administration and the Federal Aviation Administration (FAA). Over the years we and others have raised concerns about DOT's capacity to improve RD&T coordination and evaluation across the agency. As a result, in 2004, Congress created the Research and Innovative Technology Administration, RITA.

My testimony has two parts. I will discuss, one, the importance of coordinating and evaluating RD&T to ensure federal dollars are used effectively and efficiently, and two, the progress RITA has made implementing the seven recommendations in our 2006 report on coordination and evaluation of transportation and research at DOT.

On the first point, in today's environment of expected trillion dollar deficits and stimulus spending, the need for careful RD&T decisions is more critical than ever. Coordinating and evaluating research are key elements to federal stewardship of taxpayers' money. The Committee on Science Engineering and Public Policy, a joint committee under the auspices of the National Academies of Science, has recommended a formal research coordination process to enhance collaboration, explore research questions, and reduce inefficiencies.

In addition, the committee notes that evaluating the agency's research against established performance measures helps assess research quality and achieve agency goals.

In the same vein, the *Government Performance and Results Act* (GPRA) *of 1993* requires federal agencies to set performance goals and measure performance against those goals to ensure the effectiveness of federal investments. GPRA's emphasis on results suggests that federal programs contributing to the same or similar outcomes should be closely coordinated to ensure the goals are consistent and complimentary and that program efforts are mutually reinforcing.

On the second point, while we have not performed new assessments of RITA since our 2006 report, we have tracked the seven recommendations from that report. These seven recommendations are summarized in the table on pages three and four of my written statement.

RITA has implemented five of the recommendations aimed at preventing duplication of research efforts, ensuring research is evaluated in accordance with established best practices, establishing database systems to inventory and track research, communicating research evaluation efforts to Congress, and documenting the process for evaluating the results of multi-modal research pro-

grams. RITA has implemented a strategy consisting of ongoing internal reviews to coordinate RD&T activities and look for areas where joint efforts would be appropriate.

RITA has partially implemented the two other recommendations directing it to develop performance goals and overall implementation strategy, an evaluation plan, and performance measures. As a result, it is still a challenge for RITA to determine its relative success overseeing the effectiveness of RD&T activities.

In conclusion, since becoming operational in 2005, RITA has made progress towards becoming a DOT-wide resource for managing and determining effectiveness of RD&T activities. We will continue to monitor RITA's efforts to implement our two open recommendations. We look forward to assisting Congress as it considers RITA's activities during the reauthorization process.

Mr. Chair, this concludes my statement. I would be pleased to answer any questions you or Members of the Subcommittee may have.

[The prepared statement of Mr. Wise follows:]

PREPARED STATEMENT OF DAVID J. WISE

Mr. Chairman and Members of the Subcommittee:

We appreciate the opportunity to participate in this hearing on the Department of Transportation's (DOT) research, development, and technology (RD&T) activities. RD&T activities are vital to meeting DOT's transportation priorities, such as increasing safety, enhancing mobility, and supporting the Nation's economic growth. In fiscal year 2008, the department's RD&T budget totaled over $1.1 billion, primarily for projects undertaken by DOT's Federal Highway Administration and Federal Aviation Administration. Coordinating RD&T throughout DOT and reviewing it to make sure that it is evaluated is important to ensure the efficiency and effectiveness of RD&T investment.

Over the years, we and others have raised concerns about DOT's capabilities for improving RD&T coordination and evaluation across the agency.[1] In part to ameliorate those concerns, in 2004 Congress created the Research and Innovative Technology Administration (RITA).[2] RITA is responsible for coordinating, facilitating, and reviewing the department's RD&T programs and activities to identify research duplication and opportunities for joint efforts and to ensure RD&T activities are meeting intended or other goals. These include activities conducted by DOT's operating administrations as well as other RD&T and statistical programs managed by RITA (e.g., the Bureau of Transportation Statistics and University Transportation Centers). RITA carries out its responsibilities through multiple groups and actions, including its two coordinating bodies—the RD&T Planning Council and Planning Team—and budget reviews. While RITA has DOT-wide responsibilities, it does not have the authority to direct changes in the operating administrations' RD&T activities. In 2006, we reported on RITA's progress in overseeing RD&T activities and made seven recommendations to enhance RITA's ability to manage and ensure the effectiveness of these activities.[3]

My testimony today addresses the importance of coordinating and evaluating RD&T so that federal dollars are used efficiently and effectively, as well as RITA's progress in implementing our 2006 recommendations. It is based primarily on our 2006 report, a review of best practices for coordination and evaluation, and follow-up discussions with RITA officials on actions taken on our recommendations. We have not assessed whether RITA's actions have improved the effectiveness of the department's RD&T investment since our 2006 report. We conducted this work in January and February 2009 in accordance with generally accepted government auditing

[1] GAO, *Transportation Research: Actions Needed to Improve Coordination and Evaluation of Research,* GAO–03–500 (Washington, D.C.: May 1, 2003).

[2] The *Norman Y. Mineta Research and Special Programs Improvement Act of 2004,* which also dissolved RITA's predecessor administration, the Research and Special Programs Administration.

[3] GAO, *Transportation Research: Opportunities for Improving the Oversight of DOT's Research Programs and User Satisfaction with Transportation Statistics,* GAO–06–917 (Washington, D.C.: Aug. 15, 2006).

standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

Coordination and Evaluation of RD&T Activities Help Promote Efficient and Effective Use of Federal Research Funds

Coordinating and evaluating research are important elements in ensuring federal dollars are used efficiently and effectively. RITA is responsible for coordinating and reviewing the DOT operating administrations' RD&T activities so that (1) no unnecessary duplication takes place and (2) the activities have been evaluated in accordance with best practices. The Committee on Science, Engineering, and Public Policy—a joint committee of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine—has emphasized the importance of careful coordination and focused evaluation of federal research and developed principles to help agencies evaluate their research programs.[4] The committee recommended establishing a formal process to coordinate research across agencies. While this recommendation is focused on cross-agency research, the goals—enhancing collaboration, ensuring that questions are explored, and reducing inefficiencies—are important and applicable within agencies as well. Coordination of research ensures that information is shared so that, if necessary, research can be adjusted to ensure a field is appropriately covered and understood. In addition, the committee noted that evaluating research against established performance measures in agency strategic plans, developing measures that are appropriate for the type of research being developed, and using expert reviews aid in assessing the quality of the research.

Relatedly, the *Government Performance and Results Act of 1993* (GPRA) requires federal agencies to set performance goals and measure performance against those goals to ensure the effectiveness of federal investments. GPRA's emphasis on results implies that federal programs contributing to the same or similar outcomes should be closely coordinated to ensure that goals are consistent and complementary, and that program efforts are mutually reinforcing.

Making appropriate and cost-effective investment choices is an essential aspect of responsible fiscal stewardship. Such choices are even more important in today's climate of expected trillion-dollar deficits. Careful decisions will need to be made to ensure that RD&T activities achieve their intended (or other) purposes and do so efficiently and economically.

RITA Has Made Progress in Improving Its Coordination, Review, and Performance Measurement of DOT's RD&T Programs

In 2006, we made seven recommendations to enhance RITA's ability to manage and ensure the effectiveness of RD&T activities, including developing strategies for coordinating and reviewing RD&T activities and developing performance goals and measures. (See Table 1.) RITA has implemented five of our recommendations and is making progress on implementing the remaining two.

[4] Committee on Science, Engineering, and Public Policy, *Evaluating Federal Research Programs: Research and the Government Performance and Results Act* (Washington, D.C.: February 1999).

Table 1: Status of RITA's Implementation of GAO's 2006 Recommendations

Recommendations	Status
Develop and incorporate into RITA's annual budget process and the RD&T strategic plan:	
• a strategy for identifying and reviewing all of DOT's RD&T projects to determine areas of unnecessary duplication, overlap, and opportunities for joint efforts	Implemented
• a strategy to ensure that the results of all of DOT's RD&T activities are evaluated according to established best practices	Implemented
• a DOT-wide database of all of DOT's RD&T projects that will support RITA's coordination, facilitation, and review efforts and will assist in the implementation of the strategies discussed above	Implemented
• a summary of all of DOT's RD&T program evaluations, including ongoing and completed evaluations, and a schedule of future evaluations	Implemented
• a description of RITA's process for systematically evaluating the results of its own multimodal research programs and how this process will be applied to future multimodal research programs that RITA conducts	Implemented
Develop and incorporate the following into RITA's year annual budget process:	
• performance goals, an overall implementing strategy, and an evaluation plan that delineate how the activities and results of its coordination, facilitation, and review practices will further DOT's mission and ensure the effectiveness of the department's RD&T investment	Partially implemented
• common performance measures related to DOT's RD&T activities, which should be developed in consultation with the operating administrations	Partially implemented

Source: GAO analysis of RITA information.

RITA Implemented a Coordination and Review Strategy, Developed a DOT-wide Database of RD&T Activities, and Communicated Results of Evaluations

Preventing duplication of effort. In response to our recommendation, RITA developed a strategy to ensure that no unnecessary duplication of research programs occurs within the department, incorporated the results into various high-level DOT planning documents, and reported the results in its strategic plan. RITA's strategy consists of ongoing internal reviews of all of DOT's research programs. These reviews are conducted by (1) convening meetings in which officials from each of the operating administrations share information about areas of ongoing and planned research, seeking opportunities for joint effort, and (2) conducting annual reviews of each operating administration's research plans, looking for research duplication, among other things. In addition, RITA has formed eight working groups, in concert with DOT's operating administrations, to foster collaboration on cross-modal issues. According to a RITA official, results of these reviews have identified several areas for cross-modal collaboration, including climate change, freight capacity, security, alternative energy technologies, and advanced materials and sensors. According to RITA officials, as a result of these actions, RITA is better able to meet legislative and DOT requirements for coordinating its research, leverage resources for cross-modal research initiatives, and prevent unnecessary research duplication.

Following best practices. RITA also developed a strategy to ensure that the results of all DOT's research activities are evaluated according to established best practices. The strategy includes three primary mechanisms: (1) ensuring systematic application of the Office of Management and Budget's Research and Development Investment Criteria (relevance, quality, and performance) and the Program Assess-

ment Rating Tool by the operating administrations;[5] (2) annual internal program reviews with self-reporting by the operating administrations; and (3) documenting the operating administrations' external stakeholder coordination and review. According to RITA, reviews conducted in fiscal years 2007 and 2008 focused on how well the operating administrations are implementing best practices, including external stakeholder involvement, merit review of competitive proposals, independent expert review, research performance measures, and external research coordination. RITA reports the results of its reviews to the department's RD&T Planning Council, which consists of administrators from each of the operating administrations, including RITA, and officials from DOT's Office of the Secretary. According to RITA officials, as a result of these efforts, RITA is better able to determine the quality and effectiveness of its research activities and investments and determine whether they are achieving their intended (or other) goals.

Establishing RD&T project databases. RITA created two database systems to inventory and track all of DOT's research activities and provide tools for querying and searching individual projects to identify potential duplication and areas where operating administrations could collaborate. The first database, the RITA Research Notification System, captures research investments at the transaction level, allowing users to search by activity, contracts and grants, and contractor names, enabling identification of funded programs for coordination, collaboration and review. The second database is part of the annual Research Planning and Investment Coordination (RPIC) process, which captures research at the budget request level, allowing for department-wide transparency and coordination of proposed programs and projects. According to a RITA official, eventual combination of the two databases will offer a mechanism for measuring and tracking investments from request through funding and execution.

Communicating evaluation efforts. To communicate its efforts in evaluating DOT's research to Congress, senior DOT officials, and the transportation community, RITA and its predecessor organization published a summary of all research program evaluations for 2004 through 2006 and included that summary in a high-level DOT planning document and in a report to Congress. First, RITA's predecessor published what was essentially a summary of all research program evaluations conducted in fiscal year 2004—in the form of a summary of the results of its review of the operating administrations' application of the Office of Management and Budget's Research and Development Investment Criteria—in its 2005 annual RD&T plan. Secondly, RITA developed a summary of the results of its fiscal year 2005 and 2006 research program reviews, and a schedule of RITA's planned fiscal year 2007 reviews, and included it in DOT's *"Research, Development and Technology Annual Funding Fiscal Years 2006–2008, A Report to Congress."* This report also includes summaries of research program evaluations conducted by modal research advisory committees, the Transportation Research Board, and key modal stakeholders in fiscal years 2006 and 2007. According to RITA officials, as a result of this reporting, RITA has provided better continuity and context to Congress and the transportation community about the results of its research evaluations.

Documenting processes. RITA has also acted to document its process for systematically evaluating the results of its own multi-modal research programs, such as the Hydrogen Safety Program and various grant programs. RITA evaluates the results of its RD&T activities by ensuring they align with DOT goals, meet the research and development investment criteria, and are subject to an annual peer review process. RITA has documented this process in its strategic plan.

RITA Has Not Yet Developed an Overall Implementing Strategy, Evaluation Plan, or Performance Measures

Establishing performance goals. In 2006, we found that RITA lacked performance goals and an implementing strategy and evaluation plan to delineate how the activities and results of its coordination, facilitation, and review practices will further DOT's mission and ensure the effectiveness of the department's RD&T investment. RITA has partially implemented our recommendation that it develop these elements. Setting meaningful goals for performance, and using performance infor-

[5] According to the Office of Management and Budget, these criteria are rooted in best practices and include peer review as a mechanism for assessing program quality. The Program Assessment Rating Tool was developed to assess and improve program performance to inform funding and management decisions. It consists of a series of questions covering program purpose and design; performance measurement, evaluations, and strategic planning; program management; and program results.

mation to measure performance against those goals, is consistent with requirements in GPRA. Developing an evaluation plan and analyzing performance information against set goals for its own coordination, facilitation, and review practices could assist RITA in identifying any problem areas and taking corrective actions.[6] Linking performance goals with the planning and budget process, such as DOT's annual budget process, can also help RITA determine where to target its resources to improve performance.[7] Guidance provided by the Committee on Science, Engineering, and Public Policy notes that evaluating the performance of research in the context of the strategic planning process ensures the research is relevant to the agency's mission.[8] Without such goals and an evaluation plan, it is difficult for RITA to determine its success in overseeing the effectiveness of DOT's RD&T activities.

According to RITA officials, while an overall implementing strategy and evaluation plan has not yet been established, RITA has created performance goals. A RITA official told us that the RPIC process—a relatively new process that integrates the budget and strategic planning processes—will help in creating an implementing strategy. The RPIC process is meant to provide information to the Planning Council and Planning Team, which is responsible for defining the department's overall RD&T strategic objectives. The RPIC process assesses the department's RD&T activities in terms of the following performance goals: (1) balanced portfolio (e.g., mix of basic, applied, developmental, and high risk RD&T), (2) alignment of RD&T programs with DOT goals and each operating administration's mission, and (3) return on investment. The RPIC process has been in place only for fiscal year 2009, and as a result, the Planning Council does not yet have the information needed to make decisions about a strategy. In addition, RITA does not yet have an evaluation plan to monitor and evaluate whether it is achieving its goals. A RITA official told us that the RPIC process needs to be in place for two or three fiscal years before it can provide enough information for RITA to establish a strategy or evaluation plan.

Developing performance measures. In 2006, we also found that RITA did not work with the operating administrations to develop common performance measures for DOT's RD&T activities. According to RITA officials, RITA has partially implemented our recommendation that it do so. Without common performance measures for the RD&T activities of the operating administrations, RITA and the operating administrations lack the means to monitor and evaluate the collective results of those activities and determine that they are achieving their intended (or other) results and furthering DOT-wide priorities. In response to our recommendation, RITA officials told us that they are working with the operating administrations through the RD&T Planning Team—made up of senior officials in RITA and each of the operating administrations. During Planning Team meetings, representatives from each of the operating administrations share information about how RD&T projects are measured and prioritized. For example, according to a RITA official, the Federal Railroad Administration measures how frequently its RD&T projects are used in real-world applications. Once representatives from each operating administration have had the chance to share information, RITA officials will then look for commonalities and determine whether any of the measures could be adopted for the department's RD&T activities.

In closing, since it became operational in 2005, RITA has taken a number of positive steps to meet its vision of becoming a DOT-wide resource for managing and ensuring the effectiveness of RD&T activities. While we have not assessed the effectiveness of these efforts since our 2006 report, we believe that RITA has made progress. We will continue to monitor RITA's performance in implementing our recommendations. As reauthorization approaches, we look forward to assisting Congress as it considers RITA's management of DOT's research program, to better ensure that taxpayers receive the maximum value for DOT's RD&T investment.

Mr. Chairman, this concludes my prepared statement. I would be pleased to respond to any questions that you or other Members of the Subcommittee might have.

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[6] Use of performance goals can help ensure that programs are meeting their intended goals, allows programs to assess the efficiency of their processes, and promotes continuous improvement. Where activities may be fragmented or overlap, performance information can also help identify performance variations and redundancies and lay the foundation for improved coordination, program consolidation, or elimination of unneeded programs. GAO, *Managing for Results: Using the Results Act to Address Mission Fragmentation and Program Overlap,* AIMD–97–146 (Washington, D.C.: Aug. 29, 1997).

[7] GAO, *Managing for Results: Enhancing Agency Use of Performance Information for Management Decision-making,* GAO–05–927 (Washington, D.C.: Sept. 9, 2005).

[8] Committee on Science, Engineering, and Public Policy, *Evaluating Federal Research Programs: Research and the Government Performance and Results Act* (Washington, D.C.: February 1999), 37–38.

BIOGRAPHY FOR DAVID J. WISE

Dave Wise began his career with GAO in 1981. He worked at GAO until 1991, including a four year tour in GAO's former Far East Office in Honolulu, Hawaii. Dave then moved to the Department of State's Office of Inspector General, where he specialized in reviews of consular and international programs, with a focus on counter-narcotics. In 2000, Dave became a Foreign Service Officer, serving tours as (1) political officer/narcotics coordinator in Hanoi, Vietnam; (2) Director, Narcotics Affairs Section, Vientiane, Laos; and (2) political advisor, Provincial Reconstruction Team, Helmand Province, Afghanistan.

Dave returned to GAO as a Senior Executive Service candidate in September 2007, where he is working with GAO's Physical Infrastructure team on surface transportation, communications, and real property issues.

Dave has a BA in political science from the University of Pittsburgh and an MA in public administration from Pitt's Graduate School of Public and International Affairs.

DISCUSSION

Chair WU. Thank you very much, Mr. Wise, and now we will open for our first round of questions, and I recognize myself for five minutes.

Mr. Brubaker, you referred to some of the challenges that you faced as head of RITA, and Mr. Wise, you have—you and your organization have performed a lot of analysis on RITA's functions. There has been some reference to RITA's responsibilities versus its authority to implement what it is responsible for.

Mr. Brubaker, would you care to expand on your experiences in facing the frustrations of that, and Mr. Wise, if you would care to join in or any other of the panelists.

Mr. BRUBAKER. Sure. You know, I said sometimes being at RITA I sort of felt like John Belushi in the movie "Animal House" where he runs out of the room, and he says, "Let's do it," and nobody follows him. That is kind of how it felt dealing with some of the cultural obstacles that we faced in the Department.

We do have, frankly, the responsibility and the authority. The legislative authority is very clear about what we are supposed to do. What we ran into were some cultural obstacles to change, and I have got to tell you, I am kind of shocked, and GAO is used to getting criticized sometimes, and they are going to feel weird because I am a little critical that we actually met five of their open—their recommendations of the seven and partially achieved two of them. I would strongly suggest they go back and really take a hard look at all seven of those vis-à-vis RITA and see really the—and make a judgment on the efficacy of how we responded because——

Chair WU. So you are actually saying GAO might have been too generous.

Mr. BRUBAKER. I think they were, frankly. There are, I mean, they may not have reviewed, we may have just done a really good job of responding to the open recs or something, but the reality from my perspective was there was just so much more we could have done from a select control evaluate perspective of the research portfolio. But we ran into every mode sort of wanting to play hide the ball and protect their existing portfolio of research. It made it very, very difficult to ensure that the underlying research was strategically relevant.

Now, we did, like I said in my opening testimony, we did achieve a level of transparency. We know what the underlying research

projects are, but we have made no value judgment relative to how they fit in the overall strategic direction. Do they plug in nicely to the strategic buckets that are described in the strategic plan? Yeah. We were able to force-fit most of that research, but the grim reality in my perspective is that we weren't particularly effective at creating a process by which we could actually control the research through its execution and then evaluate it in terms of outcomes.

Chair WU. What mechanisms do you think RITA needs to implement, to achieve that?

Mr. BRUBAKER. It is like my good friend, Lieutenant General Bob Shay always used to say. At the end of the day it comes down to leadership. I think there is a leadership issue where the, you know, you have got to have strong leadership in the RITA position, you have got to have accepting leadership among the modes, you have got to have strong leadership at OSC (Office of Special Counsel) where the Secretary says thy will be done, to push the authorities and to ensure that the authorities are actually executed.

At the same time, I think there are some structural things that are missing. Like I said, the National Transportation Research Agenda. I don't see that. You know, we have got this RD&T Strategic Plan, and frankly, again, the first pass at it was a force-fit of all the existing research into the strategic plan of the Department. It didn't really reflect a strategic direction or a very good alignment of research, the research portfolio to achieving the objectives of the Department. That is what has got to happen, but it has got to be broader than the objectives of the Department. It has got to take into account stakeholders, universities, users, economic development people, because the transportation infrastructure is so critical to the economic health and well-being of this nation.

We saw it over the summer when fuel prices went up, you know, astronomically. We saw the impact that that had, and frankly, I think we are still feeling the effects of that increase. What would have been great had, if we would have had the data and the research capacity to do modeling and simulation and be able to understand the impact that that would have on the supply chain, on modal choices, and ensure that we were responding appropriately. And we just simply didn't have that knowledge because we have never laid it out that that is strategically important.

Chair WU. Mr. Wise, I want to give you a cut at it, and a couple of you also referred to cultural issues in research. I want to finish up that—with that—and I will also announce from the Chair that it is my intention to use a soft gavel on this hearing since there are only three of us here, but there will be a gavel, but please proceed with a set of answers about this topic and the cultural issues. And then we will proceed to Mr. Smith.

Mr. Wise.

Mr. WISE. Thank you, Mr. Chair. Also thanks to Mr. Brubaker for his frank opinions and interest in the GAO report from 2006. I think it is important to make a point that when we did this work, which is now probably just over—about four years ago, RITA had just stood up. It was a new organization, and essentially we were looking, it had just taken the place, after the Mineta Act of the, of RSPA (Research and Special Projects Agency). And we were basi-

cally looking to see that processes were in place to do the mission that it was set up to do.

Quite frankly, we have not been, other than following up on the recommendations that indicated these processes are in place, we have not really done a formal assessment to go back and see how well the organization is actually carrying out all its responsibilities. That is something that if the Committee were interested that maybe would be a useful project as the Committee sees fit.

So in that respect it is difficult to give a learned assessment of how well RITA is doing, because it really wasn't the focus of what we did in that 2005/2006 work.

Chair WU. And before we finish, anyone who wishes to address the inertia or the cultural issues, and I heard that mentioned by more than one witness.

Dr. Deakin, please.

Dr. DEAKIN. It seems to me that the cultural issue is really very serious, actually, and we have organizations that are modeled in many cases for building the interstate highway system, and they haven't really changed the organizational structure much since. They are very hierarchical. They are rather slow in being able to respond to things. They are pretty top-down. That is not true across the board. Some agencies have actually tried to innovate the organization structure, but it is pretty true for a lot of these agencies, and there isn't any real incentive for change, partly because there is no outcome focus in the legislation and partly because there is no outcome focus in the State legislation saying you have to show what you are actually producing in terms of cost effectiveness of the investments, producing outcomes like economic prosperity, lower costs for users, environmental quality improvements that you can measure and demonstrate, greenhouse gas reductions, more equity in your system. We could give them those kinds of mandates and say we want reports to come back and tell us what these are going to look like, and we haven't really done that.

Now, Congress did that with reports on the state of infrastructure some years ago, and it took awhile for all the states to get used to having to collect it and report it. They didn't always do it well, but gradually they all got so they were reporting these data, and those data have been very useful. So, again, giving them a mandate and saying, do this, let the best states do what they are already doing, and it gives everybody else a push. Everybody does better, and you actually could measure outcomes and not just dollars spent and, you know, what is being turned over but see what we are actually accomplishing with these investments.

So I think Congress could take leadership on giving us some clear mandates to show what we are producing. Thank you.

Chair WU. Mr. Skinner, if you——

Mr. SKINNER. Just very briefly. I think Dr. Deakin is correct in relating——

Chair WU. Microphone.

Mr. SKINNER. Excuse me. I think Dr. Deakin is correct in relating the cultural challenges to the institutional challenges that we have, and one could imagine an institutional arrangement that is not nearly so decentralized without so many thousands of players who are—who own our transportation system. We could imagine

that, and we might think that it would be more effective, not only for research but for managing and operating our transportation system.

And that may be true, and that is a big question. But from the research perspective, research is unlikely to drive that change in the institutional arrangements. And so the research community is confronted with this enormous technology transfer challenge, and so this, the question of stakeholders and how to involve them and how to have them meaningfully connected to the products—and connected so that when products come out they are all ready, the skids are already greased for them to implement and try these products, that is a critical feature of any strategic approach to R&D and surface transportation.

Chair WU. Thank you very much, Mr. Skinner. We may return momentarily to these cultural issues before we move onto some of the output and matrix sides, and meanwhile, I want to recognize other Members of the panel, particularly Mr. Smith, who has been very forbearing in permitting this series of answers be completed.

Mr. Smith.

Mr. SMITH. Thank you. I—this is all very interesting, especially as a relatively new Member to listen to the various challenges, and I appreciate your willingness to tackle these. And I think it speaks to kind of the largeness of the issue, the complication of the issues, not even to mention funding, that, funding of research, and then funding of carrying out that research in a useful manner. And in a way that leverages other opportunities.

I know that we had some controversy in Nebraska when the director or, well, when a person said that the Department of Roads in Nebraska really wasn't in the economic development business. And you can imagine that there was some resistance to that statement and for good reason. And when I look at the various issues, whether it is the energy issue of our vehicles, we have much different issues in rural America than urban, wherein urban America we subsidize less vehicle travel and virtually in rural America we subsidize more vehicle travel with various roads and systems.

A hybrid, for example, the benefits are less meaningful when a commute is done at 65 miles an hour or maybe a few more miles per hour on the way to work and home. So the benefits are certainly less. So we—I think we need to allow some flexibility.

That being said, Dr. Deakin, if you would perhaps point to maybe a specific research project that you could identify where many of the obstacles that have been mentioned here have taken place, maybe how you would change things but maybe a specific project as tangible as possible, if you could elaborate.

Dr. DEAKIN. Yeah. I would be glad to. The project that was mentioned by several people at our research was the installation of call boxes along part of the freeway system in Northern California at a time when wireless technology, cell phones, were proliferating already, and the call boxes I think had a useful life of about 15 minutes—a very, very short period because by the time they were actually out there along the road, most people were already using cell phones.

So it really wasn't paying attention to market. The project got put in a pipeline and pushed through because the money was

there, it had been allocated, and you know, you get in a program or projects. But it wasn't an effective investment of the funds.

That is a situation where I think that the remedy is pretty obvious. If there had been more discussion with the cell phone companies about the technologies they were developing—and we were sitting right there with Silicon Valley people who know about marketing for these things.

I disagree a little bit with Bob Skinner. I think there is a lot of research on how to change institutions, done by business schools, not in transportation institutions necessarily, but making those connections could happen.

I think there are opportunities to begin to think about how to really bring private marketing, private knowledge about markets and also university research on institutional change and markets into play much more than we have, and that is how I would fix that kind of a problem.

Mr. SMITH. Okay. Thank you. That is a perfect example. I appreciate hearing that.

In, even in places other than Nebraska, I am sure, we have what I think is a response to gridlock that is very reactive in nature. It is kind of like, well, let us wait for the problem to form and then we will solve it.

I guess, Mr. Brubaker, if you wouldn't mind responding to how we could get beyond that, what obstacles you currently see in place. I know it is going to be funding, you know, a part of that, but, again, I would say with the funding issue, I mean, the more successful we are with conservation measures when we fund our roads with a per-gallon fuel tax and there are fewer gallons being used but yet more vehicles, more tires on the road, wheels on the road, that is not a sustainable formula. If you could respond.

Mr. BRUBAKER. Sure. I just, you know, at the end of the day, yeah. Everything winds up being a resource issue, but it could be a resource allocation issue of existing resources to solve things like congestion or, for example, I mean, you heard Bob Skinner mention, you know, $400 million unencumbered for SHRP. Well, you know, that is all fine and good, but is the $400 million better spent in some other areas, like, for example, congestion mitigation, for example, rural safety research that involves more than just roads. It can involve some other things. It can involve some behaviors, human factors stuff.

It is not all about the hockey pucks. I mean, you know, the—sorry—the concrete research. I mean, I am all about, you know, it is great to have different types of asphalt and appreciate all the geographic disparity and the reasons to better understand and spend money on research for concrete and asphalt, but, you know, we have got to kick it up a higher level and look at this more holistically like you say in terms of, you know, what we can do and where we are best spending that limited resource that we already have before you start talking about more money.

Mr. SMITH. Okay. Anyone else wish to respond.

Mr. Skinner.

Mr. SKINNER. Let me just, since it was mentioned, the Strategic Highway Research Program implementation effort is not directed at concrete and asphalt research. It is a large-scale safety accident

causation project, and a large project aimed at renewing our highways in a more accelerated manner with less disruption, longer-lasting afterwards. Another piece is dealing with non-recurring congestion incidents and the like and figuring out ways to reduce that element of congestion. And another piece that is oriented towards planning and environment is looking to streamline ways to plan for new capacity in a more environmentally-sensitive and community-sensitive manner.

I think all those things would fit within strategic objectives that one would come up with for the Department as a whole and our transportation system.

Mr. SMITH. Okay. Thank you. I will have more questions later.

Chair WU. Thank you, Mr. Smith.

Mr. Lipinski. Please proceed.

Mr. LIPINSKI. Thank you, Mr. Chair, and thank you for holding this hearing early on. I know that this is an issue that is really very important to me being not only on the Science and Technology Committee but also on the Transportation Committee. I also have a background in engineering. I studied something called engineering economic systems, which was what it used to be called at Stanford, but there is a lot of operations research, optimization, all kinds of puzzles trying to—we worked on trying to solve, trying to give us the skills to solve these puzzles, which really relate very well here when talking about transportation.

There are, you know, endless possible goals that we could have, and I think it is very important that we are here talking about what these are. I mean, are we just going after, you know, trying to lessen the traffic congestion? Are we trying to cut down on fuel usage? Are we trying to make the roads safer? Then other questions of, you know, talking, besides talking about roads, are we talking about rail? What about just general inter-modal, you know, transportation and not just for people but also for freight.

And you can get into endless questions here, which—and we could so much better, I think, be using our transportation system that we have and planning our transportation system if we really got our hands around some of these issues.

And I am very happy to be here in the Science and Technology Committee and hear a witness talk about how crucial—Mr. Brubaker did—how crucial transportation is to the economy. I hear that all the time in the Transportation Infrastructure Committee but not oftentimes here. So it is good to hear that here.

So I just wanted to—there are so many different things that we could talk about, but I just want to, first of all, a question for Dr. Deakin and anyone else who wants to respond. Are we really making sure or how can we make sure we get the best bang for our buck from money that we are spending here? You know, there are a lot of great ideas, and as you put out that example there, where we put the call boxes out on the road, but we missed the fact that the technology would be changing, and it really wouldn't be that useful.

So how do we—what can we do to get the biggest bang for our buck with ITS systems and the deployment of ITS systems? I mean, I see these signs along the road, electronic signs that I don't

really see that they are being put to much good use, but we put the money out there so——

Dr. DEAKIN. The signs that say, congestion ahead when you are already in a stop-and-go traffic jam aren't particularly helpful to any of us, I think. But I think we are getting better at some of this. There are some technologies that have more applications than others, and this one example I would give you relates to Mr. Smith's question about what do we do about fuel taxes.

We are getting a lot better devices that would let us measure vehicle miles traveled in obtrusive ways, ways that don't invade people's privacy. We all know the fuel tax is running low. You know, we could raise it if there were political will to do that, and it would last for awhile. But cars have to get more efficient. They are going to change. So that doesn't seem to me to be a long-term strategy. And if we started implementing technologies that would let us monitor vehicle miles traveled in cheap, fast, safe ways of doing it, still protect people's privacy, we would also open up the possibilities of congestion pricing in those places where it is needed, and there is political will for it, which is not everywhere, but it is definitely some places. It opens up the possibilities for making it easier for people because I could pay my toll, I could pay my parking, I could, you know, get around in my transportation system a lot faster.

And there are similar things we can do in transit, by the way. So I don't want to make it sound like this is just for highways since there are a lot of options in transit as well. That is almost a no-brainer in my opinion, and it is the sort of thing where the big issue right now is which technology: are we talking wireless, are we talking radio signal devices? So there are technology competitions, but in some ways that seems less important than the fact that we have to start testing those technologies and giving the states both the authority and probably the mandate to do it would be one way to get going on that.

For making sure that these things are cost effective, there is nothing like doing a business case, and that is what I have seen missing is really the development of business cases. And, again, I think business cases are often best developed by third parties who are a little bit at arm's length and not necessarily the advocates of the project just because you need somebody else with eyes on this to make sure that we are really making wise decisions on the investment. That is what we do when the private sector is working properly, and we try to use business cases to test that.

And then post-hoc evaluations: we just haven't seen very many post-hoc evaluations, and again, they have to be done at arm's length, not by the project proponents, because if they are not at arm's length, then they are always a little suspect. So stepping back—and these are the kinds of research that can help. There is a research component to that. There is also practical partnerships that can be done to make that happen better, and I think, again, the legislation could help encourage that kind of arm's length evaluation, learning from that arm's length evaluation would then happen. They could require that business cases be developed. I actually think a lot of the DOTs are trying to do this and would welcome having that kind of support saying, yes, we have to do that, we

have to spend our money in a smarter way than we have been spending it.

And then focusing on outcomes. Are you actually—what are you actually wanting to get from these projects? It is not just turning the dollars out. It is seeing that we actually have a lasting value that is cost effective, and we know how to do that. I used to work in Terman [Hall at Stanford] before I moved up across the bay to the private—from a private to a public sector. So I know the program that you are a graduate of, and as you know, there are lots of people who know how to do these kinds of evaluations. We could put them to work.

Mr. LIPINSKI. Thank you. Mr. Wise, do you have——

Mr. WISE. Yes. I think that something that might be of interest to you either in your role in this subcommittee or on your role on House T&I (Transportation and Infrastructure) is that we have just started recently some work on real-time traffic information systems. This is a subset of ITS. And of course, I defer to Dr. Deakin, who is a recognized expert in this field, but just kind of getting into it in the beginning, we are looking at some areas that I think might be getting at some of the things you were alluding to in your question. And we are looking at things like the cupboards that exist on real-time traffic information technologies, the information that is available on the impacts and costs of the systems, and then I think one of the more interesting aspects is the option for developing a nationwide real-time traffic information system and the potential benefits of, and the barriers to developing such a system.

In different parts of the country, of course, it means different things to different people. If you are in the western suburbs of Chicago, congestion is a major issue. If you have got a 60,000 square mile district, and there is an accident on the interstate, it is good that somebody can know about it. And as Dr. Deakin was mentioning, there are serious questions about the technology. It is a very fast-moving target right now with lots of evolving technology. I think there is some interesting pilot work going on out in the [San Francisco] Bay Area on GPS cell phone technology. I think that the private sector will probably be playing a major role here, and the question is what will be the DOT or the government's role.

So there are a lot of interesting issues out there in this area. I will be happy to keep the Committee apprised of the progress as we work through this issue.

Mr. BRUBAKER. I just want to mention something. On this Safe Trip 21 pilot that Mr. Wise is referring to, you know, that is really something that I don't think would have been done in the normal construct. We actually were able to pluck that out at RITA and sort of lead that but pull together a lot of different modes to make that happen. That is a transit, that is a highway, that is a very—that is an individual mode of transportation, be it bicycle or walking. I mean, there is a whole host of things that play into that, which is really kind of an interesting approach and a unique approach.

But we started with kind of the outcome in mind of what we wanted to present, and as somebody who knows systems engineering pretty well, you know that we have really—we really kind of designed the protocol in a way that would support, you know, that outcome that we wanted to achieve.

Mr. LIPINSKI. Thank you.

Chair WU. Thank you, Mr. Lipinski.

Dr. Deakin, when you referred to Terman, were you referring to a building——

Dr. DEAKIN. Yes, I was. That is the engineering building at Stanford.

Chair WU. I spent many a lovely evening at the Earth Sciences Library nearby.

Dr. DEAKIN. Yeah.

Chair WU. Wonderful place.

Mr. Saenz, did you have something to add to the last back and forth?

Mr. SAENZ. Yes, sir, and I think one of the things when, you know, the question was how do we make sure that we get the best bang for the buck, and you know, I think it starts from being able to identify some goals within your research right now, really some goals in the management of the organization that will lead to some goals or some—and then how do you measure them.

And one of the things that we started doing in our research program a few years back is we put in place the teams at a high level that were the experts, both from, on the Department side, academic side, and even the private side, to identify some goals that we wanted to accomplish in the different—the research management areas.

And one of the things that we really looked for is we wanted to identify some research that would result in the implementation of a technology that would give us a savings. Very similar to what I talked about with—we used some of the national research in the barrier cable, but even within the Department we looked at what can be looked at that will help us create a much safer transportation system, and then how can we measure what we are accomplishing.

And that leads to ensuring that you spend your money in a safe and wise way.

Chair WU. Thank you very much, Mr. Saenz.

Ms. Edwards, please proceed.

Ms. EDWARDS. Good morning, and thank you, Mr. Chair.

For Mr. Brubaker, I wonder if you could elaborate a bit on—and good that you are the former administrator, because I think sometimes we can see things differently inside versus outside, and I wonder if you might elaborate on priority setting. I think it is easy—it is an easy answer to say, well, we just need more money to do X, Y, and Z, and I know that in some of your testimony you focused on priority setting and, you know, rejiggering the kinds of research that we are doing. And so I wonder if you might elaborate on that.

Mr. BRUBAKER. Sure. I would be delighted to.

You know, the—what we have never really done, again, and I mentioned this in my written testimony, is establish this national transportation research agenda, which I believe should really be the driver of all the research investment rather than try to force-fit, you know, activity that we are already doing, things like SHRP, for example, that we are already doing into specific buckets.

And I don't mean to pick on, you know, the Federal Highway Administration, but, you know, they kind of want to be left alone in that prioritization process, as does federal transit, as does rail. Everybody wants to kind of be left alone and do their own, you know, research.

And I think it is absolutely critical that we call a time out, we take a step back, we assess what we want our priorities to be, we clearly state those in terms of what kind of outcomes we want. For example, I had the Intelligent Transportation System Joint Program Office under my purview when I was at RITA. I actually shared it administratively with the Federal Highway Administration, which created some really interesting situations, which I can elaborate on off-line. But the point is that they have always sort of just been doing projects, and what I asked them to do was really focus in on what they wanted to achieve in terms of, you know, did they want to take a safety focus and reduce the six million crashes that we have every year using Intelligent Transportation Systems, making a big dent in the 40,000 lives that we lose every year. And put those, make that a priority. Really design the research program to have a measurable impact on reducing crashes, reducing the fatalities, reducing the $230 billion in economic costs that we incur every year because of those six million crashes. And put it in terms of outcomes. And then how do you basically reverse engineer the research program to achieve those results.

That is the kind of thing I am talking about but on a macro scale for the entire Nation. What are like the five or six things that we really want to accomplish? Reduce congestion, greenhouse gas emission reduction, you know, rural safety. I mean, what are the big impact things that we need to do. Then we need to look at that $2.1 billion——

Ms. EDWARDS. And how to develop a system——

Mr. BRUBAKER. Right on. We have got to take that $1.2 billion and then begin to plan how we spend it to achieve the outcomes in those big areas. So that is what I am talking about.

Ms. EDWARDS. I appreciate that.

Let me just—Dr. Deakin, very quickly, can you talk to me a little bit about what you think the appropriate role for social science research is in thinking about a more coordinated transportation system?

And I want to just share with you, you know, I know locally we, you know, we have an economic development team that works on economic development in one spot. And then you have a set of transportation people who go, oh, we are doing an economic development project. We need to think about transportation. And those things are thought about very separately, and so the rail people are in one place and the roads people are in another place, and it never seems that we are really looking at the linkages there.

And then how are we going to use that? As a consumer, what does a system mean for me? And so I wonder if you could talk about the way that we could use a social science research base to inform more strategic thinking around transportation planning.

Dr. DEAKIN. Yeah. I would be glad to. It seems to me that those linkages are exactly where social science can shine and make a big contribution to helping us figure out how to do this better, because

the social sciences, among which I would include planning and policy sciences in, as well as business administration and management sciences, as part of a bunch of people whose expertise is to really think about organizations and organizational behavior and how to create collaborations. There is a lot of work that has been done in collaborative processes. Some of that is theoretical. Some of it is evaluating different processes to see which ones work and which ones don't and is very practical.

So there is a whole range of social science work that is looking at how different organizational structures—how to flatten organizations because we have got a lot of evidence that flatter organizations are more efficient. But networked organizations, organizations like Google are not highly hierarchical. They are pretty flat, but they have got a lot of networking and a lot of linkages. The importance of informal networks of knowledge as a way of really quickly getting new ideas out in the field.

It is not, you know, that people go and read papers. They call a friend that they know because they met at a meeting or a conference and say, "Hey, what is going on in your field?" or, "What do you think about this idea?", and how to facilitate that sort of behavior instead of punishing it, which actually happens in some of our current organizations. Don't talk to your boss's boss without permission, or you might be in trouble in hierarchical organizations. Of course talk to your boss's boss and then tell everybody what was said is a flat organization approach to that. So that is what is coming out of the social sciences on how to restructure institutions, new institutional ways of doing business.

Studies on public-private partnerships. What does it mean to have a public-private partnership? That term captures a lot of territory, and some of these partnerships work well, and some don't work well at all, and we really need to get that knowledge into people's hands about what has been effective and what hasn't been effective. And it is social scientists who are doing that research.

I think it is a question of specialization. My colleagues who are mechanical and civil engineers and electrical engineers and computer scientists are really good at what they do, and I don't want to try to do their work for them, because, boy, I couldn't do it. By the same token, they are not necessarily very good social scientists. They are not necessarily the best people to be doing evaluations. They are not necessarily the best people to be thinking about markets or institutions. There are other disciplines that do that, and that is where the social science people, I think, really can help us a lot.

Ms. EDWARDS. Thank you. Thank you, Mr. Chair.

Chair WU. Thank you, Ms. Edwards, and since we have had a couple of folks on this side of the aisle, Mr. Smith, why don't you proceed.

Mr. SMITH. Okay. Thank you, Mr. Chair.

Mr. Saenz, in your testimony you state that the boundaries of various State and federal programs need to be defined more clearly. Can you describe how the multiplicity of R&D programs affect the planning and operations at TxDOT?

Mr. SAENZ. A lot of times as we are doing our work we work with different areas. We got planning, and you have the, more of the

technical side, and then sometimes we don't have the good communication or the good coordinated effort. What we have been trying to do at our level, at the State level, is, as I do have the research management committees, we also have an oversight committee that is made up of all of the chairs of our research management groups, as well as our key administrative staff of the Department so that when we can coordinate and then we can—that way we can communicate with the different areas as we go up to the federal side.

We just, all I think we need is more cooperation, more coordination.

Mr. SMITH. Okay. Thank you very much. You know, it is interesting as we hear, you know, kind of a request, somewhat of a request for more clearly-defined programs, you know, that, if you get too detailed, then I think we discourage that cross-communication. And so that is interesting, and I am not criticizing your suggestion for more-clearly defined responsibilities, but do you sense any obstacles such as that?

Mr. SAENZ. No. I think what we are trying to get is I think we need some definite goals and then we can work together at both the State and the federal level to identify these strategies as well as the implementation plans. And then at the same time we can define the roles and responsibilities of each so that we don't have the duplication of efforts, and we in a sense get more done with less is where we are trying to get at.

Mr. SMITH. Okay. Thank you.

Chair WU. Thank you, Mr. Smith.

I have two major areas that I want to explore and then two smaller areas, and at least in this round the major area I want to open up to the extent that folks don't want to continue talking about cultural issues or inertia, because I want to fully explore that topic before moving on.

But in a related field a number of you have referred to a concern about developing a coordinated research agenda in moving to outcome-based measures, and I wanted you to finish addressing any of the cultural and inertia issues that we face, and the challenges of moving to a coordinated research agenda. And what would be outcome-based metrics and to give further examples and then elaborate on your written testimony.

Whoever wants to begin to take a cut at those areas.

Mr. Brubaker.

Mr. BRUBAKER. If I may, yeah. And I will try to keep my answers a little briefer than they have been in the past here. I am just remembering from my staff days. The, you know, it is really interesting that as we look toward developing a coordinated agenda, to understand that how we move people, how we move freight today is multi-modal, it is multi-dimensional, it is multi-disciplinary and keeping that in mind. So you have got to bring—and I think Dr. Deakin really nailed it when she said, you know, how you approach these things. It is not just a civil engineering problem. It is an electrical engineering problem, it is a, you know, structural engineering, it is social science, it is economists. All of them have to be in the room to help develop this thing.

Chair WU. So the problem is siloed——

Mr. BRUBAKER. Siloed thinking. Right. You know, you go to, I mean, and here is the problem that I have got, and with all due respect to Bob Skinner and TRB and Federal Highway Administration with SHRP, is that it is housed in Federal Highways. You are more likely to get a Federal Highway type answer to the question, even though it might be taking advantage of a multi-modal problem, even like cooperative freight research, for example, you know, we have done research and funded research and are aware of research where we track shipments of things like seafood from the Pacific Northwest down to the Southeast of the United States. And we see that it travels by short-sea shipping, it travels on rail, it travels on the highways. So you have got to have an in-depth understanding of all those things, plus the economics, plus the behavioral issues, you know, to really understand how that system works holistically.

I keep coming back to this term, holistic, because things really are multi-dimensional and multi-modal and multi-disciplinary, and you have got to break down that siloed thinking, and there is really no place in the Department I think to do that other than RITA.

Chair WU. Anyone else?

Mr. Skinner, since you have been referred to.

Mr. SKINNER. Yes. Well, let me just—I just want to emphasize what I think is, that it is an enormous challenge to have a broad, integrated research plan.

Chair WU. Uh-huh.

Mr. SKINNER. The transportation sector is roughly the same size as the health care sector, and so imagine what our comprehensive health care research R&D program would look like. Now, I am not saying we are as good as the health care sector in constructing a research plan, but I just want to stress the enormity of the task that would be before us.

And linking that, I think the strategic plan, yes, it has to think about the goals, it has to think about outcomes. But it also has to think about processes and how do we allocate our resources across the entire innovation cycle so that some research that is of a highly-applied nature, relatively, can be implemented fairly soon, and we can judge it pretty easily, perhaps with respect to its rate of implementation and its outcomes.

But for other research such as, say, the SHRP work on understanding accident causation, crash causation it will be years before that fairly advanced research is translated to specific changes in the way the vehicle is designed or the roadway is designed. But it holds the promise of giving us the knowledge that we need 10 years from now, 15 years from now, for having breakthroughs in understanding the interaction between the driver and the vehicle and the roadway in accident causation.

Chair WU. Thank you for that insight, Mr. Skinner. When you think about it, the health care sector, the transportation transit sector, and the housing sector are roughly equal in size. If you consider the amount of research that goes into each of those and the nature of that research, it is very, very different. And if you consider energy savings, the building and housing sector is much more ripe than either transportation or some of the other areas.

Anybody want to address the out—I am sorry. Dr. Deakin or anybody else wants to address the metrics side of this challenge? And Dr. Deakin, you may have something on the existing topic.

Dr. DEAKIN. Yes. Actually, I have been doing some research on how other countries are actually handling this problem of a research agenda, and we are falling behind our competitors on this. The EU countries, Canada, and Australia all have been trying to develop these kinds of strategic plans that are really focused on outcomes, and the kinds of outcomes they are measuring: Are we getting good value for dollars spent, and what is good value? They are measuring, are we getting faster, cheaper, more reliable transportation service than we would have without that investment and for how—for what period of time, because not all of them last forever. Are we reducing greenhouse gasses? Are we reducing pollutant emissions? Are were providing better service to everybody? Is service equally, you know, equitably distributed to our population?

So those are measures of outcomes. You know, is there—basically they are looking for economic performance and economic development is certainly one of those things that you want to measure, you know, did it help get you better, you know, more access to jobs?

We can argue about how to actually measure those things, and there is a lot of research actually that has been done on what are good performance measures and not-so-good performance measures that we can look to on this.

So I think measuring outcomes is something we can actually look to our trade partners for and see how they are doing it, borrow their ideas, and build on what they have done and go a step farther and get ahead of the game on this. So I don't think that is—that part I think we could do pretty easily.

I think there is a difference between focusing on what to do and focusing on what to achieve. I mean, what to achieve is the outcome measure. With what to achieve you might say to people, you know, you decide what is the best way to improve the reliability of your transportation system, but you have got to show that the reliability is being improved. And they pick—figure out what is the best way for them to do it in their own situation.

An output—that is really different from saying a highway design manual where you have to look it up and do it by the book, and we have done I think a little too much of the "by the book" we are going to tell you how to do it, and not enough of the, we are going to focus on what you accomplish by making those investments.

The final point I would make, and this is echoing something Bob Skinner just said, sometimes we do need to set aside money for research that is not immediately tied to a product, because that long-term research is incredibly important. And I want to speak on behalf of CalTrans on this. CalTrans had the confidence in its universities, they gave us matching funds for our transportation center funds without earmarking a penny of it. They didn't tell us what to spend it on.

And we ended up with a very mixed portfolio of projects, some of which were applied and actually were done with CalTrans, but some of which were on topics that weren't on the national or the State agenda, including research that was done on what we could accomplish in transportation systems with new fuels, new vehicle

technologies, and other technologies, and travel demand management strategies, transportation pricing studies, all of which were done well before any of this hit either the State or the national agenda.

And because of that I think we are way ahead of the game in being able to provide leadership on these issues as we are coming to the conclusion we need to address these kinds of topics now, because we have got that research that started in the late '80s, early '90s that we kept building on it, and it wasn't, we couldn't have said at that point, what did this study on transportation pricing alternatives actually do for CalTrans or for anybody else for that matter. But now we can look at that study and use it and say, well here are some ideas, and here are some analyses that actually show you what we might be able to accomplish if we did a VMT (vehicle miles traveled) price instead of a fuel tax, or what we might get if we did congestion pricing and how effective it would be, and where it would be. And oh, by the way, what are the politics of congestion pricing in our major metropolitan cities, because that is not a straightforward thing.

So we did that research, there wasn't a clear tie to a deployment immediately, but it has helped us 10 and 15 years later.

Chair WU. Terrific. Before I turn to Mr. Smith, anybody else on this topic?

Mr. Smith, please.

Mr. SMITH. Thank you, and anyone wishing to respond to this, but when we talk about the matching fund requirements and changing those to a heavier federal side of the funding, what do you think, how would that impact, obviously it would free up funds locally or at the transportation, the TRB, and given the fact that, and we have heard criticism of current research programs as lacking the technology transfer, are the UTCs (University Transportation Centers) capable of turning long-term projects into the real-world benefits given a funding, matching, matching funding change?

Mr. SKINNER. Okay. I will start. I imagine this is a topic others will address. You have a center director here with us, and you have the former administrator responsible for UTCs.

And the—as mentioned in my testimony, a committee that we had that looked at the Federal Highway Administration's research program, which—of which a big component of UTC research is highway research. That committee recommended that the matching percentage drop from 50/50 to a 20 percent match. And the argument there is that many states were not operating in the manner that Dr. Deakin described for California in that they were—they did have expectations if they were providing matching funds, and those expectations were towards fairly highly applied research products.

And the universities have this opportunity, which Dr. Deakin has explained, to do longer-term, higher-risk, blue-sky research on the areas that we haven't thought of, and our committee felt that that was being stifled to a degree by that matching percentage. And so if the matching percentage is reduced, the universities would have greater autonomy in setting their own agendas. There would still be the opportunity for overmatches by states and others. Some uni-

versities, no doubt, would choose to continue to do highly-applied research, but other universities might choose to go off in the direction of longer-term, higher-risk research, and others might have a mix like Dr. Deakin described.

Chair WU. Mr. Smith, may I jump in just for a second?

I understand where we are going with this change from 50/50 to a 20 percent match, but can't you earmark just as effectively with a 20 percent portion and leverage the other 80?

Mr. SKINNER. I think in certain cases that would happen, but I think it would certainly happen to a lesser degree with 20 than it does with 50/50. As you said, even, as Dr. Deakin explained, even with the 50/50 California allows quite a bit of latitude.

So I think it is, I think our committee, you know, whether the number should be 30, should it be 15, should it be zero. They settled on 20 as a step in the right direction.

Mr. BRUBAKER. Okay. I will go next.

On a non-controversial subject, you know, my experience with the 50 percent match is that it works, and it leverages the dollars that we invest into the system.

I come back to the—sort of the fundamental objective for what historically we have tried to achieve under the University Transportation Center Program, and that is training the next generation of transportation leadership. That in many cases, in fact, in most cases involves training individuals who go out and work in the field. Work in the field on applied—on real live applications, things they need to do.

So there has been a criticism that the program is a little too focused on applied research, and I don't know that that is such a bad thing when you are actually training people who need to go out and work in the field and be marketable. And if they are doing really the squishy, sort of basic research that, where there isn't really a solid performance-type outcome but it leads to other research or further sustains the knowledge, which by the way, is very good, then, you know, I would expect that person or those people to be a little less marketable or a little less attractive to the field.

So, frankly, I think the program has been fairly effective. I think, well, actually, not fairly effective. I think it has been very effective in the current mix and how things are sort of arranged, and I would hate to see us tinker with something that I think is fairly well leveraged today and fairly well balanced and produces the result that we expected to create.

Mr. SMITH. Anyone else wishing——

Dr. DEAKIN. Yeah. I obviously have a self-interest in this topic. We have over 100 faculty members in the UC (University of California) system who participate in the UC Transportation Center, and we let any faculty member who does transportation research at any of our campuses compete for funds. The funds are reviewed entirely outside our university by people who don't have any close connections. It is an NSF (National Science Foundation)-kind of review process. CalTrans also reviews them and then we meet and prioritize which ones will be funded.

We use the USDOT research agenda as one of the bases for prioritizing what we fund. We also use Cal Trans research priorities since they are providing matching funds. We, as I said, end

up with a mixed portfolio. We have produced literally 100 students a year for 20 years who have gone to work in transportation. So that is a pretty big chunk of people coming out of that program for the investment. And many of them have now risen to positions of leadership. In my home state, in California, both assistant directors at the Metropolitan Transportation Commission are graduates of our program, Jose Luis Moscovich of the San Francisco County Transportation Authority, Christine Monsen of the Alameda County Transportation Authority, Malcolm Carson of the LA DOT Commission for the city, and I could go on and list all kinds of people who have been out of school for awhile and have now risen to positions where they are in considerable positions of authority and are really providing a lot of leadership.

So we are pretty proud of that as part of our product in addition to our research product.

Frankly, we couldn't have attracted some of those students into transportation, into transportation as opposed to another area of work, if we hadn't had the ability to offer them fellowships and graduate research assistantships through our research. And if we got hit with a cut, and you know, CalTrans might be generous enough, but our State budget is in a terrible situation so I am not so convinced, we might get some of the match. They might not be able to do it. I don't think it is because they don't love us. I think they do love us. I think it would be because they don't know where their next dollar is coming from.

So that kind of a loss of match would certainly hurt us, would hurt our ability to produce the students, would hurt our ability to produce what I think has been overall a very positive set of research findings, many of which have been implemented, many of which are changing policy and creating new ideas all the time.

So, you know, it is basically a cut in funds for the transportation centers, I think, is the only way to realistically look at that. It doesn't mean that we couldn't make it up later when it looks like CalTrans might not, we might have a budget this year in California. I scrambled around and looked at foundations and found money from Hewlett and the Energy Foundation, but even they, now with the downturn are telling us that they lost 30 percent of their endowments. And so that is not even going to be easy in the future.

So I think you have to look at it as if you cut it to 20 percent, it is going to be a cut in the amount of funds, a cut in the amount of the research, and a cut in the amount of product that you are going to get, and that is the only way I can interpret it.

Mr. SMITH. Thank you, Mr. Chair.

Chair WU. Thank you, Mr. Smith.

A number of you have referred to technology transfer problems, consulting with end-users, implementers before proceeding on research, in the course of research, and in implementation phases. Could you expand on some of the pinch-points, some of the impediments, how to overcome them, your recommendations for more effective tech transfer going forward?

Whoever wants to start. As an end-user. Mr. Saenz.

Mr. SAENZ. And I think I will tie it really to not just the research program but the—anything that we do. We in Texas have 25—the

state is broken up into 25 districts. Sometimes I think we have 25 Departments of Transportation, and a lot of our district engineers in a lot of those offices work independently, and they try things, and they do things, and they evaluate things, and they identify best practices. And even within our state we were having problems in sharing that information so that the state could benefit as a whole.

One of the things that we have been trying to do as a whole is, under my administration, I put in place an assistant executive director that is working with all of our outside offices to ensure that we do get that kind of information collected, presented, using different methods through, either through reports, through being able to use technology, chat rooms so that we can get that information to the other people across the state because we can generate some efficiencies.

The same thing can be done on the research program. We already communicate closely, but I think we always need to look at what we are doing today and how we can make it better. Because we thought we were communicating as a state in sharing information district to district because they communicated, but we found out that there was a lot of things going on that one area of the state did not know anything about.

So we need to always go back and look at what we are doing, how we are doing it, how we are sharing it, and how could we ensure that we are doing it. Again, you measure your success of what you are doing.

Chair WU. Thank you very much, Mr. Saenz.

Mr. Skinner.

Mr. SKINNER. We could talk all afternoon about tech-transfer, and I would probably enjoy it. We manage cooperative research programs, what we call cooperative research programs in highways, transit, and airports. Each one of those programs is governed by a committee that is not created by TRB. It is a—the institutional arrangements vary, but for example, the committee of—the research committee of the American Association of State Highway Officials governs our highway cooperative research program, and the Secretary of Transportation appoints the governing group for the airport program, and so on.

These programs are highly applied, and so the tech transfer problem is not nearly so great for that kind of research, because stakeholders know what their problems are, they program money to deal with those projects. Oftentimes they are connected with the association committees and the operators. And so the panels that we put together that steer the research have the people on-board that would help with tech transfer later on.

So that those kind of programs work very well, but I would never claim that the entire research program should be comprised of these programs. They are—they don't handle crosscutting issues very well. They are at the highly-applied end of the scale. They are not doing the longer-term stuff. And for the kinds of programs implementation is a considerable challenge, particularly when it must ultimately trickle its way down to county road officials.

So they are relying on, you know, there is no perfect set of things. The Federal Highway Administration has a Local Govern-

ment Assistance Program. That is good. Many local governments have terrific relationships with states and depend on the—depend on minimizing essentially State practices and materials and designs. MPOs—Metropolitan Planning Organizations—probably depend heavily on their own network and individual contacts for improvement in planning methods. And champions in getting states to go out and pilot and then lead the way for others is terribly important.

So, again, I just would stress that this is a complicated subject. There is no one answer, and there are a lot of different tools in the toolbox that have to be employed.

Chair WU. Well, believe me, we work on tech transfer, whether it is from NIH (National Institutes of Health) labs to transportation to nuclear detection, and I guess it is what I think Boswell or Johnson said about dogs walking on their hind legs. It is not done well, but one is amazed that it is done at all.

Mr. SKINNER. At all. Right.

Chair WU. And a lot of the world thinks that we do it better than most, but I am kind of amazed by that, too.

Mr. Brubaker, you had something to say.

Mr. BRUBAKER. Ditto. I couldn't agree with you more. Yeah. I mean, fundamentally, and I am going to say something which may be a little controversial here, but it is designed to have a little bit of an impact, but I don't think tech-transfer is truly a priority of the Department's research program, and it needs to be. I think the priority needs to be clearly stated. I think it needs to be programmed. I think you need to take some element of existing resources and direct it toward a tech transfer and commercialization-type activity.

I used to serve as Chairman of Virginia's Innovative Technology Authority, and that whole authority was established almost exclusively and initially, when it was initially established to do tech transfer from Virginia's colleges and universities and laboratories and to ensure commercialization of the most promising technologies. And Virginia, frankly, had done a really good job of doing that, and helped manage the SBIR (Small Business Innovation Research) program, and the context of tech transfer and doing some other things.

So I come at this with that background. So I actually believe that there should be a very deliberative program, activity around technology transfer and commercialization where we can glean some best practices from some of the universities that do a really good job, some of the State associations that do a really good job, some of our overseas, you know, folks who do a really good job of it. Glean those best practices and apply them.

I am amazed at some of the things that I have seen in terms of technology transfer by some of the universities, particularly, I mean, I think UC–Berkeley has a good program, I know Texas A&M does because we have gotten underneath it pretty substantially, and I think there are some clear lessons that can be learned by that.

But I am perplexed because—and I do think this is, again, a function that really needs to be in RITA, and I will tell you why. Because I am really perplexed by how you can promote something

like the Universal Freight Shuttle that was developed out of the Texas Transportation Institute, which is effectively a new mode of transportation. It is a monorail effectively that uses individual rail cars that move freight containers through—from, you know, ideally when it is originally, when it will be deployed, it will be Monterey, Mexico, through Laredo, up to a land port in Dallas, Fort Worth. At least that is the initial design of it. But it doesn't fit nicely into federal railroads, it doesn't fit nicely into highways, but here this is this great innovation, and I know that they had a heck of a time trying to figure out how to commercialize something like that, how to get the knowledge out.

One of the things that I think we fall victim to in the Department is we tend to have researchers and create forums where researchers talk to other researchers, which is a form of tech-transfer, but it is not necessarily getting the technology out in a forum where it can be effectively utilized.

So I think we need to take a look at this. I think the Department needs to make it a priority. It should be a priority in the next reauthorization, and it should be programmed and resourced effectively.

Chair WU. Thank you very much, Mr. Brubaker.

Anyone else on this topic of tech-transfer, impediments, and procedures going forward?

Dr. Deakin.

Dr. DEAKIN. I think there has been a model of tech-transfer that it is something that happens at the end of a process, that you develop research and then you move it forward into refinement, after refinement, and then eventually you deploy it, and at that point you start doing tech-transfer. And that is, I think, a recipe for failure, that kind of a model. I think you have to start thinking about users, demand, markets in the beginning, and one of the—if it is short-term research as Bob Skinner pointed out, that is easier to do than if it is long-term research. But in other areas we have business councils and business science, science councils that help talk about these things and keep this on track. And there are other mechanisms I think that could be devised that would help us integrate thinking about what is—where are we headed, what is the vision for this, what is the scenario that we have in mind.

Mr. Saenz was saying to me that he thought that the things we ought to be doing are scenario planning and use, having think tanks but also doing scenario planning and then doing evaluations on projects. Each of those could use some guidance from people who are really thinking, what is the vision here that we have. Is that a realistic vision, challenging that at the beginning, sharpening up that vision of where it is going.

Let me give you an example. A problem we have in California a lot is that people say, gee, if we could manage the freeway system and the arterial system as a couplet, then everything would be a lot more efficient, and we could spread traffic around, and we wouldn't have so much congestion. We could put, you know, make use of the capacity better. Well, if the arterial happens to be the kind of arterial where having more traffic on it is okay, that might work. But two-thirds of the time, in my experience, those arterials are also main street, residential streets, shopping streets. They have got all kinds of other values associated with them, and maxi-

mizing throughput is not the objective of the owners of those facilities.

And so we actually had to change our thinking about that and recognized that we have to do context-sensitive design and context-sensitive operation. But I still hear some of my colleagues on the technology side say, gee, if we could only operate this system as a whole, not even recognizing that there are these other values that have to be brought in.

And that is just a question of not communicating with the right people, because other people could tell them, let us talk about the context in which that will work and the context in which that won't work.

So starting to think about deployment, starting to think about markets and public consent and people's values and what is being proposed fits with values and markets and preferences really from the beginning seems to me to be critical to make tech-transfer work.

Chair WU. Thank you very much, Dr. Deakin.

Before we turn to what I hope to be one final topic here, Mr. Skinner, since I made an at-best neutral comment about one of your findings earlier, I wanted to return to that and give you a chance to address it.

In your written testimony there was a number of a $400 million increase in research funding, and before we head into a, shall we say, disjuncture between aspirations and resistance to additional research funding, I want to ask you about where you get your number about 0.9 percent of sales, research for transportation versus 3.6 percent of sales in other industries. And then, and also to give you a chance to address what I take you to say as not just an increase in current surface transportation research but perhaps a reorientation of that research into other fields where there may be current research going on but to associate that with transportation.

Please proceed, Mr. Skinner.

Mr. SKINNER. Thank you, Mr. Chair. That is quite a lot. Let me first start by saying that I certainly didn't want to leave the impression, and I don't think our reports wanted, committees wanted to leave the impression, that the answer is money, and money alone.

Chair WU. We have parallel goals.

Mr. SKINNER. That regardless of what—of the resources that are available, there are a variety of things that our committees have documented—and are in my written testimony—that we can do to make our research programs—technology programs more effective.

The 0.9 percent of total expenditures is arrived at simply by adding up all of the highway research program spending that we can find in the United States and comparing that to total highway expenditures, and that compares with this, you know, three percent figure, which comes from—it is not compiled by us. It is probably compiled by the Commerce Department. It is referenced in our report.

And I think you will find in the private sector that even mature industries spend at least one percent and——

Chair WU. Let me ask you about that. You are probably including industries like pharmaceuticals where the spending is in the

mid teens. You might be including technology industries where the spending is at a slightly higher percentage. But if you compare it to, shall we say, heavy industries, like steel or ag, that might be perhaps more—although it is unfair because we are also talking about computer systems and transportation.

Mr. SKINNER. That is right. You are making my point, that it is quite a range. It is one, you know, one to ten to fifteen percent, depending on these very high-tech industry and the like. And my point there is that this is not a low-tech industry. Yes, we have very mature technologies that are difficult to change like asphalt and concrete, but we have Intelligent Transportation Systems, we have very complicated institutional problems that the private sector doesn't deal with. We have behavioral issues related to safety, and travel demand, and the like.

So, yes, you know, as to where we should be in that spectrum, we are just observing that we are on the, you know, on the low end.

Chair WU. So it is different percentages, if you will, different—a different baseline for different parts of transportation research because it is a large segment of the economy just like health care, just like construction.

Mr. SKINNER. Right. I mean, we spend, I think, probably three times more to try and save a life in our cancer research than we do in research related to highway safety. So—but now let me—so that is the first number. Where I got the 0.9 percent.

The other one was the $400 million, which is relating to, you know, the total expenditure that we estimated in a Congressionally-requested study on the implementation of the Strategic Highway Research Program products. And there is a little bit of a crystal ball work there because the research program is still just fully underway, and we were required to submit a report this year.

But it is, we—it is illustrative of how much importance our committee placed on the tech transfer process and its complexity. In this particular case I will say that there is a bit of apples and oranges, because this—I referred earlier to the accident causation piece of it, where at the end of the SHRP program, we will have a very large database. So the $400 million also includes the care and feeding of that database, as well as further research on the—on that database, which will hopefully give us the products that will make their way into vehicle design and roadway design.

Chair WU. Now, do you have a recommendation about a proper amount of funding for the next appropriations period, for the next highway bill period, and what the uptake limitation might be for the research infrastructure that we currently have in place?

Mr. SKINNER. Thankfully, I do not have a recommendation.

Chair WU. I will tell you what. For each of the panelists and your friends in the research community, that is a question that I am very, very interested in, and I am sure that other Members of the Committee would be very interested in that as we develop the research title of this reauthorization.

Mr. SKINNER. Right. I mean, our committee has, you know, we have observed that we could, you know, we could—more money could be justified, but certainly if the money were doubled or something of that nature, there would be the capacity issue that you are referring to. And regardless of the money, there are a host of re-

forms that we can make to make the overall program more effective.

Chair WU. Terrific. Thank you very much, Mr. Skinner.

Anybody else on that topic before—Mr. Brubaker.

Mr. BRUBAKER. Yeah. I mean, I come back to this that I said in my oral testimony and that I referred to in my written testimony, and that is that I think it is really difficult to assign, I don't know how you can assign a number as to what the right number is for what we should be spending on transportation research.

I go back to that national transportation research agenda as sort of being the driver. The right number is the number that it takes to spend on research to achieve the outcomes that you are looking to achieve. But I would really caution that the thing to do or to ensure as part of the process is that there is an ability to select, control, and evaluate the research portfolio. That is—and I view that as an inherently-governmental function. It should rest somewhere in the Department. In fact, I think it should, the development of that plan and the monitoring, the execution I believe should rest in RITA.

You know, and moreover, I mean, if somebody really wants to increase the funding, maybe make it, maybe gate that funding, maybe make it, you know, there is a percentage increase that increases every year of the authorization where, perhaps, it is predicated on successful implementation of such a construct of oversight, if you will, where you are actually controlling and evaluating those underlying research programs.

That I think would be a responsible, frankly, approach to that type of a discussion.

Chair WU. Terrific. Thank you.

Dr. Deakin.

Dr. DEAKIN. I guess I take a slightly different way of thinking about this myself. We could draw a technology innovation curve and think about that as when you are first starting to develop technologies, high risk, potentially high payoff, you have to spend a lot of money on research. When technologies are well understood, well deployed, the rate of change, rate of innovations slows down a bit (and this is over-simplification, obviously), you don't need as much research money.

And so the question is not just a question of how much do you need in transportation but what are you going to do in transportation and where do you want to put that money, on the innovations or on the stuff that is relatively stable? And that is a curve, and you can actually do an analysis and figure some of that out, I think, a little better than maybe we have done in the past.

We have had a tendency to staple together everybody's proposals in the past, and stapling is not the best way to do this, I don't think.

The other piece of it is, I think, this is a huge question about what you want to count as being as part of the problem, part of the problem set. If you think about the supply of transportation, just the supply, you have got vehicles, fuels, operations, and facilities. And DOT doesn't do most of the vehicles and fuels. Those are actually private sector, EPA (Environmental Protection Agency) and DOE (Department of Energy). And if you are going to talk

about transportation systems improving as a whole, and you are only talking about the facilities and operations, you are already shooting yourself in one foot. If you don't recognize that the private sector has to be part of that discussion because they are producing most of what we are talking about, you are shooting yourself in the other foot.

So it seems to me that that is a big issue that the way DOT has been organized and the difficulty that DOTs had, not just internally, which Mr. Brubaker spoke about, but also in creating those partnerships that go to EPA, that go to DOE, that go to the Department of Agriculture, that go to Housing [and Urban Development] (because there is a big housing and community development aspect) that go to Commerce on the economic development aspect, are also part of what would really have to be discussed seriously here. And that affects how much money you want to spend in research. You know, it doesn't seem to me that all the research is necessarily going to be inside Department of Transportation. It might be in these kind of new forms of organizations that might be semi-formal, that is they might be partnerships mandated by Congress among agencies that create networks and advisory committees to supervise how the dollars are spent.

They are really different from what you have been doing. They are not all internal. It might not be in RITA at all, or it might have RITA manage part of the process but have to be told to create these partnerships and do it in a different way.

So I just think we could open this up and really think about it differently.

Chair WU. And that is part of the opportunity and the frustration of this moment. You are quite correct that the transportation issues are not just in DOT, and it would be much better to have linkages between DOT and DOE, for example, but this committee, or this, the larger Science and Technology Committee, does have jurisdiction over the research components of DOE and DOT.

And the opportunity is that the new Energy Secretary is very, very enthusiastic about moving forward on a broader front and coordinating with other agencies and is very cognizant of issues of culture and inertia.

In fact, to speed up the research process in his agency, he is looking at bringing in folks from ag because they have dispersed funds faster, traditionally.

Mr. BRUBAKER. Right.

Chair WU. So that is part of the reason why we focused on cultural issues a little bit because, you know, there is a lot of discussion about how to get agencies reoriented to address issues. I mean, we push legislation out of here, and we kind of assume that it is done when we push legislation out, and it could be three to five years later and it hasn't hit the ground yet.

Mr. BRUBAKER. Right.

Chair WU. And I just want to be very sensitive to the multiple layers that it has to go through before it hits the ground.

Mr. Brubaker.

Mr. BRUBAKER. Can I—I would like to add something to that because I think we did something fairly unique when I was over at DOT that in the alternative fuels arena where we did engage the

Department of Energy, and we had really close relationships with the folks in EERE, on—the Energy Efficiency and Renewable [Energy] folks. We had good relationships with them, particularly as it related to hydrogen fuel cell vehicles and battery development and some of the things that we were really interested in.

To my knowledge, and I don't know, I hope that that activity is still going on, but that was informal, and I think as we begin to have, you know, a new generation of people who come into the government, government service, and are used to collaborating and are used to dealing with Facebook and are used to picking up the phone and asking people questions no matter where they sit or what organizational stovepipe they are in, that is going to be more of the rule rather than the exception.

But I will tell you, I got a lot of raised eyebrows when I first started to engage our colleagues at the Department of Energy on these issues, and initially, you know, there was some dancing around, turf battles, and, you know, like whose turf is what, but when we broke through all that stuff, I think we had—and they played an integral part in the success of a hydrogen road tour that we did over the summer where we took a fleet of hydrogen fuel-celled vehicles from Maine to Los Angeles, across the country. And we were in lockstep for that particular project. That wasn't formal. It wasn't mandated by anybody. It was just something that we did.

At the same time at the secretarial level we were not at the plate at all when gas prices were going through the roof, but the impact that those fuel prices were having, you know, at—on the transportation infrastructure, on our supply chain, our passenger movement system was profound. And it is unfortunate, but I almost think it is sort of a generational issue where people are used to collaborating who—when they are somewhat younger or more, you know, more interested in that sort of thing. And when you get to sort of the older folks who are used to working in their rigid agencies, and you know, they are getting advice that they have to stay in that lane, that occurs. And fortunately, I think technology is going to break down all that stuff ultimately but—and create new paradigms for work, but I just wanted to offer that concrete example, although it is not a concrete example.

Chair WU. Thank you very much. I have always thought of myself as a young pup, but now as I get older I find that, you know, I am more sympathetic to the old dogs and maybe I am one, but there has been constant reference to the sociological aspects of organizations and technology and a more intermodal approach rather than a pyramidal approach to problems and organizations.

Anybody else on this topic before we move onto my final one. And I will also give you all a chance for a catch-all at the end of this.

Well, for me the last topic I have is the proposals for reorganization of UTCs or organizing them differently. We have already addressed the splits for funding matches, and we might return to that at a different moment in time as we get closer to reauthorization, but there has been some discussion on a competitive process versus whatever you would call the process that we currently have. It occurs to me that we have 50 centers, we have 50 states. That could be a coincidence, but, you know, I know that coincidences do occur. I just haven't seen one in Washington yet.

But to the extent that any of you would like to address the—what it would look like to have a competitive system for UTCs and awards, what the criteria would be, I would like to hear your—I would like to have your input on that topic.

Mr. BRUBAKER. Mr. Chair, I don't mean to—I am very, I hate to say this in this way, but I can't think of a better way to say it. I am passionately indifferent to whether they are competitive or not. I have seen ones that have been competitively awarded. I have seen ones that are earmarked, and both to a large extent are effective. There are a handful that may need some help on both sides of that equation, you know, so I, frankly—it is not one of my—the recommendations that I am passionate about in any way, shape, or form.

So I just think, you know, not that I want to say don't rock the boat on this thing, but it seems to be, the system seems to be working reasonably well. I am a big proponent of competition. I love competition in contracting and you know, everything else, but the reality is I think we have struck this delicate balance, and it is probably best not to expand or contract in terms of the number of centers; contract because I don't think you want to deal with, I don't think anybody wants to deal with the political fallout that is a grim reality of this situation. But at the same time I am more focused on what can you do to make whether they are earmarked or competitive more effective.

Chair WU. Well, I was not aware that this issue existed until fairly recently, and I guess I am trying to decide, Mr. Skinner, whether I should be passionately indifferent or, you know, passionately care about this.

Since you all have had some recommendations, let us hear from you next.

Mr. SKINNER. Yeah. I think on this topic, and I think I am on firm ground in saying that throughout the work of the National Academies, that we consistently come down on the side of competition and merit review as one of the hallmarks of quality control in scientific research.

Now, does that mean that someone can't do excellent work at an earmarked center? No, of course not. And the program is fairly mature now, so that it is conceivable that the current portfolio of centers is better than the ones that we had 15 years ago.

But I do think that if one did want to open up a purely competitive environment and restructure the program in that manner, I think there would be this question that Dr. Deakin alluded to—is the dual purpose of the program; research on the one hand but also attracting young, talented professionals into the field and giving them a good educational experience.

And that—it is not that you can't do both of those things, and probably there are many people in this room that were in programs that did both, but I think it would require some thought. Because there are other ways to provide support for graduate students besides University Transportation Centers programs. And so that would have to be considered if we were starting from scratch.

Dr. DEAKIN. I would say that the centers actually started out as a competitive program in the first round in 1987. Unfortunately, the competition was organized by federal region, and transpor-

tation excellence isn't necessarily distributed evenly by federal region, and so that wasn't purely competitive in the way I would think you would want to organize it.

If you look at the earmarked centers, they are a very mixed group. Some of them are top research universities. Two that come to mind immediately are Northwestern and Minnesota, either of whom would be able to compete very effectively for research dollars. Some of them are much more modest, local teching colleges that are not known particularly for research, and their research is modest, and I would actually leave it to their own State and local people to tell us whether they are producing the people that they need, because I see those as workforce development investments for those centers.

And I think RITA has encouraged that aspect of it, that they really try to make sure that they are measuring whether their people are ending up going into transportation jobs and being productive in those jobs. So looking at that dual role, that has certainly been an issue in this business.

One thing that I've thought about that might be a way to manage this process, I believe in competition. I think competition sharpens everybody up, makes us all work harder, think harder, try to get creative. It is good to get a push, so I don't mind having to compete. I think it is actually good for us, and if we got our comeuppance, I think it probably would teach us a lesson. So we would do better the next time. So I support competition.

One strategy that has been discussed and has operated in the past has been you got an earmark but then after a few years you are expected to compete, and there won't be as many centers as there are competitors or maybe new people can come in and compete as well. And I think that has actually worked pretty well, because it is removed from the process some centers that really weren't able to be productive and let other people who might not have either the political connections or the famous professors yet——

Chair WU. Uh-huh.

Dr. DEAKIN.—to get into that process, and some of those centers have really developed and become good research centers frankly, so—from the earmarked center. So I think we have seen the earmarks being productive in both producing people and producing research in at least some cases that would be competitive on any ground.

So I would say go for a process that encourages competition periodically after an initial period, even if there are earmarks, because that sharpens everybody back up. Let those centers that haven't been able to get their act together and perform be removed from the process in a rational way, and let other people take a chance and say, we want to do this, we think we can, and go for it.

Mr. BRUBAKER. Yes. I just—if I can add one additional thing, though, I want everybody to be really clear that the money that is designated for the UTC Program only represents a portion of the work that gets done. Obviously you have got the match issue, but frankly, most of the UTCs that I go to get, collect a lot of additional money from Federal Highway Administration, Federal Transit Administration, really the Department of Transportation, as well as

the private sector. They do privately-funded activity that builds on that foundation, whether it is an earmarked UTC or a competitive UTC.

So, I mean, they have sort of stood alone, for the most part they kind of stand alone and have their transportation credibility, if you will. You know, they are—and I think that is a relatively positive impact.

Now, there are other universities out there who are not UTCs at all who get millions of dollars in federal money from the Department of Transportation. I will give you a prime, you know, Virginia Tech is one, for example. They do a lot of great research, they get quite a lot of money from the Department of Transportation as well as the private sector, and operate outside of the UTC Program. The only issue that I have got with that is I don't have the same visibility into what goes on there as I do in the UTC Program as former RITA administrator.

Chair WU. Well, as we look at this issue I do want to capture the strengths of competition but recognize that we have different missions to perform, whether it is research or workforce development.

And also recognize that there are failed or imperfect markets or competitive environments. In a country like ours it is hard to criticize competition or merit review unless you look at the history of how some of these organizations or processes developed. And in the development of the science establishment after World War II, it was dominated by a few institutions, and into the '60s and '70s the peer review mechanism shall we say was just far from perfect, because people knew each other. People knew each other's work, so even in a blind analysis of publications or grant proposals, you knew whose proposals were coming through.

So, you know, any reconsideration of this has to take into account the realities of whether a merit review truly is blind or not, the multiplicity of functions ranging from personnel development to applied research to fundamental research, and sort of the shifting centers, the foci of research, you know, who would have thought that Wisconsin would be a biomedical research center 60 years ago. I am not sure that anyone would have thought of that.

Those things need to be taken into account as we consider this going forward.

I want to invite any of you who have any closing comments to make, you all have traveled a good long distance, if you have anything else to add to this process overall, I would like to invite that at this moment.

Mr. Saenz—and I want to apologize to you as someone whose name has been spelled out and mispronounced for a long time myself——

Mr. SAENZ. You pronounced it perfect.

Chair WU. Oh, my gosh. You are very generous. Thank you, sir. I think I have massacred it at least once or twice today.

Mr. SAENZ. Mr. Chair, I think just going back and just based on our prior topic about earmarks versus competition, we at Texas thrive on competition. We think competition brings the best of both the public sector and the private sector in trying to solve problems.

I think one of the things that starts, with all things, especially in the research program, is we need to have a national plan. This national plan can be there to solve for, not highway solutions or rail solutions or public transportation, but we need to look at it as a whole to try to identify how we solve those transportation issues. And it may be a rail project, it may be a highway project or an aviation project, inter-modal system, but we need to look at it as a whole, having that one focus, having that one goal, that one plan, and then be able to then look across lines and also at the same time be able to figure out how you measure success will lead to a better program.

Chair WU. Terrific. Thank you very much.

If there is nothing else for the good—Mr. Brubaker.

Mr. BRUBAKER. Just briefly for the good of the order here. I, first of all, I just want to commend you and the Ranking Minority Member for your leadership on this issue. I think this is really critical, and like I said in the opening, represents a real tipping pointing in our ability to transform the transportation infrastructure and make it more flexible and responsive to our needs.

The one thing that, and you know this, this goes without saying, and I don't want to minimize the complexity of this issue, but at the same time I have been in Washington long enough to know that when people use the word, complex, they really mean can't be done, don't bother doing it, don't bother breaking the rice bowls, don't bother breaking the stovepipes.

I firmly reject that. I think this is a very manageable situation. I think we just need to look at it from a high level. I think Mr. Saenz said it very well when he said, you know, we need that plan. We need that holistic plan.

For example, you know, if we are thinking about how to best move congestion at the ports, well, if you give that project to the Federal Highway Administration, they are going to give you a highway answer. You give it to Federal Rail Administration, they are going to give you a rail answer. But it needs to be some holistic answer, and I think the only organization within the Department of Transportation that has the ability to focus multi-modally and holistically is, in fact, RITA.

Lastly, I would just be remiss and as an ex-staffer I always loved to do this, I want to thank Meghan and Mike and Travis and Victoria for their help here, and as, and certainly Shep, and Shep, I know it is your last day. We are really going to miss you over at the Department, and really just appreciated your service here. So thank you.

Chair WU. You are good. You are good.

Anything else for the good of the order?

Well, I want to invite all of you to think—one topic I did not get into at all today, and it—we will save this for—as a topic of a future hearing, because it is a very big topic, and that is green transportation, green infrastructure, and better ways to plan and do things so that we are cognizant of the footprint that we leave both today and in the future and looking at our inputs as well as outputs.

And I want to commend that set of considerations to you all because I know that many of you, or all of you have been dedicated

to that already and will have suggestions for us as we go forward in considering the green transportation and green infrastructure issues and as we go forward in developing a research title for the Surface Transportation Bill.

I want to thank you all for appearing now this afternoon and thank you for coming a good decent distance. The record will remain open for additional statements from Members and for answers to any follow-up questions that the Committee may ask of you all. The witnesses are thanked and excused, and the hearing is now adjourned.

[Whereupon, at 12:15 p.m., the Subcommittee was adjourned.]

Appendix 1:

Answers to Post-Hearing Questions

ANSWERS TO POST-HEARING QUESTIONS

Responses by Paul R. Brubaker, Former Administrator, Research and Innovative Technology Administration, U.S. Department of Transportation

Questions submitted by Chair David Wu

Q1. You believe that a "holistic" approach to transportation research is needed. How does that differ from the current approach? What are the barriers that keep the Department of Transportation from utilizing this holistic approach?

A1. The current approach to transportation research is modal-centric and territorial. Research budgets are based on overall funding levels and historical funding levels rather than actual need or value to the overall transportation enterprise. This approach needs to be fundamentally re-thought and the approach must not only be much more multi-modal but must be integrated and enterprise-wide. That is, the Department should be approving research in the strategic context of what will add the most value to the national transportation system. Additionally, some portion of research should look to new and innovative approaches to transportation that do not fit nicely into one of the traditional modal stovepipes. For example, there should be a robust transportation-related alternative fuels component to research as well as intermodal and multi-modal modeling and simulation. While some of this activity exists within the modes today the activity is modal specific.

Fundamentally the barriers that exist that prevent taking this holistic approach are structural and cultural. The Department is organized around "modes" when in fact passengers and freight often use multiple modes to get from their origin to destination. We need to think of passenger and freight movement more holistically and begin to address challenges within the transportation system in this context. When commuters come into work they often drive or take a bus to a train station, board a train then may take a bus to their destination—involving multiple modes. When freight moves it often uses short sea shipping, rail and highways. Yet these multiple modes are hopelessly stovepiped and do not focus on the most efficient way to move people and freight in a holistic end-to-end manner.

This situation clarifies the notion that our national transportation system is really a system of systems that are poorly coordinated and are consequently not as efficient as they could be. There are also Congressional jurisdiction issues that come into play. For example, despite the fact that we move goods and people using multiple modes—the authorization does not take into account these multiple modes in an holistic manner. For example, if we could make tradeoffs between investment in high speed rail and airport investments in major cities it could result in obviating the need for building more airport capacity and replacing it with a more environmentally friendly high speed rail system—as well as result in taking a number of vehicles off of the road that travel between city pairs. Yet the separate authorizations between rail, air and road are not really set up to address this holistic view. Moreover, the tradition of using highway trust fund dollars to only support highway projects is antiquated. We must think of the entire transportation enterprise—whether it is the research program or the overall operation—much more holistically.

The lack of this holistic, system of systems approach has also resulted in missing some major issues and has perhaps even stifled innovation. For example, the transportation system is dependent on a cheap, abundant supply of energy. When the price of gasoline and diesel fuel jumped up over the past summer—the Department was caught completely off guard and unprepared. Naturally, vehicle miles traveled plummeted and suddenly congestion was reduced. However public transit ridership increased substantially and demand for Amtrak seats up and down the Northeast corridor was at capacity. There was no modeling and simulation capability within the department to even understand or predict what would happen. The devastating impact this situation had on the supply chain could have been entirely predictable if research and information gathering activity was directed in a manner that better understood the holistic condition of the passenger and freight movement system performance rather than focused on the traditional needs and narrow interests of the Department under its current modally focused research and information gathering structure.

Questions submitted by Representative Adrian Smith

Q1. You say in your testimony, "currently, there is no systematic or focused program, process, or set of activities that are driving innovations out of the laboratory and onto our nation's roads, rails, runways or waterways." In your opinion, what are

the current mechanisms for uptake of new transportation innovations? How could these mechanisms be improved? Does this assessment hold true for innovations in vehicle design and safety? If not, what are the differences between vehicle and infrastructure improvements?

A1. The Department and research community within the Department specifically has discussed technology transfer and many individuals have that role in their job descriptions. Additionally, many programs within the department like the Intelligent Transportation Systems Joint Program Office are required to consider technology transfer as part of its mission. Within RITA the RD&T program has a technology transfer role and the Federal Highway Administration, Federal Aviation Administration and other modes have key roles in driving innovation into the transportation system. However there is not well organized, systematic, enterprise-wide effort to drive innovation out of the laboratory and into the transportation system.

If you were to ask the research community about technology transfer they would suggest that the Transportation Research Board annual meeting represents a major technology transfer activity as does publishing research in peer reviewed journals. In my view, and this is based on a general familiarity with technology transfer and commercialization programs in major universities, research institutions and states, the Department and transportation community does not do a very good job of driving innovation into the transportation enterprise. This is mostly because transportation research has been an inside game—one that is managed and controlled by those with the biggest pockets who do not see anything wrong with the current system or the pace of innovation deployment.

Given the Department's almost $1.2 billion investment in research each year, and by virtue of the fact that our economy requires rapid deployment of innovation to maintain its competitive edge in an increasingly competitive global economy—this somewhat casual approach does not seem to make sense. Based on my experience, I would advocate an office of technology transfer and commercialization be established within the Research and Innovative Technology Administration that is adequately resourced to monitor the research activity of the department and highlight the intellectual property that is being developed for opportunity to commercialize or transfer in a manner that would further the state of research in a particular area.

You asked if my assessment of weak mechanisms for uptake of new technology applies to vehicle design and safety innovation. The short answer is yes but not because the mechanisms don't exist or don't ultimately produce a result but rather because they are slow, excessively bureaucratic and cumbersome. To be sure, the National Highway Traffic Safety Administration (NHTSA) does a good job of collecting data and statistics to support their recommendations—its just the processes they employ and the timelines they find acceptable are inconsistent with technology development cycles and tend to stifle innovation and companies who desire to build, test and deploy safety-related technologies. For example, when I left the Department we were still waiting for NHTSA to validate that certain communications technologies were appropriate to use in safety applications. This is important work to be sure—but something we have been examining for the last four plus years and it was going to take NHTSA two years to complete its study. When technology improvement cycles follow 18 month timeframes—it is difficult to see how these processes can support timely and effective deployment of new safety technologies.

NHTSA does not like criticism. To be sure, they have presided over many beneficial safety regulations and requirements and there are people alive today thanks to the work of the agency. However, there is room for improving research and how technology transfer, innovation and commercialization in the vehicle safety area. However, any constructive criticism or attempt to influence research in the safety area generally results in turf warfare. Any attempt outside of NHTSA to suggest new opportunities or processes related to safety generally elicits a negative reaction—and the agency is great at working the office of the Secretary—at least this was true during the last administration—so that any criticism was met with the suggestion that any change these processes or procedures will compromise the safety of the American people. In other words, criticize the process you criticize safety—when in reality these processes—particularly the safety benefit validation processes—could be significantly improved to expedite innovations into the field.

It might interest you to know that NHTSA carved out an exemption from RITA oversight during the drafting of the Mineta Act. The argument, as I understand it, was that the safety research conducted by NHTSA was too important and critical to be subject to oversight by a centralized research oversight organization. Frankly, this exemption speaks to desire and ability of the agency to insulate itself from criticism, oversight and review by hiding behind the safety mission. Undoubtedly, the response from NHTSA will be that the roads are the safest they have ever been.

However, when more than 40,000 people die on the Nation's road each year—roughly the entire population of Grand Island, Nebraska—we should do whatever we can do ensure that the latest safety technologies are deployed as quickly as possible.

Certainly there are differences in vehicle and infrastructure research but they should not be artificially stovepiped as they both represent individual systems in the holistic system. We should begin looking at vehicles and infrastructure in a more integrated fashion—particularly with the development of next and future generation intelligent transportation systems when the vehicle and infrastructure will become significantly more integrated. Before I left, we launched the IntelliDrive initiative which envisions modern sensor and communication technologies enabling an entirely new safety paradigm that integrates vehicles with the infrastructure.

Q2. Do we need to produce a new, comprehensive strategy for our nation's highways? If so, should this strategy include other transportation modes? Who should be charged with developing such a strategy and how often should it be updated?

A2. We do need a comprehensive strategy for not only out nation's highways but an integrated strategy for the entire transportation system—including how we fuel the transportation system. This comprehensive strategy—I have called it holistic but I mean the same thing—should include all of the modes of transportation—ships, transit, highways, rail and air. The focus of the strategy should be on how both freight and people move across the system with a keen understanding and data regarding system performance. This would help us better understand how people and good really move across the country and where the bottlenecks and safety issues are in the system.

This strategy should be fact-based and contain analysis, business cases and public benefit business cases outlining how projects and programs will measurably improve the performance and/or safety of the Nation's transportation system. This will require a robust and modernized ability to collect, analyze and disseminate transportation-related data. Currently, the Bureau of Transportation Statistics—which is inside of RITA, does not have an adequate or complete picture of all of the system and safety performance data that would be required to support such a strategy—mostly because it is grossly underfunded and does not have the data resources and personnel that would be needed to develop such a comprehensive view and analysis of the passenger and freight systems. In this same area, we also need to better understand how the system responds to externalities—like natural and man-made disasters, changing fuel prices and unexpected events. The Department should have an organic capability to conduct modeling and simulation around various policy, project or event scenarios.

The National Transportation System Strategy should be developed collectively although the Secretary of Transportation should be charged with developing the strategy and putting pen to paper. Congress could and should propose a restructuring of the Department along the lines suggested—although if nothing else could propose a commission to study and recommend a new structure that better reflects the way people and goods move across the country. I think this strategy should be developed every year and reflect a rolling five year vision of where we are going with the transportation system in this country—that lays out the very clear priorities of the Department and drives investment and alignment over the period. When I was at RITA we put together a forward looking document called *"Transportation Vision for 2030"* which from a thematic perspective could provide a useful construct—but the goals should be bolder and the strategy should provide tactical guidance in terms of organizational alignment and budget formulation and execution.

ANSWERS TO POST-HEARING QUESTIONS

Responses by Elizabeth Deakin, Professor of City and Regional Planning; Director, University of California Transportation Center, University of California, Berkeley

Questions submitted by Chair David Wu

Q1. You recommended in your testimony that more research be subject to "arms-length" evaluations. Could you describe how many of these evaluations are currently done and how you believe they should be done? How would these evaluation processes be changed? How can this be encouraged either by the DOT or by legislation?

A1. Arms-length evaluations of research are important for credibility and can help target research dollars on the most cost-effective and creative topics. Independent evaluators can be asked to point out strengths and weaknesses in the research design, comment on the reasonableness of proposed expenditures, evaluate the qualifications of the researchers and their track records, estimate the contribution that the research is likely to make, and identify whether the proposed research is innovative or duplicates other past or ongoing research.

In the research community, peer review is the norm. Journals and some university transportation centers use either double-blind or confidential reviews and the reviewers are selected both for their subject area knowledge and for their ability to provide a dispassionate evaluation. In the most rigorously organized peer reviews, research collaborators, former students and former professors, and anyone with a close professional or financial interest in the outcome are disqualified from participating in a review.

Peer reviews are not perfect—for one thing, reviewers often know or can surmise the authors and vice versa, despite the removal of identifiers, and big names and big institutions may sometimes be given deference that the proposal might not actually deserve. Despite these flaws, most researchers agree that outside peer review is the best way we have devised for obtaining independent evaluations of research proposals and products and reducing biases in the evaluations.

On the other hand, there is also a desire research to be relevant to users, especially short-term, applied research that is expected to lead directly to a deployable product. For this reason reviews by outside researchers are often complemented by reviews or project oversight by practitioners, industrial partners, and others with a direct interest in the outcome. Such reviews and oversight are especially helpful in raising practical questions about the utility of a product, the size of the market for it, competing products and their pros and cons, etc.

In addition to peer review and end-user reviews, strategies for obtaining evaluations that can be of value in guiding research programs include:

- Using independent expert panels to generate research topics, review research proposals, oversee research as it proceeds, and review products. (This can be the same panel or different panels at each step.)
- Public agency and industry advisory committees, who can bring user and researcher viewpoints into the evaluation process while maintaining some intellectual distance. Independence of the reviewers can be built into this process. For example, some state DOTs enlist representatives of other state DOTs and universities outside the state to evaluate their research programs and major projects. Because panel members are not competing for the grants, they are more likely to be dispassionate than local reviewers might be.

NSF uses independent expert reviewers, and NAS committees evaluating research and research needs are typically independent expert panels. NCHRP and TCRP use stakeholder review panels to select and review projects. USDOT also uses these methods for some of its programs, but also does many reviews internally, in some cases because there's a lack of resources to bring in outside reviewers. Many states have research advisory committees, but for projects rely on internal staff review and (sometimes) project advisory committees composed of likely end users. The University Transportation Centers program calls for peer review of research proposals and products but does not provide much guidance on what qualifies as peer review.

Congress could mandate independent reviews by peers and end-users for all major research programs (as well as for field tests, demonstration projects, and other major projects) and provide funding for such reviews as part of program costs.

Q2. Please elaborate on your comment that other countries, like EU countries, Canada, and Australia, are ahead of the U.S. in terms of developing a strategic out-

come based plan for transportation research. What strategic outcome metrics do these countries use? What have been the impediments in the U.S. to utilizing a strategic outcome approach and what can the U.S. draw on the experiences of these other countries in developing its own national strategic transportation research plan?

A2. Transportation research would benefit from a mixed portfolio including some long-term, basic research whose application is uncertain as well as more applied research and development—some of which may nevertheless be years from application, and some of which could be implemented in the short-term and therefore should be coordinated with transportation plans and programs in order to move R&D results into implementation. Partnerships for implementation should extend not only to federal and State transportation agencies but also to the many other federal, State and local agencies, businesses and industries that have roles in implementation of transportation projects or products or are users of transportation products.

A study currently underway with funding from the Volvo Educational and Research Foundation, involving researchers from Leeds University in the UK as well as from UC–Berkeley, is examining the problem of moving research from studies to actual use by investigating how innovative cities and regions learn about innovations. Preliminary findings are that loose networks of professional acquaintances are a principal way for information on innovations to be transmitted among end users, and that professional meetings and short articles in publications are more valuable to professionals than are journals. Further, meetings that cross disciplinary boundaries are more effective in transmitting new ideas than are specialty conferences, which are better at developing expertise than at spreading new ideas. Researchers use both formal journals and their own networks to learn about new ideas and to share them. The work suggests that an important way to speed up knowledge transfer is to encourage participation in professional activities, especially ones that can attract participation from multiple disciplines and specialties.

In a related study just getting underway, UC–Berkeley researchers are looking at ways that transportation, urban development, and environmental agencies and foundations select and evaluate research and disseminate research findings. While the study is just getting underway, we have identified several good examples that could be adopted by U.S. transportation agencies. For example, Sweden uses international panels of experts to help evaluate its research agendas, assess research progress, and advise on action items.

A second study reviewing transportation policies in Canada, the UK, and Sweden, conducted by the Center for Global Metropolitan Studies at UC–Berkeley, offer examples of best practices in prioritizing projects, including research projects. The general approach is as follows:

1) **Adopt national goals and objectives, along with performance measures which track accomplishments.** Typical goals for transportation are improved access, efficient movement, economic growth, environmental quality, and social inclusion. For each goal, specific performance measures are identified and agencies must measure and report their achievements.

2) **Require horizontal and vertical policy integration:** National transport policies are required to be coordinated with policies for other infrastructure, housing and urban development (both urban redevelopment and new town programs), economic development, and the environment. In addition, local and regional policies are expected to be consistent with national policies. Inter-departmental and inter-governmental coordination mechanisms including joint committees and jointly funded programs have been established to help achieve this integration. In some countries policy integration is also being accomplished in part through institutional restructuring: Canada's and Sweden's national transport authorities lie within broader ministries, the Ministry of Transport, Infrastructure and Communities in Canada (created in 2006) and the Ministry of Enterprise, Energy and Communications in Sweden. The UK Department for Transport (DfT) is a stand-alone ministry but transport plans must align with the umbrella land use (spatial) plans at the local, regional and national level and local transport plans are reviewed by the DfT for adherence to the spatial plans and the DfT Smarter Choices campaign to lower carbon emissions.

3) **Align project selection criteria to national goals.** Project selection criteria are required to reflect the national goals, objectives, and performance measures.

4) **Provide information and incentives for government at all levels as well as citizens and businesses to support and help meet the goals.** Funding programs, tax policies, and pricing strategies have been revised to focus on achievement of national goals and objectives. Programs have been funded to encourage citizens and businesses to reduce their carbon emissions, for example. In the UK, nationally sponsored marketing programs are also underway to let people know what they can do to reduce emissions.

5) **Provide funding and create room for experimentation with innovative strategies.** For example, both the UK and Sweden have used pricing to manage congestion in their largest cities, London and Stockholm; in the Swedish case this experiment was led by the national government.

6) **Encourage public-private partnerships.** Canada recently established and funded an Office of Public Private Partnerships as a component of the $33B multi-year Infrastructure Plan.

While these steps are largely aimed at aligning investment programs and projects with national goals, research agendas have been developed to help achieve the national goals and are being funded. In the U.S., such research agendas have sometimes been developed (e.g., the Transportation environmental research program requested by Congress) but there has been less consistency in connecting research expenditures to either the research agendas or to national policy directives.

Q3. If UTCs were competitively awarded, what are the criteria that should be used in the award and evaluation process?

A3. RITA currently requires that University Transportation Centers report on their products in research, education, human resources, and tech transfer. The specific criteria are:

1) the number of projects selected for funding
2) the amount budgeted for those projects
3) the number of research reports published
4) the number of research reports presented at academic/professional meetings
5) the number of transportation courses offered
6) the number of students participating in transportation research projects
7) the number of transportation degree programs offered
8) the numbers of students enrolled in those programs,
9) the number of transportation-related masters and Ph.D. degrees awarded
10) the number of seminars, symposia, and other activities conducted for transportation professionals and
11) the number of professionals participating in those events.

In addition, RITA requires centers to demonstrate the capacity to manage the grant effectively, both in terms of business services and in terms of a Principal Investigator who can provide appropriate intellectual leadership.

These are straightforward performance criteria that can be used to evaluate the productivity of the transportation centers or the capacity of prospective centers to perform well. The 11 criteria focus on inputs and outputs and hence are useful in measuring productivity. They are easily and objectively measured. Even so, the meaning of the numbers—what value to place on a high or low result—still requires interpretation.

In addition, university transportation centers could be evaluated based on **outcomes or accomplishments resulting from these activities,** including:

1) extent to which research results have opened up new research directions, led to new fields of study, and/or led to new or substantially improved practices. including systematic interdisciplinary approaches addressing emerging issues in science, technology and multi-agency, multi-jurisdictional, and/or public-private partnerships to improve implementation of research results
2) percent of graduates in last five or 10 years who are practicing in the field of transportation; number who have risen to leadership positions in the transportation field
3) extent to which professional practice has changed in notable ways as a result of technical assistance and tech transfer activities.

These latter criteria are harder to measure and are more subject to interpretation. However, they are the sorts of criteria often used to evaluate quality and outcome

changes. Independent peer review panels are a common way to implement evaluations using such criteria.

Nascent groups would be placed at a disadvantage compared to long-established centers of excellence if the focus is primarily on accomplishments and resources already in place, and so it may be useful to have separate criteria for new centers, such as the following:

1) a minimum of three regular/permanent (tenured or tenure-track) faculty members whose teaching and research is primarily in the field of transportation (or a university commitment to hire such faculty members during the first two years of the grant)
2) a university commitment to offer at least one degree program with a formal, university-approved specialization in transportation
3) transportation research funding of at least 20 percent of the amount of the grant on average over the past three years or a commitment of matching funds of at least 20 percent of the amount of the grant for the period of the grant
4) evidence of current or proposed collaboration (extant and planned) of major State, regional and/or local transportation agencies and private sector organizations with an interest in transportation, as evidenced by letters of support and commitments for matching funds.

These criteria would also be useful in sizing grants to institutional capacity.

Ouestions submitted by Representative Adrian Smith

Q1. Your testimony suggests that one reason for limited adoption of transportation technologies may be a lack of trust in the assessments that are available. Can you describe what factors limit the credibility of current assessments and can you give us an example of assessments, perhaps in other research areas, that have been successful? What actions would be required for transportation officials to restore their trust in these assessments?

A1. Trust in technology assessments, and more generally in assessments of the likely impacts of prospective investments, depends in large part on how accurate past assessments have been. Many studies have found that benefits have been overestimated and costs underestimated; the pattern of error is not random. Technology assessments, travel demand forecasts and cost estimates for new transportation investments (roads, tunnels, bridges, rail projects) have been the subject of considerable study in recent years, and scholars such as Bent Flyvbjerg and Daniel Kahneman (among many others) have examined why forecasts and other prospective assessments are inaccurate. Kahneman has identified psychological factors leading to "optimism bias" whereas Flyvbjerg believes that there is considerable "strategic misrepresentation." Other factors including unforeseen changes or instabilities in factor prices (e.g., fuel price fluctuations) also have affected the accuracy of forecasts, of course, but these factors have been found to be insufficient to explain the gap between forecasts and results.

Strategies that have been recommended for overcoming these problems include:

- Use of independent peer review committees as evaluators. For example, both U.S. and EU universities call upon outside panels of experts to review university programs. Some transport programs in the EU also use peer reviews of this sort to take an independent look at the justification for proposed projects. While peer reviews are not perfect—especially if peers are drawn from a "club" of associates—awareness of their limitations has led to improvements in the design of peer review teams, often by including international experts, experts drawn from industry, and experts from a variety of disciplines as part of the assessment team: people with a bit more distance from the individuals and agencies being reviewed.
- Scenario testing is a method that acknowledges uncertainties in key factors that could shape future markets and opportunities. Scenario testing has been used in the U.S. by several states and Metropolitan Planning Organizations to assess alternative urban development and transportation investment packages and has been used by corporations such as Shell to investigate energy futures as a function of, among other things, public attitudes toward energy conservation and the environment. The development of the scenarios is typically done with multi-disciplinary expert panels, and in public settings, with public involvement.

- The UK Department of Transport has adopted a cost estimation procedure, reference class forecasting, that accounts for "optimism bias uplift" by adjusting costs upward and/or demand forecasts downward, based on past experience with similar projects. It is most easily applied when there are in fact similar projects, and is not as easy to apply to unique projects or new ideas that have not been examined before.
- Focus groups are used to test consumer responses to new products and options in relatively quick, inexpensive ways.
- Other market research techniques that can help assess technologies include stated preference surveys and consumer panels that participate in repeated surveys and/or focus groups over a period of time, sometimes several years.
- Demonstration projects and field tests are ways to further test markets but also to investigate implementation barriers and opportunities. Demonstrations and field tests often can be improved by including a wide range of stakeholders in the design (so that all the factors that might affect implementation are included). Third party, arms-length evaluation of demonstration projects can be valuable in reducing the danger of optimism bias (a risk if the evaluators of the demonstration are also the proponents of the demonstration) or too narrow a scope in the design and evaluation of the demos and field tests.
- Markets can offer a test of technology readiness, risks and opportunities: is there a business plan for implementation and are private investors interested in the opportunities presented?

Q2. Do we need to produce a new, comprehensive strategy for our nation's highways? If so, should this strategy include other transportation modes? Who should be charged with developing such a strategy and how often should it be updated?

A2. I see several reasons for a new, comprehensive plan for the U.S. transportation system that is multi-modal.

First, we need to find an effective way to pay for the transportation system. The highway trust fund is depleted, and changes in vehicle and fuel technologies seem likely to make the gas tax increasingly problematic. How to pay for both urban/metro and rural highways needs to be considered in terms of emerging energy futures and technology options. In metropolitan areas, how to pay for transit services also needs to be part of the discussion. New technologies can make paying for transportation fast, efficient, convenient, private, and flexible, and multi-modal applications could be made available.

Second, we need to pay more attention to freight movements, which are critical to the economy but also have high impact on the Nation's transport systems. Truck and rail freight systems must link to each other and to ports and airports more effectively. Better strategies are needed to manage the heavy and often concentrated traffic impacts that result from international trade through major ports. Freight movements are inextricably linked to security concerns and technology applications and better planning and management could yield major improvements. A plan to pay for freight improvements equitably is also needed.

Third, there are promising opportunities to reduce costs and improve performance by implementing new technologies for applications ranging from data collection to user fee collection to improved safety and security, but these options need evaluation in the context of ongoing investment programs and in comparison to more conventional approaches.

Fourth, we might be able to have better, cheaper, faster transportation services for both passengers and freight if we coordinate across modes better. For example, it's increasingly important to discuss whether we should be investing in truckways, moving more freight to rail, or finding new truck-rail combinations for freight movements. Opportunities for better service at lower cost could result if we plan for and coordinate urban transit, conventional passenger rail, and (in some cases) high speed rail with air travel modes; rail could not only serve as an airport access mode but could simultaneously serve a substitute for some short-haul air trips (as is happening in the Boston-Washington corridor), and a commute option in some markets.

MPOs currently prepare transportation plans that cover highways and transit, and increasingly address freight within their boundaries. Some states also have been developing strategic plans covering these critical topics. It would be timely to evaluate the performance of MPOs under the new responsibilities given them since ISTEA , to review State transport policy, planning, and investment strategies over the same period, and to look at how well states and MPOs are coordinating investments and evaluating projects. Such a critical review and assessment could be done in one to two years if mandated by Congress, and could provide valuable information on best practices and needed changes in practices. The resulting information

would be extremely valuable in shaping a new strategic plan for USDOT and the Nation, and might offer new ideas on how to restructure categorical grants, create incentives for cost-effective and high benefit investments, and make better use of new technologies in transportation.

ANSWERS TO POST-HEARING QUESTIONS

Responses by Amadeo Saenz, Jr., Executive Director, Texas Department of Transportation

Questions submitted by Chair David Wu

Q1. In your testimony you described the benefits from the first Strategic Highway Research Program (SHRP). What benefits do you envision from SHRP–2?

A1. The Texas Department of Transportation (TxDOT) envisions that there will be benefits from all areas (Safety, Renewal, Reliability, and Capacity) of the SHRP–2 Program. All are very significant issues in Texas and around the country. I understand that an Implementation Committee with quite a few "high level" people involved in implementing technologies at their respective agencies has been established. Although I am not an expert on the report, I am aware that a Transportation Research Board Special Report 296, *"Implementing the Results of the Second Strategic Highway Research Program"* has been published. I am confident that Texas and the rest of the country will be able to use the results to improve safety and maximize the benefits of our transportation systems.

Q2. The Texas Department of Transportation (TxDOT) sets aside funds for implementation of its research projects. Would you recommend that the Federal Government consider an implementation set-aside for transportation R&D projects as well?

A2. TxDOT recommends that the Federal Government consider an implementation set-aside for transportation R&D projects. This set-aside could be used specifically for actual "demonstration projects" around the country. This would enable it to be used for activities such as training while capturing the additional costs associated with implementing new technologies. It is also necessary to provide assistance as needed and preparing implementation documents to maximize the R&D findings. Since a lot of money is spent on research, it is only responsible that we pursue cost effective implementation.

Q2a. What percentage of the TxDOT R&D budget goes towards implementation and do you find that this is sufficient to fully implement all successful research projects?

A2a. Roughly 15–20 percent of the TxDOT R&D budget is allocated towards specific implementation projects. We follow up only a small percentage of completed research projects with an implementation project since many do not require one. Implementation can consist of activities such as adopting a specification or new standard and incorporating recommendations into our operating procedures as appropriate. I feel the budget set aside specifically for the TxDOT implementation program is sufficient because we incorporate that into the R&D project. Many times the issues are overcoming other obstacles such as staffing and the time and training requirement to prepare for a new technology. This is "new" and most of our staff is already extremely busy dealing with issues of the day and week.

Q2b. Also, in your experience, what is required for successful implementation of R&D?

A2b. Successful implementation of research begins with conducting excellent research projects applicable to TxDOT. Most of our investment is applied research, meaning we have a specific problem we are trying to resolve. As TxDOT considers implementation of research results, we carefully monitor the research throughout the entire life of the project. We set up the project to receive deliverables needed. For example, if you need a specification, set up a specification as an actual required deliverable.

Deliverables should be provided in ready to use formats to increase the chance of successful implementation. Training may also be necessary for employees that will have to implement a new technology. Perhaps, one of the most important things we discovered is the agency has to "own" and "champion" the research. Within TxDOT, for example, the Division responsible for the research results would then have to incorporate them into their standards and operating procedures as appropriate. Of course, we need to have the people and resources to make this happen, which is one of the obstacles I addressed in my testimony.

Q3. In your testimony, you noted that the USDOT could help states, locals, and counties implement the results of research more quickly and effectively if infor-

mation and requirements for the new technologies were provided in a ready-to-use format. What do you mean by ready-to-use format?

A3. Ready-to-use format would mean an actual specification or standard that could easily be adopted by State and local agencies. Another example would be to distribute something similar to our Project Summary Reports (sample attached) with completed federal research projects.

Q3a. What information do state and local transportation officials need for implementation?

A3a. We believe that what would help State and local transportation officials with implementation is to make readily available a brief synopsis of completed research. For example, our Project Summary Reports are limited to two pages and include information about the following: (1) Background, (2) Research (3) Findings and (4) Conclusions. This makes it much easier to determine how they might use the research results. We also provide for our entire agency and local communities all of our Project Summary Reports on the Internet.

Q3b. Why do you think the DOT does not already provide this type of information?

A3b. The DOT does make this type of information available on some of the projects. It just does not appear to be a consistent practice. We are simply advocating the DOT have more consistent practices in Research and Development in order to have the findings available for the State and local communities.

Q3c. Can you provide some specific examples where the lack of usable information slowed the deployment of new technologies?

A3c. While I do not have any specific examples of lack of usable information slowing down the deployment of new technologies, there are research results from the DOT and other states that we have not implemented simply because we were not aware of the results and their utilization. This responsibility of course rests on the State and federal DOTs, lack of communication both ways can be improved. We need to do a better job of "scanning" the provided information, web pages and newsletters from TRB, RITA, FHWA, etc. While USDOT needs to do a better job of distributing information to the right State and local people.

Q4. You mentioned that there was resistance by contractors towards new technologies. What types of incentives or aid did TxDOT use where TxDOT was able to convince contractors to use new technologies? Do you think a similar model would be successful at the federal level?

A4. We can classify incentives or aids that TxDOT has used to convince contractors to implement new technologies and requirements into the following categories: bonus/penalty in specifications, measuring performance-related characteristics and giving contractors flexibility to achieve them, provide tools to allow contractors to lower their costs, and implement new quality monitoring programs to reduce impact. All of these strategies include education and cooperation with the contracting industry. There would be a significant advantage if a similar model would be used on a federal level. See specific examples below for benefits at a national level.

- **Bonus or Penalty in specifications**
  - *Development and implementation of Quality Control/Quality Assurance Hot Mix Asphalt Concrete specifications.*

    When we implemented QC/QA Hot Mix Asphalt Concrete specifications in the 1990's, we included bonuses and penalties for mixture characteristics that produce good performing hot mix. We require contractor testing for quality control and TxDOT testing for acceptance, all with certified technicians. We worked with the Texas Asphalt Pavement Association to develop certification courses to insure that all technicians, both contractor and TxDOT, were certified to perform the required testing.
  - *Implementation of Ride Quality Specifications for Pavements.*

    TxDOT conducted research to develop ride quality specifications in late 1980's and early 1990's. Research showed that the public's top interests were smooth roads and safe roads. Implementation of the current iteration of the TxDOT ride specification includes bonuses and penalties, giving contractors the incentive to produce smooth pavements. Additionally, specifications require certified profilers and operators. TxDOT worked the Texas Transportation Institute to develop and operate a certification program for profilers and profiler operators.

- **Measuring performance-related characteristics and giving contractors flexibility to achieve them**
  - *Implementation of HMA specifications to address aggregate segregation, thermal segregation, and joint density.*

    TxDOT originally developed specifications requiring specific pieces of equipment (usually costly shuttle buggies, etc.) to address these issues. These were met with resistance on the part of contractors. Resistance was reduced when we implemented testing to identify the problems, but allow contractors flexibility to develop "fixes" on their own without requiring specific pieces of equipment.
  - *ASR Mitigation Options (Preventing Alkali-Silica Reaction and Delayed Ettringite Formation in New Concrete)*

    Research enabled TxDOT to add an 8th mix design option and validated the previously existing seven ASR mitigation options in our concrete specification. It has been successfully implemented by giving the contractor any of eight options for concrete mix designs to choose from. Their choice is based on their local materials, experience, etc., and been widely accepted due to the flexibility given to the contractor combined with the extensive training/awareness campaign that we undertook.
- **Provide tools to allow contractors to lower their costs**
  - *Low Coefficient of Thermal Expansion/Modulus of Elasticity.*

    Continuously Reinforced Concrete Pavement Standard with reduced steel percentage (to address horizontal cracking in Portland cement concrete pavements). This process will begin to be used on projects by the end of the summer of 2009. It will be presented to the contractor as a cost-savings measure to utilize if the materials he is providing for the concrete pavement meet certain criteria.
- **Implement new quality monitoring programs to reduce impact.**
  - *Implementation of the Superpave Performance Graded Asphalt Binder specifications for use in all Hot Mix.*

    The Superpave Performance Graded Asphalt Binder Specifications, a result of the Strategic Highway Research Program (implemented by TxDOT in 1997) involved a significant education and training program. We used the FHWA, Asphalt Institute, Texas Asphalt Pavement Association, and newly formed User/Producer groups to educate contractors, asphalt suppliers, and TxDOT personnel. TxDOT developed a new binder approval program to address asphalt producers concerns that Performance Graded Binder testing took longer to complete. We now approve a binder supplier's production instead of individual tanks as in the past. We give monthly approval to ship product and perform "check sample" testing at least weekly to monitor production.

Questions submitted by Representative Adrian Smith

Q1. How are the research needs of State and local highway decision-makers transmitted to federal research agencies?

A1. The main and perhaps most formal way that State and local research needs are considered is through the various Cooperative Research Programs managed by the Transportation Research Board (TRB). Each State DOT is afforded this opportunity on an annual basis. At least some of the various TRB technical committees collect research needs from their committee members, who are from both State and local agencies. With regards to transmitting our research needs to the Federal Highway Administration, we are not aware of a formal mechanism.

Q1a. Alternately, how are the results of research performed with federal funding transmitted to these independent, local decision-makers?

A1a. All of our completed research reports are available on the Internet so if a local agency needs information, they may be able to access it through those means. The larger local agencies are typically more in tune to some of these activities so it is easier for them. They are also fairly familiar with our specifications and standards. The smaller local agencies have, of course, different needs. They would only be able to apply results from a small number of our research projects. Our local TxDOT dis-

trict employees have very good working relationships with these local officials and often assist them with some of their technical questions and needs.

Q1b. Do the research projects themselves need to be changed to meet the needs of the local officials, or do the results of these projects simply need to be communicated more efficiently?

A1b. We all need to do a better job of simply communicating the results more efficiently, and perhaps more importantly, making this information readily available and easy to find.

Q2. Do we need to produce a new, comprehensive strategy for our nation's highways? If so, should this strategy include other transportation modes? Who should be charged with developing such a strategy and how often should it be updated?

A2. Not only do we need a comprehensive strategy for our nation's highways, we desperately need a national transportation plan. This national plan should not be limited to the highways but should include all modes of transportation. We need to do more than mandate processes, we need to establish goals and meet them. States are looking for Congress to define a national strategy and provide the policy framework that empowers states to set these goals, make decisions, and deliver projects that implement the national strategy.

Transportation legislation should be consumer-focused and recognize that Americans expect congestion relief, cleaner air, improved economic opportunity, well maintained roads, and increased safety. Transportation systems should be evaluated based on improvements in performance standards and predictable travel times. Processes mandated by law should be streamlined and harmonized to enable the delivery of new transportation systems, not arrest their development. The national strategy should be reviewed every few years to make sure it is still viable and not just a place holder for transportation policy.

ANSWERS TO POST-HEARING QUESTIONS

Responses by Robert E. Skinner, Jr., Executive Director, Transportation Research Board of the National Academies

Questions submitted by Chair David Wu

Q1. TRB will be issuing recommendations regarding research on climate change mitigation and adaptation.

A1. The TRB Executive Committee has been proactive about addressing transportation's role in climate change for some time. A self-initiated study in 1997 was designed to raise awareness about highway transportation's large and growing role in GHG emissions and to begin debate about mitigation options.[1] Another self-initiated study completed in early 2008 addressed the potential impacts of climate change on transportation; it includes recommendations for important initiatives, research, and standards revisions to facilitate adaptation.[2]

Q1a. What has prompted this new approach?

A1a. In reviewing the proposals being developed for surface transportation research last summer, the Executive Committee noted the absence of proposals addressing climate change mitigation and adaptation. Hence, it initiated a fast-track project to develop research program proposals for Congress to consider. The first drafts of the background papers commissioned for that project have been shared with your staff. This study is being conducted by a committee of experts, who will use the revised drafts of these papers, other relevant materials, and their own experience and judgment to develop their findings and recommendations. The report is expected to be complete in the August–September 2009 time frame.

Q1b. How much has FHWA spent to date on climate change issues?

A1b. FHWA provided an estimate that they have invested about $6 million over the FY 1999 to FY 2006 time period on planning and environmental research directly related to climate change. The USDOT total share of the Federal Government-wide Global Change Research Program for 2007 to 2009 has ranged between $0.7 and $1.9 million, most of which is attributable to aviation research by the Federal Aviation Administration.[3] Focusing only on FHWA R&D expenditures specific to climate change, however, is misleading. Important areas of ongoing research at FHWA are directly related to strategies for mitigating transportation greenhouse gases. For example, the results of ongoing traffic operations research, including ITS, to reduce congestion; programs to encourage and evaluate road pricing strategies; and improvements to regional travel and land use models will be quite helpful in informing future policy choices and operational strategies. FHWA research related to adaption will also be valuable. It has been investing in bridge hydraulics research to better understand and predict hazards from bridge scour, which may become more of a problem in areas that become more prone to flooding in the future.

Q2. TRB recommended that University Transportation Centers should be competitively awarded. What specific evaluation criteria does TRB suggest be used to evaluate and define a successful UTC?

A2. TRB has been involved in the UTC program since its inception, most directly in its early years. The Board convened peer review panels to assist USDOT in evaluating the initial applications of university consortia in the late 1980s, and, subsequently, to review the third and fourth year program plans of the centers. In 1993, TRB issued a report requested by USDOT to help them assess the quality of the centers.[4] Much of the advice in that report remains relevant, even though the UTC

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[1] Special Report 251, *Toward a Sustainable Future: Addressing the Long-Term Effects of Motor Vehicle Transportation on Climate and Ecology.* Transportation Research Board of the National Academies. Washington, D.C. 1997.

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

[3] *Our Changing Planet: The U.S. Climate Change Science Program for Fiscal Year 2009,* A Report of the Climate Change Science Program and the Subcommittee on Global Change Research: A Supplement to the President's Budget. p. 232. *http://www.usgcrp.gov/usgcrp/Library/ocp2009/ocp2009.pdf*

[4] *Measuring Quality: A Review Process for the University Transportation Centers Program.* Transportation Research Board of the National Research Council. Washington, D.C. 1993.

program has grown from 10 to 60 centers and expanded its focus to include education and training.[5]

The committee convened to prepare *Measuring Quality* recommended a three-tiered review process: (a) a program-level review to evaluate the collective products of each center, (b) a center-level review to evaluate the performance of individual centers and (c) a project-level review to assess the quality of individual research projects and courses. The committee noted that measuring quality requires making subjective judgments about the value of programs and the quality of products. It recommended reliance on review panels made of academicians and professionals free of conflicts of interest. USDOT subsequently required regular peer review of UTCs. The committee also recommended the development of quantitative measures of output, such as the number of students supported by and graduated from UTC centers and the number of articles and the number papers on UTC-supported research published in peer-reviewed journals, conference proceedings, and other scholarly publications.

In its assessment of highway research, including the UTC program, the Research and Technology Coordinating Committee (RTCC) noted that a more useful output measure of the UTC educational mission than the number of students graduated would be the number placed in transportation agencies and firms.[6] The RTCC also reiterated the value of reporting on peer-reviewed publications of research supported by UTC funds. It noted that, whereas the UTC program requires that centers be peer reviewed, these reviews are not shared beyond the center. RITA's UTC program managers, at least, should have access to such reviews as a basis of judging the quality of the centers funded with federal aid.

The intent of the committee's second question implies development of criteria for the selection of UTCs through a competitive process. Although most UTCs are not selected competitively currently, the UTC program does have competitions for the selection of the 20 Regional and Tier 1 centers. TRB has not been involved in these competitions in recent years, so we are less familiar with current practice. Presumably, the criteria in use derive from the goals of the UTC program (multi-disciplinary education; human resource development through undergraduate and graduate programs; diversity of student body and faculty; center process for research selection; ongoing program of basic and applied research; and technology transfer). Also important would be the strength of the UTC proposed strategic plan and multimodal focus. Based on the work our committees, we would encourage consideration of output measures such as the success in placing students in transportation positions and track record of publishing peer-reviewed research, as well as the strength of center advisory committees. We would also stress the role of merit review involving peers in awarding funds to UTCs through a competitive process.

Q3. TRB has consistently advocated that FHWA and DOT invest more in long-term, advanced research. What is your assessment of FHWA's Exploratory Advanced Research Program? Is this a model FHWA should follow? What lessons can be learned from the program?

A3. The RTCC has, indeed, long advocated for more advanced research at FHWA. In Special Report 261 issued in 2001, the RTCC recommended that advanced research represent approximately 25 percent of FHWA's R&T portfolio.[7] SAFETEA–LU authorized $14 million annually for the Exploratory Advanced Research (EAR) Program. The RTCC has, subsequently, paid close attention to the implementation of this program. The committee is very pleased that Congress authorized and funded the program, and it views it as a genuine opportunity to expand federal investment in advanced highway research. The committee, however, is reserving judgment about whether the way FHWA has chosen to administer the program is the most effective approach to advanced research for the highway field.[8]

The RTCC is pleased with the first round of research solicitations though a Broad Area Announcement (BAA), which was wide open to good ideas from across the spectrum of highway research topics. It is also pleased that last year's technical corrections legislation changed the local matching requirement for EAR projects from 50 to 20 percent. In its 2008 report, *The Federal Investment in Highway Research,*

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[5] Eight centers are authorized in Title III of SAFETEA–LU (the transit title) and 52 are authorized in Title V.

[6] Special Report 295: *The Federal Investment in Highway Research, 2006–2009: Strengths and Weaknesses.* Transportation Research Board of the National Academies. Transportation Research Board of the National Academies. 2009, p. 121.

[7] Special Report 261: *The Federal Role in Highway Research and Technology,* Transportation Research Board of the National Academies, 2001.

[8] Research and Technology Coordinating Committee, Letter Report of September 18, 2007. *http://gulliver.trb.org/admin/blurb/blurb_detail.asp?id=8152*

2006–2009, the RTCC expressed some concern about the narrowing of topics in the second round of solicitations and the share of funding for advanced research projects devoted to intramural research (23 percent of the funding allocated through 2008).[9] Based on funds committed through 2008, the committee prefers that a larger share of the funds be devoted to extramural research. (Subsequent projects may have been selected and funded by the program, which the RTCC has not yet reviewed, so the share to intramural may have declined.)

The administration and conduct of an advanced research program is something new and exciting for the highway community, but it is one that will take some time to develop and mature. Advanced research requires a different approach than the highway research community is accustomed to for research administration, stakeholder involvement, research partnering, requests for proposals, contracting (statements of work, deliverables), merit review, and tolerance for risk of failure. FHWA, and the highway research community more broadly, is learning about these features as the EAR program proceeds. The good signs so far are a growing list of intriguing and promising projects, a much higher proportion of research conducted by universities than is true for the FHWA program in general, a new set of research partners adept at advanced research, and FHWA's outreach to scientists and experts in other federal agencies to assist it in merit review. Because the highly applied, short-term research model is so well established in the mind set of the highway research community, signs to watch out for are whether the program becomes too focused on near-term deliverable products and reliance on research organizations that have proven track records in applied research but less so in advanced research. The RTCC hopes that the EAR program will succeed and bring new understanding and breakthroughs, but it is premature to judge whether the program's current approach is the best model for the future.

Q4. TRB emphasized the need for performance-based metrics for transportation R&D. Specifically, what should those metrics be?

A4. My written testimony mentions performance-based metrics only in the context of the administration of the highway program, in which I was attempting to point out the data issues that would arise from adoption of a performance-based highway program,

> "Proposals already circulating that address reauthorization of the surface transportation program, including the reports of both SAFETEA–LU commissions, recommend that the federal aid program become performance based. A true system of performance measures will create enormous new demand for better data on inventory condition and value, real-time system performance, safety, environmental protection, and other performance metrics."

This comment was meant to support the RTCC report recommendation for additional support for data collection.

TRB has, and has had, committees providing peer review of the research programs of FHWA, FTA, and FRA and for peer reviews of USDOT strategic planning for research during the Bush and Clinton Administrations. From this experience, we have become somewhat circumspect about the prospects of developing and implementing successful empirical performance measures of research and development outcomes. It is, of course, relatively easy to develop and implement output performance measures for short-term, highly applied research, such as progress against milestones. This is widely done in both government and industry and in programs managed by TRB, as described in more detail below. We strongly endorse, however, the recommendation of a National Academy panel convened to address the question of evaluating R&D in response to the Government Performance Results Act (GPRA),

> "The most effective means of evaluating federally funded research programs is expert review. Expert review—which includes quality review, relevance review, and benchmarking—should be used to assess both basic and applied research programs."[10]

Our committees have tended to be circumspect about research outcome performance measures for a variety of reasons: the need to have different expectations across different areas of research, such as policy, materials, ITS, safety; the long lead-time for basic research results to find their way into products, technologies, and practices; and the difficulty crediting individual research projects for outcomes influ-

[9] See pages 91–92 of Special Report 295.

[10] *Evaluating Federal Research Programs: Research and the Government Performance and Results Act.* Committee on Science, Engineering, and Public Policy. National Academy of Sciences, National Academy of Engineering, Institute of Medicine. National Academy Press, 1999, p. 5.

enced by other research and other factors. It is much easier to measure the impact of a materials research project that leads to a new specification than for a policy research project that leads to new understanding about travel behavior, but both outputs are important for the advancement of the field. As a result, committees of the National Academies have tended to place more emphasis on getting processes right—appropriate stakeholder involvement, merit review, and peer review of both projects and programs that help ensure achievement of the desired outcomes.

Q4a. What are the performance metrics TRB uses for the Strategic Highway Research Program (SHRP), SHRP–2, and any other research that it funds?

A4a. Most projects undertaken in the cooperative research programs, the original SHRP, or SHRP–2 are expected to yield products that will find application in transportation practice, consequently TRB relies upon review of the research it manages at both the project and the program levels by committees that include practitioners as well as subject matter experts. For SHRP–2 and the cooperative research programs, every project is overseen by a panel of researchers and practitioners. Each panel prepares requests for proposals, conducts a merit review of the proposals received, and monitors the progress and outcomes of each project. We rely upon these panels for quality review of individual projects. Although the research reports prepared through the SHRP–2 and cooperative research programs appear under the name of the authors of the research, the results are only published by TRB if the panels so recommend. These panel determinations are based upon such considerations as whether the authors have been responsive to the statement of task of the RFP and whether the quality of the work meets standard practice. During the course of the research, the contractors are required to report to the panel on progress against milestones, including schedules.

At the program level, an ongoing review is provided by the committees that oversee the research programs that TRB manages. For example, the National Cooperative Highway Research Program (NCHRP) is funded each year by the voluntary contributions of each member state of the American Association of State Highway and Transportation Officials (AASHTO). The projects are selected by AASHTO's Standing Committee on Research (SCOR), which also makes the funding allocation decisions. At the semi-annual meetings of SCOR, they are briefed on projects completed and published, progress against milestones of individual projects, and other metrics, including implementation, or usage, of report results (see Appendix 1). NCHRP tracks the adoption of AASHTO standards, specifications, and guidance that are based on NCHRP research results.[11] Also, the panels of completed projects are surveyed every four years to find out about applications of the research they oversaw.[12] In addition, TRB monitors the diversity of contractors selected. In 2008, NCHRP was subject of a benchmarking analysis conducted by directors of State and FHWA research programs.

The funding and governance models vary from NCHRP in the Transit and Airport Cooperative Research Programs (TCRP and ACRP), because Congress authorizes these programs and appropriates the funds. The governance of the programs, however, mirrors that of the NCHRP program. A special committee of the American Public Transportation Association (APTA) allocates funds and picks TCRP projects and a committee appointed by the Secretary of Transportation provides the same functions for ACRP. These governance committees also provide ongoing program reviews. As does NCHRP, in addition to reporting on program and project statues, TCRP briefs its oversight committee on products adopted by APTA members and others (see Appendix 1 for examples) and reports on periodic surveys of transit industry users of TCRP reports.

The Strategic Highway Research Program 2 is yet a different model. Although AASHTO supported authorization of the program in SAFETEA–LU, and the states agreed to fund it through Title I as a percentage take-down of their federal aid for capital and maintenance, as directed by Congress the oversight committee was appointed by TRB's administrative parent organization, the National Research Council (NRC). (The NRC is the operating arm of the National Academies.) This oversight committee is made up of representatives of State DOTs, researchers, environmental and safety groups, and other highway research stakeholders. As a fairly "young" program, SHRP–2 has few products to review to date. So far, the oversight committee has been briefed on program and project status. Moreover, in authorizing

[11] *Leveraging Resources for Better Transportation.* National Cooperative Highway Research Program. Transportation Research Board of the National Academies. 2002. See page 3 for a listing of the 40 AASHTO specifications, guides, and other documents based on NCHRP research over the previous decade. *http://www.trb.org/NotesDocs/NCHRPBrochure.pdf*

[12] *http://www.trb.org/NotesDocs/NCHRPSurveyResults.pdf*

this program in SAFETEA–LU, Congress chose to have it evaluated by the Government Accountability Office.

We believe that the determination of the relevance of the research managed by TRB is built into the structure of these programs. The decisions about what research to conduct is made by the oversight committees themselves. The relevance of individual projects is further ensured by having panels that include practitioners oversee each project. In research programs such as these, another important measure of relevance is the ongoing satisfaction of the organizations that requested that TRB manage the research in the first place. NCHRP, for example, has been in existence for over 40 years, and the states have demonstrated their commitment to it through their annual, voluntary contributions to fund the program. In all these years, only one state has ever opted out, and it did so for only one year. The other cooperative programs are much younger, and are funded through a different mechanism, but both APTA and Airports Council International–North America (ACI–NA), along with FTA and FAA, have demonstrated strong support.

In response to a follow up question to your staff, we were asked to indicate how TRB decides to begin or terminate research projects. As indicated above, the oversight committees of the cooperative research programs and SHRP–2 make all the decisions about project initiation. Projects are occasionally terminated if the project panel overseeing the project concludes that the contractor is not addressing the commitments made in the agency's proposal or not providing quality work. In the case of SHRP–2, contracts for higher-risk research generally contain "go/no go" gateways which require the researchers to formally demonstrate the feasibility and or the utility of the research at an early stage in order to receive continued funding. The decision to continue or terminate is made by the oversight committee.

Q5. How does TRB disseminate the results of the research it funds to standards development organizations (SDOs)?

A5. As described above, the products of the SHRP and cooperative research programs are expected to be applied in transportation practice. Such application, however, is constrained if standards that agencies can reference for design and contracting do not exist. Therefore, the volunteer expert groups overseeing projects encourage the research contractors to deliver materials that will directly enable SDO development of new standards or the revision of existing standards. For example, Superpave, a major product of the first SHRP now in use throughout North America, is the systematic amalgamation of 26 different AASHTO standard specifications, test methods, and practices. The initial data used for development of these standards was supplied by the original SHRP research teams. Similarly the Load Resistance Factor Design (LRFD) guideline for bridge design adopted by AASHTO several years ago was preceded by a series of NCHRP projects addressing a variety of different technical concerns of AASHTO's subcommittee on bridges and structures. The Mechanistic–Empirical Design guidelines for pavements, which has been endorsed by AASHTO and is being adopted by states, was developed in the same manner. In both these cases, SCOR embarked on a deliberate program of research to revise and modernize these design guidelines. TCRP has also funded projects that have resulted in transit standards, for example a TCRP project provided technical information and resources that helped result in the adoption of many IEEE electric rail passenger vehicle standards for system and subsystem interfaces.[13] TCRP also provided information to ASME that led to ASME standards on light-rail vehicle crash-worthiness.

The cooperative programs often include members or liaisons from SDOs when conducting a project that will provide information that may be of use to the SDO that has responsibility for a standard. For example, NCHRP panels have addressed issues such as traffic signal visibility requirements and maintenance practices for LED traffic signals, and have involved ITE members and staff in doing so because ITE is the SDO for traffic signal heads.

While AASHTO, APTA, and ACI–NA have strong influence in selecting TRB projects, other organizations also develop standards applied in transportation. To ensure these organizations also have access to TRB information that supports standards development, all reports of the Cooperative Research Programs and SHRP–2 are posted on TRB's website for free download. Completed reports are announced in TRB's weekly e-Newsletter, which reaches more than 30,000 recipients.

TRB's Technical Activities Division has about 200 standing committees made up of 4,000 individual practitioners and researchers. This standing committee structure

[13] TCRP Research Results Digest 44: Consensus Standards for the Rail Transit Industry. Transportation Research Board of the National Academies. *http://onlinepubs.trb.org/Onlinepubs/tcrp/tcrp_rrd_44.pdf*

functions much like a professional society. The mission of the standing committees is to bring practitioners and researchers together to identify research needs, stimulate needed research, provide input on research priorities and procedures, facilitate the adoption of appropriate research findings into practice, and provide a mechanism for mutual exchange of information on social, economic, and technological developments within transportation. The committees organize workshops, conferences, and the sessions of TRB's Annual Meeting, which attracts over 10,000 participants. Many of the members of these committees serve on the standards committees of organizations such as the ITE, American Concrete Institute, AASHTO, APTA, IEEE, ASME and similar organizations. The TRB's Annual Meeting is the world's largest meeting designed for the sharing and dissemination of research information. Much of it finds its way into the hands of SDOs.

Questions submitted by Representative Adrian Smith

Q1. Do we need to produce a new, comprehensive strategy for our nation's highways? If so, should this strategy include other transportation modes? Who should be charged with developing such a strategy and how often should it be updated?

A1. There has not been a Transportation Research Board (TRB) report addressing Mr. Smith's important questions. SAFETEA–LU did call for two major commissions to provide guidance to Congress on the future of the highway program, particularly with regard to how it should be funded. Both Commissions have prepared extensive and reports to Congress; The National Surface Transportation Policy and Revenue Commission provides recommendations for a comprehensive, multi-modal strategy, and well as recommending how such a strategy should be funded.[1] The National Surface Transportation Infrastructure Financing Commission provides recommendations regarding funding the highway program.[2] Funding issues will likely be paramount in Congressional debates about reauthorizing SAFETEA–LU, which expires at the end of September of this year, as the authorized funding from the Highway Trust Fund in 2008 and 2009 exceeds available user tax revenues.

If a TRB committee was charged to address Mr. Smith's question about developing a new, comprehensive strategy for our nation's highways, it would need to consider the character of the current highway program and whether it is meeting the Nation's needs as currently structured. The federal highway program began in 1916 with the first authorizing legislation and has been reauthorized and reshaped from time to time over the last nine decades. Although the program has evolved, particularly with the federal emphasis on the Interstate program in the middle of the last century, it has retained a federalist structure in which the Federal Government provides a share of the cost of new and rehabilitated highways, while the states, and to a lesser extent metropolitan areas, make the decisions about where and how funds should be invested to serve urban, rural, and inter-city passenger and freight travel demand. The states are also primarily responsible for maintenance, enforcement, and safety and develop the standards by which highway infrastructure is designed, constructed, and operated. The federal program is a user financed system that is almost completely funded by taxes on highway gasoline and diesel sales and through commercial vehicle excise taxes. Authorizing legislation also pursues federal environmental, safety, equity, and mobility goals through provisions in the law; moreover the law provides and allows for expenditures of about 15–20 percent of all user taxes paid by motorists and motor carriers into the Highway Trust Fund for investments in new transit capital. As noted in my original written testimony, the federal investment in highway research and development is an absolutely critical component of the innovation process.

Because federal highway funding as currently structured operates something like a block grant to the states, there is no comprehensively stated strategy per se, even though the law addresses many important federal goals through its requirements and program funding categories. For example, in addition to pursuing the goals listed above, the law requires and helps fund metropolitan planning organizations to ensure adequate investment in highway and transit programs within urbanized areas. Thus, it is fair to say that whereas there is no single strategy for the current program, there are many federal, State, and metropolitan transportation and environmental strategies accomplished through current legislation.

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[1] National Surface Transportation Policy and Revenue Commission Report, *http://transportationfortomorrow.org/*

[2] National Surface Transportation Infrastructure Financing Commission, *http://financecommission.dot.gov/*

I provide this background in part to address the question of who should be charged with developing a new, comprehensive strategy and how often it should be updated. Clearly one option would be for the U.S. Department of Transportation (USDOT) to assume a leadership role in any such an endeavor in concert with states, metropolitan areas, and highway and transit users. The USDOT has prepared such policy guidance in the past in the form of major reports, often as a prelude to reauthorization.[3] The commission model is another option. Mr. Smith may find that the report of the National Surface Transportation Policy and Revenue Commission provides the comprehensive strategy he seeks. Because the current program serves so many goals and has evolved over decades to balance federal, State, metropolitan, highway and transit and environmental interests, development of a new comprehensive strategy would no small undertaking. It would not only reconsider transportation goals, it would have to include reconsideration the current intergovernmental institutional structure for carrying out current highway and transit programs.

Mr. Smith also asks about whether a strategy should be multi-modal. As noted, Congress has already incorporated transit into the highway program by taxing highway users to pay the federal share for new transit capital investments and by requiring and funding comprehensive planning for urbanized areas. An open question is whether other surface modes should be financed in this manner. We have not addressed inter-city passenger rail for some time, but in a 1991 report, our study committee concluded that subsidies for high-speed rail could be justified in some corridors, but progress in doing so was stymied by lack any dedicated mechanism for funding these subsidies.[4] Current highway and aviation trust fund legislation preclude subsidies for inter-city rail.

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[3] See, for example, the last such report prepared by USDOT, The Changing Face of Transportation. *http://www.bts.gov/publications/the_changing_face_of_transportation/*

[4] *In Pursuit of Speed: New Options for Inter-city Passenger Transport.* Special Report 233. Transportation Research Board, National Research Council. Washington, D.C. 1991. *http://trb.org/news/blurb_detail.asp?id=2690*

Appendix: Examples of Usage of TCRP and NCHRP Reports

TRANSIT COOPERATIVE RESEARCH PROGRAM

- **Transit Capacity and Quality of Service Manual:** TCRP Project A–15, produced a *First Edition, Transit Capacity and Quality of Service Manual,* that was initially available as a CD–ROM and on the TRB website as TCRP Web Document 6. In late 2003, TCRP Report 100, *Transit Capacity and Quality of Service Manual: Second Edition* was issued, updating and adding to the material provided in the first edition. Report 100 is a fundamental reference document for public transportation practitioners that contains quantitative techniques for calculating the capacity of bus, rail, and ferry services, and transit stops, stations, and terminals. It also provides a framework for measuring transit availability and quality from the passenger point of view. TRB established a Task Force on Transit Capacity and Quality of Service that will manage the transit manual much as a TRB standing committee has long overseen revisions and expansions of the *Highway Capacity Manual.* The University of Arizona, University of Idaho, Massachusetts Institute of Technology, Portland State University, and the Queensland University of Technology all report incorporating the manual into transportation education programs. In addition, all Metropolitan Planning Organizations in Florida, at the request of the Florida Department of Transportation, are assessing their transit systems using the quality of service concepts outlined in the manual. Transit agencies in Atlanta, Birmingham, Broward County (FL), DuPage County (IL), San Antonio, New Orleans, Seattle, Washington (DC), San Francisco, MTA New York City Transit, Adelaide (Australia), and Dublin (Ireland) also report using the manual for transit planning processes and quality of service evaluations. AC Transit in Oakland reports that its Board of Directors is currently reviewing the quality of their services as they relate to the quality of service parameters in TCRP Report 100. The National Transit Institute offers a course on the material in the manual.

  The Institute of Transportation Engineers (ITE) reports that it is using material from TCRP Report 100 in a new textbook that they are developing, titled *Professional Transportation Planner (PTP) Certification Program Refresher Course Handbook.*

- **Transit Vehicles and Maintenance:** TCRP Report 29, *Closing the Knowledge Gap for Transit Maintenance Employees: a Systems Approach,* addresses the maintenance skill supply, the skill needs and effective training methods. It is very popular with maintenance personnel, because it is "down to Earth" and squarely addresses the technology, diagnostic, and skill development issues mechanics are facing. The Transit Authority of River City in Louisville, Kentucky, has given copies to all of its maintenance personnel, and uses the report as a basis for staff meetings and maintenance services delivery. Pierce Transit in Tacoma, Washington, also used the report as part of their maintenance team concept. It provides ideas for skills utilization and performance measurement that are being incorporated, with union support, into skills-based career ladders. The National Transit Institute selected Report 29 for a very successful teleconference seminar that featured prominent maintenance managers in a call-in radio format.

- TCRP Report 43, *Understanding and Applying Advanced On-Board Bus Electronics,* is being used by Pierce Transit in Tacoma, Washington, and other transit agencies to give staff a better understanding of multiplex wiring and intelligent fleet systems. A comment received on the APTA TCRP website states," this is a great report; a terrific help to understanding what is going on, written at the level of the intelligent layman/engineer." This report has become a basic primer for bus on-board electronics.

- Pierce Transit also reports that TCRP Report 25, *Bus Operator Workstation Evaluation and Design Guidelines,* was used to change the specifications for new coaches. Specifically, they ordered smaller steering wheels and air-ride seats to reduce driver fatigue. Also, a major North American bus manufacturer advertises that its new driver workstation "is ergonomically designed to meet TCRP recommendations," indicating that Report 25 and its comprehensive companion, Web Document 1, were used in the redesign of the bus.

- *TCRP Synthesis 2,* "Low-Floor Transit Buses," described the technology and issues associated with low-floor transit buses as of January 1994. TCRP Report 41 updates information on the current market for low-floor buses, and provides a summary of operating experiences on the basis of discussions with transit agencies and low-floor bus manufacturers. Many transit systems have used this material in their evaluations of low-floor vehicles for bus purchasing decisions.
- TCRP Projects C–12, *Configuration Options Supplement to Standard Purchase Specifications for Transit Buses,* and C–13, *30-Foot, Heavy Duty Bus Technical Specifications* developed standard bus specifications for different types of heavy-duty transit buses using an industry consensus process administered by the American Public Transportation Administration (APTA). Specifications were prepared for the following buses: (1) 35/40-foot, heavy-duty, diesel, low-floor; (2) 35/40-foot, heavy-duty, compressed natural gas, low-floor; and (3) 30-foot, heavy-duty, diesel, low-floor. In addition, generic specifications for the bus operator workstation and on-board bus electronics have been completed, and incorporated in the bus specifications described above. These specifications are available through APTA. Many transit systems are incorporating the standard specifications in their bus procurement processes.
- TCRP Report 61, *Analyzing the Costs of Operating Small Transit Vehicles,* provides a User's Guide that explains an accompanying Small Transit Vehicle Economics (**STVe**) computer-based model. **STVe** is a tool designed for transit planners and others making decisions about the purchase of small transit vehicles for different services and operating environments. The **STVe** is based on the principles of engineering economics and allows the user to assess whether it makes economic sense to invest in a particular type of vehicle, based on user-defined inputs. The User's Guide describes how to run the model and interpret the results. It also explores non-financial aspects that may influence the vehicle purchasing decision. A number of transit systems have indicated the use of the report and its tool in their bus purchasing decisions.
- **Bus Stop Location/Design:** TCRP Report 19, *Guidelines for the Location and Design of Bus Stops,* provides guidelines for locating and designing bus stops in various operating environments. The Central Contra Costa Transit Authority reports that it uses this report to assist them in making recommendations for the location of bus stops to their member jurisdictions.
- **Pedestrian Safety:** TCRP/NCHRP Report 112/562, *Improving Pedestrian Safety at Unsignalized Crossings* was approved by the National Committee of the MUTCD. As a result, the next version of the MUTCD will include changes in the area of Pedestrian Beacon and Pedestrian Signal Warrant.
- **Standardized Railcar Systems:** Transit rail operators could save as much as $120 million as a result of the development of uniform technical standards for rail vehicle systems and subsystems. Through TCRP Project G–4, an Institute of Electrical and Electronics Engineers (IEEE) Rail Transit Vehicle Interface Standards Committee was formed as part of the standards-development process. The Committee formed 15 working groups to prepare standards for specific interfaces. In addition, an American Society of Mechanical Engineers (ASME) Committee was formed to develop mechanical standards for railcars. This ASME Committee focused on the structural strength and crash-worthiness of light rail and rapid transit cars. The standards, which should lower the cost of transit railcars and replacement parts, reduce parts inventories, and simplify maintenance, evolved through a consensus-building process. The project involved significant in-kind contributions by the transit industry, leveraging the TCRP investment by a ratio of approximately eight to one. Under the TCRP project, nine standards were formally published by the IEEE, and a number of others were in various stages of production in 2002, when the process was transitioned to APTA sponsorship. It has been reported that SEPTA used a draft version of a standard outlining communications-based train control (CBTC) performance and functional requirements in its CBTC procurement document for its light rail tunnel. The MTA NYCT has indicated that the standards have helped them finalize technical specifications for the procurement of more than 2,000 new subway cars. In addition, New Jersey Transit reported that it would save approximately $420,000 per year as a result of the use of the IEEE standard for communications protocols aboard trains developed by this effort. To date, the standards have been cited

in specifications issued by the Chicago Transit Authority, Massachusetts Bay Transportation Authority, MTA Long Island Railroad, MTA New York City Transit, New Jersey Transit, Washington Metropolitan Area Transit Authority, and the Southeastern Pennsylvania Transportation Authority. The Illinois Department of Transportation also cited the standards in their positive train control procurement project.

- **Rail Infrastructure Research:** TCRP Report 57, *Track Design Handbook for Light Rail Transit,* provides guidelines for the design of various types of light rail transit track. Track structure types include ballasted, direct fixation ("ballastless"), and embedded track. The components of the various track types are discussed in detail. The handbook includes chapters on vehicles, alignment, track structures, track components, special track work, aerial structures/bridges, corrosion control, noise and vibration, signals, and traction power. These chapters provide insight into considerations that affect track design and require interface coordination. A consultant reported that he had used the handbook on LRT design projects in Baltimore and Tampa. In addition, the Charlotte Area Transit System reported that it used the report to review the design aspects of its planned light rail system as they were developed by the system's consultants. The Denver RTD also reported that the handbook was used as the basis for designing its light rail extension. AREMA Committee 12 is currently updating Chapter 12 of the AREMA track standards for transit application. The committee is drawing heavily from TCRP Report 57.
- **Fare Structures, Systems, and Technologies:** TCRP Report 80, *A Toolkit for Self-Service, Barrier-Free Fare Collection,* addresses the full range of issues and parameters that an agency must consider in determining the applicability of self-service fare collection systems, including those related to policy and enforcement issues, operational issues, and capital and equipment issues. The Charlotte Area Transit System (CATS) reports that this TCRP publication served as the centerpiece for recommendations associated with establishing regulations to address fare evaders, and other safety/security matters associated with operating the barrier-free fare collection system proposed for their light rail system.
- **Track Sharing:** TCRP Report 52, *Joint Operation of Light Rail Transit or Diesel Multiple Unit Vehicles with Railroads,* identifies and discusses issues associated with the joint operation of light rail transit (LRT) or lightweight diesel multiple unit (DMU) vehicles with freight and/or passenger railroads. For the purposes of this report, joint operation is defined as co-mingled, simultaneous train operation on shared track by railroad trains (freight and/or passenger) and rail transit vehicles that are not fully compliant with current Federal Railroad Administration (FRA) regulations. The report identifies and discusses issues associated with such joint operation, focusing on the current regulatory and institutional environment, railroad and rail transit operations, infrastructure, and rolling stock. In addition, substantial information concerning joint operation overseas is presented and discussed. This report has been a primary source of information to assist in the debate on the issue of track sharing in the United States.
- **Public Transportation to Airports:** TCRP Report 62, *Improving Public Transportation Access to Large Airports,* presents available data on the use of public transportation at large U.S. airports and selected international airports, as well as related evolving trends. The report provides examples of successful airport access systems from around the world; presents key factors affecting the use of public transportation by airline passengers and employees; identifies new and emerging technologies that have the potential to improve public transportation services at airports; and describes the institutional environment and factors affecting public transportation at large U.S. airports, including airport structure, funding for airports, and agreements with airlines. This report has been useful to several transit agencies investigating potential rail links to airports in their service areas.
- **Evaluating Fuel Options for Buses:** TCRP Report 38, *Guidebook for evaluating, Selecting and Implementing Fuel Choices for Transit Bus Operations* (C–8), provides information on the performance, cost, safety, and facility requirements of five transit bus fuels: diesel (baseline for comparison), compressed natural gas, liquefied natural gas, methanol, ethanol and liquefied petroleum gas. An accompanying cost model spreadsheet, *FuelCost 1.0,* en-

ables users to estimate and compare the cost impacts of fuel choices. VIA Transit in San Antonio used the software to aid them in selecting an alternative fuel and in justifying the decision to their management and Board of Directors.

- **Rural Transit:** TCRP Report 54, *Management Toolkit for Rural and Small Urban Transportation Systems,* identifies an array of management principles and techniques, for use by small urban and rural public transportation providers, to assist in managing their transportation services more effectively. The toolkit has two parts: a guidebook and a self-assessment tool. The guidebook introduces the idea of customer-driven transit service attributes and includes general management philosophies. Included in the guidebook are exemplary practices and "how to" instructions for some topics. Additional sections describing "rules of thumb" or "things to avoid" are included for some management processes. A self-assessment computer-based tool on disk accompanies the report. The tool is designed to give the user a baseline or current picture of the status of the transit system. The West Virginia Division of Public Transit distributed copies of this report to all of the rural operators in the state and also brought in the consultant who produced the report to give a training session. The Division of Public Transit indicates that the report, and its accompanying tool, have been very useful to the rural operators in West Virginia.
  - TCRP Report 70, *Change and Innovation at Rural and Small Urban Transit Systems,* addresses the culture for change and innovation, and presents more than 40 initiatives and innovations implemented by an array of organizations including public and nonprofit transit systems, regional planning agencies, State transit associations, and State departments of transportation. The Southeast Missouri Transportation Service reports that the report ". . . has been a valuable resource in improving our service." They have used the report to ". . . define our corporate culture, and focus on our values, attitudes and beliefs for the process of change." Also, ". . . this report has challenged us to be the best we can be and view challenges as opportunities for new ways of doing things."
- **Bus Rapid Transit:** TCRP Report 90, *Bus Rapid Transit,* a two-volume set, identifies the potential range of bus rapid transit applications through 26 case studies, and provides planning and implementation guidelines for bus rapid transit. The Charlotte Area Transit System reports that they found the case studies in Report 90, Volume 1 very helpful as they were preparing information on bus rapid transit to share with their board. The Fairfax County (Virginia) Department of Transportation reports that it has used Report 90 extensively in the planning for a BRT system in the Richmond Highway corridor of the county.
  - TCRP Report 118, *Bus Rapid Transit Practitioner's Guide,* provides information on the costs, impacts, and effectiveness of implementing selected bus rapid transit (BRT) components. It includes practical information that can be readily used by transit professionals and policy-makers in planning and decision-making related to implementing different components of BRT systems. This report updates some of the information presented in TCRP Report 90: *Bus Rapid Transit* and presents the latest developments and research results related to the costs and impacts of implementing various BRT components and their effectiveness. The California Department of Transportation (CALTRANS) indicated that they use TCRP Report 118 as the basis for a course for CALTRANS personnel, particularly highway/traffic engineers. Purdue University notes that the material in Report 118 is used in a course covering bus rapid transit.
- **Transit Operator Fatigue:** TCRP Report 81, *Toolkit for Transit Operator Fatigue, documents principles, techniques, and strategies that can be used in the development of fatigue-mitigation plans. The Toolbox* includes a "how to" component on the design, implementation, and evaluation of fatigue-mitigation plans. An accompanying CD–ROM provides specific tools, such as posters for operator rooms, that address fatigue issues. The National Transit Institute (NTI) prepared a one-day course on the report, and offered it at eight locations throughout the country in the first half of 2003. The Santa Clara Valley Regional Transportation Authority (VTA) in San Jose, California reports that it has implemented many of the tools in the report that were taught at the NTI training classes.

- **The Image of Transit:** TCRP Report 63, *Enhancing the Image and Visibility of Transit in the United States and Canada,* assists professionals at the local, regional, and national levels interested in improving the visibility and image of transit in the United States and Canada through the implementation of image campaigns. The report documents and presents how the image of transit can be strengthened by building on existing positive perceptions. The research provides a communications strategy to guide national, regional, and local efforts to enhance the image and visibility of transit in order to create a more positive and supportive environment. The results of this effort are being used in APTA's Public Transportation Partnership for Tomorrow (PT)2 program. It has also been reported that the results were used in the development of marketing campaigns in Arizona and Pennsylvania. Funding assistance for the Canadian element of the research was provided, in part, by Transport Canada through the Canadian Urban Transit Association.
- **Professional Capacity Building:** Universities and State departments of transportation have requested TCRP materials, and sometimes the author, in support of training courses. The New York State Department of Transportation requested copies of TCRP Synthesis 22, *Monitoring of Bus Maintenance Performance,* for use in state-level training. The Pennsylvania Transportation Institute used copies of *Measuring Customer Satisfaction and Service Quality: A Handbook for the Transit Industry* in a course on customer service. The tools from that report were utilized in Pennsylvania. Minnesota DOT reported that Synthesis 30, *ADA Paratransit Eligibility Practices,* was beneficial to the DOT staff and was frequently requested by transit agencies in Minnesota. The author of TCRP Synthesis 8, *Retrofit of Buses to Meet Clean Air Regulations,* conducted six workshops on the subject at the request of agencies striving to comply with the complex regulations. He also conducted workshops for Florida DOT based on Synthesis 12, *Transit Bus Service Line Cleaning Functions.*

  The Civil Engineering Department at the University of Nevada, Las Vegas developed a graduate course in transportation using TCRP Reports 16, 27, 30, 33, 35, 36, and the CD–ROM on Transit Capacity and Quality of Service as source materials.

  Rutgers University is using TCRP Report 30, *Transit Scheduling: Basic and Advanced Manuals,* and TCRP Report 100, *Transit Capacity and Quality of Service Manual: Second Edition* in a course entitled Transit Management and Planning. The course is part of the Master's program at Rutgers University Bloustein School of Planning and Public Policy.

  Two products are especially useful to travel demand forecasters:

  —TCRP Report 95, *Traveler Response to Transportation Systems Changes: Third Edition* will be published as a 19-volume report, updating a handbook last published in 1981. This handbook will equip members of the transportation profession with a comprehensive, readily accessible, interpretive documentation of results and experience observed across the United States and elsewhere of traveler responses to different types of transportation system changes. To date, the first thirteen volumes of this report have been published—Chapter 2, *HOV Facilities;* Chapter 3, *Park-and-Ride/Pool;* Chapter 5, *Vanpools and Buspools;* Chapter 6, *Demand Responsive/ADA;* Chapter 9, *Transit Scheduling and Frequency;* Chapter 10, *Bus Routing and Coverage;* Chapter 11, *Transit Information and Promotion;* Chapter 12, *Transit Pricing and Fares;* Chapter 13, *Parking Pricing and Fees;* Chapter 14, *Road Value Pricing;* Chapter 15, *Land Use and Site Design;* Chapter 17, *Transit Oriented Development;* and Chapter 18, *Parking Management and Supply.* Remaining chapters will be published throughout the remainder of 2008 as they become available. The Metropolitan Atlanta Rapid Transit Authority reports that it used Chapter 11 in the development of its 2005 Marketing Action Plan. Bloomington (IN) Transit reports using Chapter 3 in discussing commuter parking lot impacts with adjacent community groups. The University of Florida reports that Chapter 15, *Land Use and Site Design,* has been incorporated in a course being offered.

  —TCRP Report 73, *Characteristics of Urban Transportation Demand,* examines macro transportation characteristics such as daily trips per capita, daily trips by mode, average trip length, vehicle miles of travel per household, trip chaining, and parking ratios by type of work site. The final report

provides a compendium of multi-modal information for transportation planners, provided in both printed and electronic form.

The Southeastern Pennsylvania Transportation Authority (SEPTA) human resources department indicates that they use the following TCRP publications, among others, in their on-going training programs:

(1) TCRP Report 27, *Building Transit Ridership: An Exploration of Transit's Market Share and the Public Policies That Influence It*
(2) TCRP Report 28, *Transit Markets of the Future: The Challenge of Change*
(3) TCRP Report 77, *Managing Transit's Workforce in the New Millennium*
(4) TCRP Report 88, *A Guidebook for Developing a Transit Performance Measurement System*
(5) TRB Special Report 257, *Making Transit Work: Insight from Western Europe, Canada, and the United States* (funded through TCRP)
(6) TCRP Synthesis 16, *Changing Roles and Practices of Bus Field Supervisors*
(7) TCRP Synthesis 40, *A Challenging Employment System: Hiring, Training, Performance Evaluation, and Retention of Bus Operators*
(8) TCRP Synthesis 45, *Customer Focused Transit*
(9) TCRP Synthesis 47, *Corporate Culture as the Driver of Transit Leadership*

The American Planning Association is incorporating material from several chapters of TCRP Report 102, *Transit Oriented Development in the United States: Experiences, Challenges, and Prospects* in their Transit Oriented Development Planners Training Service course.

The Commonwealth of Puerto Rico, Highway and Transportation Authority, Department of Public Works, Oversight Systems Safety Manager, incorporates TCRP publications for training at Tren Urbano.

- **Workforce Development Initiative.** Two TCRP reports have served as key inputs to APTA's Workforce Development Initiative. *TCRP Research Results Digest 45,* "Identification of the Critical Workforce Development Issues in the Transit Industry," provides a scoping study that identifies: the most important challenges that the transit industry faces in workforce development; current innovative approaches to workforce development on the part of both transit agencies and external "benchmarks"; the most useful potential products of the Workforce Development Initiative; and the next steps that should be taken to help the transit industry address workforce development on an effective, ongoing basis.

  TCRP Report 77, *Managing Transit's Workforce in the New Millennium,* assesses the transit industry's workforce needs and prospects for the coming decades. Further, the report provides guidelines to enable employers to assess the their own workforce needs, describes best practices for recruiting and retaining employees, and identifies ways to enhance or establish partnerships between management and labor for attracting, training, and maintaining a qualified workforce.

- **Transit Scheduling:** Scheduling is one of the basic skills in the transit industry. TCRP Report 30, *Transit Scheduling: Basic and Advanced Manuals,* updates a 50-year-old predecessor, providing step-by-step instructions in trip building, blocking, run-cutting, and rostering. The report is written in the form of a training manual, and has proved very popular. The Metropolitan Transit Development Board in San Diego requested copies for the scheduling staff. University and state DOT staff have also requested multiple copies for use in graduate level courses and for training staff: Institute for Transportation Research and Education, North Carolina State University; the National Center for Advanced Transportation Technology, the University of Idaho; and the Oregon Department of Transportation. SunTran (Ocala, FL) reports using Report 30 to train their schedulers.

- **Software for Transit Risk Managers:** Identification of risk exposure is the cornerstone of the risk-management process, because the other elements of risk management rest on the accuracy and completeness of this process. TCRP project G–3 developed risk management software and a User's Guide tailored to the needs of transit risk managers. The software was dem-

onstrated at the 1996 APTA Risk Management Seminar and at the 1996 APTA Annual Meeting. Copies were also distributed by the usual J–1 distribution method. Through the TCRP J–1 project, APTA prepared the product for distribution, professionally packaged like commercial software. Two companion Research Results Digests cover identification of risk exposure, risk assessment, loss control programs, and guidelines for consistent collection of loss data. The Hillsborough Area Regional Transit Authority reported that they have used the software extensively to help identify potential risks.

- **Technology Transfer from International Experience.** TCRP Project J–3, International Transit Studies Program: The International Transit Studies Program is a leadership development program intended to foster a multimodal-mobility-manager approach to urban transportation. Participants in the program bring innovative ideas from overseas to transportation agencies in the United States. The Massachusetts Bay Transportation Authority reported three major operational changes as a result of staff exposure to new ideas from abroad. The Blue Line was converted to single-person train operation, saving over $1 million per year. Opponents of the change were won over by the extensive documentation of European cities that made successful conversions to single-person train operation, by installing CCTV cameras on platforms as observed in Vienna, and by engaging in a public outreach campaign. The MBTA also introduced low-floor light rail cars and accelerated the change to a new station management system supported by the integration of automated fare collection equipment and security systems based, in part, on the observations of the modernization of older European transport systems to much safer, more secure, customer friendly station environments. NJ Transit reported that information gathered by staff who participated in a study mission greatly increased NJ Transit's confidence in low-floor light rail cars and helped support the decision to purchase low-floor cars. Also information on transit's contribution to livable communities in Europe was used as part of a transit-friendly land use initiative in New Jersey. NJ Transit also reported that information obtained in Europe about contactless smart cards was evaluated for possible application in New Jersey. At that time, European applications had gone beyond testing to implementation. Riverside Transit reported that information about integrated school and public transportation in Europe assisted them with an initiative in the Los Angeles area to demonstrate the feasibility of such integrated service. She also reported that information about corridor preservation, the use of art in transit, and strategies to improve livability of cities were applicable to issues she was facing at home. The London Docklands LRT is using moving block signal technology, and American transit agencies that are considering this technology found it reassuring to see that it works in practice as well as in theory. Participants were also impressed with improved transportation efficiencies achieved in Britain through increased use of private contractors and increased competition.

- **Low-Floor Light Rail Vehicles:** A number of transit systems, e.g., NJ Transit, SEPTA, and Santa Clara County, have used a TCRP database on available low-floor light rail vehicle (LFLRV) technologies and their characteristics as input into the development of potential LFLRV specifications. The project demonstrated, according to reports from Santa Clara County, that LRVs with 70 percent of the floor area in low-floor configuration minimize the risks associated with new rail car design, because they use traditional trucks, but still provide the advantages of a low floor for ADA compliance. This influenced their decision to plan for low floor LRVs. Santa Clara County staff estimated savings on the order of $20 million, attributable to not building expensive ramps for access by the disabled. Low-floor vehicles accommodate disabled persons, please the general public because the ramps would have detracted from the architectural aesthetics of a downtown transit mall, and save money. This was a win-win decision.

- **Alternative Fuel Safety:** NJ Transit and several bus manufacturers reported that they used TCRP Synthesis No. 1, Safe Operating Procedures for Alternative Fuel Buses, as a planning tool. One bus manufacturer reported that it made copies available to staff to inform them of safe handling procedures. At two conferences in Pennsylvania on alternative fuel buses, sponsored by the Rural Transportation Assistance Program (RTAP), most of the 35 to 40 attendees reportedly had this document with them or had read it. The majority of knowledge that these operations personnel had about alternative fuels at this point reportedly came from TCRP Synthesis No. 1. Fuels

like methanol, compressed natural gas, and liquefied natural gas have characteristics very different from diesel fuel or gasoline and are dangerous if handled incorrectly. This synthesis provided information on safe procedures for handling alternative fuels.

- **Operational Savings:** TCRP Report 4, *Aids for Rail Car Side-Door Operation,* provides guidance on the safest ways for the operator to observe door operation, thereby making it possible to eliminate conductors in some circumstances. This report was a key information resource for the Massachusetts Bay Transportation Authority (MBTA) during the conversion of the Blue Line to a single-person train operation in 1996, saving $1 million annually. The report was submitted to the Massachusetts State Legislature and the state regulatory agency during public hearings concerning the initiative.
- **Standardized Light Rail Signing for Improved Safety:** A draft version of a new light rail chapter for the Manual on Uniform Traffic Control Devices (MUTCD) was prepared as part of TCRP Project A–5, Integration of Light Rail Transit into City Streets. The TCRP contractor worked closely with the LRT Subcommittee of the MUTCD Committee on Railroad-Highway Grade Crossings to incorporate a new LRT chapter into the Millennium version of the MUTCD. The MUTCD is the document that contains nationally accepted standards for roadway signing and signaling, a critical element of traffic safety.
- **Track Maintenance Safety:** A National Transportation Safety Board (NTSB) report that was released in January 2008 referred to track-worker alert technology in its report on how to prevent future track-worker incidents. That track worker alert technology that NTSB referred to was developed and tested in TCRP IDEA Project 55, *"Warning Device for Rail Rapid Transit Personnel for Approaching Trains,"* and NTSB demonstrated that technology at their public board meeting. The IDEA project included testing of the technology at MTA New York City Transit and the Greater Cleveland Regional Transit Authority.
- **Reduced Visual Impact of Overhead Wire:** The Greater Cleveland RTA used the results of TCRP Project D–4, *Visual Impact of Overhead Contact Systems for Electric Transit Vehicles,* in planning an RTA extension. The findings of this project were particularly significant, because citizen opposition to overhead wire is one of the primary roadblocks to LRT acceptance.
- **Transit Performance Measures:** The Wisconsin DOT reported that two TCRP publications were very useful in reviewing transit performance measures and their use in allocation formulas: TCRP Synthesis No. 6, *The Role of Performance-Based Measures in Allocating Funding for Transit Operations,* and *The Quality Journey: A TQM Roadmap for Public Transportation.* The experiences of other states were found to be particularly helpful. TRB documents were reported to be of value in developing a long-range statewide transportation plan and in providing guidance to the Metropolitan Planning Organizations in the state. The Greater Cleveland RTA reported that it used TCRP Report 88, *A Guidebook for Developing a Transit Performance-Measurement System,* to assist in a review of their performance-measurement system. In addition, LYNX in Orlando, Florida indicated that it used TCRP Report 88 during its 2004 strategic planning process.
- **Public Transportation Boards:** TCRP Report 104, *Public Transportation Board Effectiveness: A Self-Assessment Handbook,* provides a self-assessment process and tools to measure public transportation board effectiveness and provides references on how board characteristics can be changed to improve board effectiveness in various areas. The handbook also identifies the characteristics of public transportation boards that influence transit system performance. A number of transit agencies, including the Dallas Area Rapid Transit (DART), indicated that they implemented the board self-assessment process developed in the report. The Small Urban & Rural Transit Center reports that it is using Report 104 as part of a 2.5 hour presentation on the roles and responsibilities of transit board members at the 2007 Dakota Transit Association Conference.
- **Application of Artificial Intelligence To Railcar Maintenance:** A potentially cost-effective use of artificial intelligence technology was identified to assist railcar maintenance personnel in their diagnosis of railcar propulsion system maintenance problems. TCRP Report 1, *Artificial Intelligence For*

Transit Railcar Diagnostics, recommended testing the technology on the propulsion system, because the potential for savings is the greatest. The project was continued in order to conduct an operational test of the concept. A successful demonstration was completed at the Washington Metropolitan Area Transit Authority. The results of the demonstration are summarized in TCRP Report 44.

- **Commuter Benefits Programs:** TCRP Reports 87, *Strategies for Increasing the Effectiveness of Commuter Benefits Programs,* and 107, *Assessing the Costs and Benefits of Commuter Benefits Programs,* provide significant information and guidance regarding the implementation of commuter benefits programs. The U.S. Environmental Protection Agency (EPA) has indicated that information from these publications is being used to document some of the impacts that might result from the EPA's Best Workplaces for Commuters Program. In addition, the contractors for Report 107 were presented with the 2005 Transportation Demand Management Institute Research Excellence Award. This award is presented annually to the research project noted for its substantial contribution to the field of transportation demand management.
- **Transit Security:** The Cambria County Transit Authority (CamTran) in Johnstown, Pennsylvania reports that it used the revised final report for Project J–10D, *Security Planning Tools for Rural, Small Urban, and Community-Based Public Transportation Operations* (to be published as Report 86/Volume 10 in early 2006) to assist them in the development of an Emergency and Security Plan that was required from the Department of Homeland Security to receive security funds for their Johnstown Inclined Plane. CamTran reported ". . . the TCRP document has been invaluable to us in providing structure and direction in what we need to get it done properly . . .. We have looked at many other agency plans and we have looked at what FTA and FEMA has to offer and it is just overwhelming. This TCRP document kept us on track and focused on what we needed."

SEPTA in Philadelphia reports extensively using TCRP Report 86, Volume 8, *Continuity of Operations (COOP) Planning Guidelines for Transportation Agencies,* as a valuable resource in developing their internal continuity of operations plan. The City of College Station, Texas, is using material from this report to develop its COOP plan.

Florida DOT reports that it hired the principal investigator of TCRP Report 86, Volume 10, *Hazard and Security Plan Workshop: Instructor Guide,* to offer the workshop in several locations statewide. Mississippi DOT has also made the course available for its transit systems, both pre- and post-Hurricane Katrina. The Texas DOT is conducting four workshops around the state that are based on this TCRP report and its CD–ROM. At one of the workshops, a participant indicated ". . . the things addressed were instantly applicable to our operation at Citibus and for the first time since I got the responsibility of our security plan, I felt like I learned strategies that I could suggest for implementation."

The Coast Guard reports that it is incorporating material from TCRP Report 86, Volume 11, *Security Measures for Ferry Systems,* in its training for new terminal pilots. The general security measures (GSM) evaluation and selection tool included in the report will also be included in a Coast Guard Navigation and Vessel Inspection Circular (NVIC). Material from the revised final report was also incorporated into internal Coast Guard documents for its operational commanders.

The California Office of Homeland Security used material from the TCRP Report 86 public transportation security series (Volumes 1–12) in developing its internal policies and procedures.

The Chicago Transit Authority reports that it has frequently turned to reports from TCRP when analyzing security issues and policies. They indicate that TRB is the first source turned to when looking for reports on useful transportation security practices.

NATIONAL COOPERATIVE RESEARCH PROGRAM

See the following which gives examples of the impact of NCHRP reports on practice. A series of such reports can be reviewed at this link to NCHRP section of the TRB website: *http://www.trb.org/CRP/NCHRP/NCHRPImpacts.asp*

NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM
Impacts on Practice—NCHRP Report 422

Quality assurance for the maintenance world

State DOTs expend tremendous resources to maintain their highways, bridges and other facilities. Many states use Maintenance Management Systems to plan and budget maintenance activities, but until recently DOTs' quality assurance programs were largely limited to the realm of construction.

Documenting field conditions

Responding to this need, NCHRP initiated Project 14-12, "Highway Maintenance Quality Assurance," to expand the use of QA programs in highway maintenance. The project's goal was to create a template for an MQA program that could be implemented by any state DOT. A program like this allows agencies to make educated decisions about where to invest limited maintenance resources, and to assess the benefits of investing in one type of asset over another.

The program template took the form of NCHRP Report 422, *Maintenance QA Program Implementation Manual*. Published in 1999, the report lays the groundwork for developing and implementing an MQA program, including guidelines for a Level of Service rating system and for field inspections, analysis and reporting.

> "I can't imagine trying to start the program without this report."

Building a program from scratch

For Wisconsin DOT, Report 422 was a key factor in the 2001 launch of the department's ambitious maintenance quality assurance program, called Compass.

"I can't imagine trying to start the program without this report," says Alison Lebwohl, former Compass program manager. "We had our pilot launched in six months, and I don't think we could have done it without having this step-by-step guide."

Tennessee DOT also put Report 422 to use in developing its Maintenance Rating Index, including program details such as TDOT's inspection form and the weighting factors assigned to roadway characteristics.

> "The report was a real steppingstone to advancing the national trend toward maintenance quality assurance."

More thorough inspections

Before TDOT developed the Maintenance Rating Index, Tennessee county supervisors evaluated roadway conditions using a traditional "windshield inspection"—rating highway segments while driving.

"Overall it's been a very positive program for us," says Chris Harris, an operations specialist with TDOT. "Inspectors like it because it gives them an opportunity to see more within their county than if they were just doing a windshield inspection."

Bringing MQA to practitioners

A unique aspect of Project 14-12 was its aggressive approach to technology transfer. The project included funding for six workshops that brought the manual's principles to state DOT managers and maintenance professionals across the country.

"We walked them through it," says Marshall Stivers, the project's co-principal investigator and formerly ERES Consultants' director of maintenance systems. "We took them out in the field and let them evaluate the quality of a highway segment. It was interesting—there were lots of variations in what people saw."

Lee Smithson, former deputy director of the maintenance division at Iowa DOT and a workshop attendee, said the workshops had a great deal of practical value.

"The workshops demonstrated how to use condition ratings as a target—how to go to policy makers and say 'Here's where we are, and here's how much money or staff it will take to get to that next level,'" Smithson says.

Interest builds nationwide

The workshops helped expand awareness of the new NCHRP manual and of the MQA concept, which was in its infancy when the manual was published in 1999. By the time Wisconsin DOT and the University of Wisconsin held a Maintenance Quality Assurance Peer Exchange five years later in 2004, participation was very strong, with staff from more than 35 agencies attending the event.

"The report was a real steppingstone to advancing the national trend toward maintenance quality assurance," Lebwohl says.

NCHRP Report 422 is available for purchase from the TRB Bookstore at **http://www.trb.org/bookstore/**. A related report, Web Document 8, is available online at **http://www.nap./edu/catalog/6346.html.**

Winter performance measures

NCHRP—Transportation research that works

Objective national highway research since 1962 • Focused on practical problems of state DOTs • Contract researchers competitively selected • Overseen by balanced panels of technical experts • Reviewed by TRB highway specialists

ACKNOWLEDGEMENT OF SPONSORSHIP Work was sponsored by the American Association of State Highway and Transportation Officials, in cooperation with the Federal Highway Administration, and was conducted in the National Cooperative Highway Research Program, which is administered by the Transportation Research Board of the National Academies.
DISCLAIMER The opinions and conclusions expressed or implied in reports are those of the research agencies. They are not necessarily those of the Transportation Research Board, the National Academies, or the program sponsors.

NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM
IMPACTS ON PRACTICE
NCHRP from a Chief Engineer's Perspective

Delivering value across a transportation agency

Bill Temple, chief engineer of the Louisiana Department of Transportation and Development, can name off the top of his head a dozen NCHRP research reports that his office uses on a regular basis to get its work done. Topics range from Superpave testing to pavement drainage issues, from access management to design-build contracting. However, when Temple did some asking around Louisiana DOTD, he found that his list was just the tip of the iceberg.

NCHRP research contributed to the accelerated design and construction of the new I-10 Twin Spans Bridge.

Serving Louisiana DOTD's engineers

To get a broader picture of how Louisiana DOTD uses NCHRP research, Temple asked division heads throughout the agency to identify NCHRP research products that they commonly rely upon. He received an impressive response, with some 150 reports cited by the Engineering Office alone, and 40 more by other areas of the agency.

Each part of the Engineering Office—spanning research, project development, construction, systems engineering, and traffic engineering—has examples to share. For instance, Project Development makes extensive use of NCHRP's load and resistance factor design research for bridge and structural design. Discussing recent rebuilding efforts on the Interstate 10 Twin Spans Bridge, Skip Paul, the director of the Louisiana Transportation Research Center, says, "The agency's design team never could have completed this work without relying on NCHRP research."

Systems Engineering is another frequent user of NCHRP research, calling upon many studies to support its mechanistic-empirical testing of state pavement materials and implementation of new design strategies. And NCHRP research studies are a standard reference for Pavement and Geotechnical Services' life cycle cost analyses. The list goes on.

Benefits across the agency

NCHRP's impact reaches beyond engineering and into virtually all areas of the agency. To name just a few:

- Highway Safety relies on NCHRP 500 Series guides for safety implementation and for data collection and analysis.
- Intelligent Transportation Systems has incorporated NCHRP research on traffic management centers into its statewide plans.
- Legal commonly uses NCHRP research on data management resources.

Small investment, large return

Louisiana DOTD enjoys a wide range of benefits from what Temple describes as a "flow of NCHRP material that arrives at our agency all year long." He estimates that Louisiana's annual voluntary contribution to NCHRP could by itself fund only a few research studies of a similar scope and magnitude. Pointing to all these NCHRP projects, Temple notes, "NCHRP is an extremely smart way for our department to leverage our research funding." Complementing the program's full-scale research projects is a variety of other research products cited by Louisiana DOTD division heads, including NCHRP synthesis reports, series 20-07 "quick response" studies, and Innovations Deserving Exploratory Analysis reports.

> "The agency's design team never could have completed this work without relying on NCHRP research."

Growing intellectual capacity

Beyond practical guidance, NCHRP research delivers additional benefits to Louisiana DOTD. "NCHRP assembles the best and brightest around the table when investigating a topic," says chief engineer Temple. Louisiana DOTD actively encourages employees to participate on Transportation Research Board technical committees and on NCHRP research project panels. Says research director Paul, "This not only helps us address areas of concern, but we also build a network of contacts among experts and grow our intellectual capacity to be worldwide leaders in our field."

> "NCHRP is an extremely smart way for our department to leverage our research funding."

Skip Paul (left), research director for Louisiana DOTD, is one of many users of NCHRP research reporting to Bill Temple (right), the agency's chief engineer.

NCHRP—Transportation research that works

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ANSWERS TO POST-HEARING QUESTIONS

Responses by David J. Wise, Acting Director, Physical Infrastructure Issues, U.S. Government Accountability Office

Question submitted by Chair David Wu

Q1. What would GAO consider to be adequate performance measures for evaluating the impact of the DOT RD&T investment?

A1. RITA's primary responsibilities include reviewing DOT's research activities to ensure that research throughout DOT has been evaluated according to best practices, thereby demonstrating the effectiveness of RD&T investment. We recommended that RITA develop an overall strategy, evaluation plan, and performance goals and measures for this and its other coordination and facilitation responsibilities. RITA has taken some steps to do so, but still lacks an overall strategy, evaluation plan, and performance measures for its review responsibilities.

While evaluating RD&T impact is not an easy undertaking, it does not have to be solely focused on gauging outcomes—since the outcomes of RD&T often cannot be quantified in advance. The National Academies and our previous work echoed that setting clear RD&T goals and measuring their progress, using expert review to evaluate the quality of research and outcomes, and reporting periodically in evaluation results can help agencies systematically evaluate RD&T outcomes.[1] One approach that has been used in this area is to measure technology transfer. For example, key experts and stakeholders told us that one way that the Office of Pipeline Safety's RD&T program could be measured is by the degree to which new technologies developed by the program were actually used by pipeline operators. Similarly, according to a RITA official, the Federal Railroad Administration measures the performance of its RD&T activities by how many times RD&T programs are used in real world applications.

Questions submitted by Representative Adrian Smith

Q1. Your report states that RITA has taken steps to develop appropriate performance measures, including gathering information of the operating administrations on their performance measures through the RD&T Planning Team. You further state that RITA officials will determine what measures could be adopted after all of the operating administrations have had input. Do you know when RITA began these meetings of the Planning Team and how often the Team meets? Has DOT moved expeditiously to meet this requirement?

A1. In 2006, we recommended that RITA work with the operating administrations to develop common performance measures for the department's RD&T activities.[2] RITA has taken some steps to do so. According to a RITA official, in November 2008, the agency began gathering information from the operating administrations on performance measures during RD&T Planning Team meetings. The Planning Team is required to meet quarterly, but has met more frequently. In 2008, the Planning Team met 13 times, and the team has met twice thus far in 2009. A RITA official told us that they have finished the process of gathering information on performance measures, and are analyzing the information for commonalities and to determine whether any of the measures could be adopted for the department's RD&T activities. We will continue to monitor RITA's progress in developing and implementing performance measures.

Q2. Overall, does GAO believe that RITA can successfully plan and coordinate transportation R&D projects in-house and across the Department? Is the RPIC process as currently operating sufficient for these purposes? For instance, does RITA have access to data on the budget and performance of all R&D at the Department?

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[1] The National Academies. *Evaluating Research Efficiency in the U.S. Environmental Protection Agency,* Committee on Evaluating the Efficiency of Research and Development Programs at the U.S. Environmental Protection Agency (2008) and GAO, *Pipeline Safety: Systematic Process Needed to Evaluate Outcomes of Research and Development Program,* GAO–03–746 (Washington, D.C.: June 30, 2003).

[2] GAO, *Transportation Research: Opportunities for Improving the Oversight of DOT's Research Programs and User Satisfaction with Transportation Statistics,* GAO–06–917 (Washington, D.C.: Aug. 15, 2006).

A2. The RPIC process began in fiscal year 2009 and has not been in place long enough to assess whether it will enable RITA to successfully coordinate, facilitate, and review the department's RD&T activities, or enable RITA to develop an overall strategy. A RITA official told us that they have begun the RPIC process using fiscal year 2009 planned budget information (they do not have performance information at this time) and plan to compare planned budget information to actual budget information once the budget is enacted. While the RPIC process seems like a step in the right direction, DOT has not yet documented this new process or explained how it complements or replaces its existing coordination and review strategies. According to a RITA official, RITA is planning to develop a detailed description of the RPIC process and hopes to have this completed by late spring. In our 2006 report, we recommended that RITA develop an evaluation plan for its own activities, so it could better assess whether its activities and process, including RPIC, are meeting intended goals. RITA has not yet developed such an evaluation plan.

Q3. Do we need to produce a new, comprehensive strategy for our nation's highways? If so, should this strategy include other transportation modes? Who should be charged with developing such as strategy and how often should it be updated?

A3. We have reported that surface transportation programs need to be re-examined, especially given the Nation's financial crisis and growing congestion and travel demand.[3] Since federal financing for the interstate highway system was established in 1956 because of the national interest in interstate mobility, the federal role in surface transportation has expanded to include broader goals, more programs, and a variety of program structures. To incorporate additional transportation, environmental and societal goals, federal surface transportation programs have grown in number and complexity. However, the federal highway program's financing and delivery mechanisms have not substantially changed and their continued relevance in the 21st century is unclear.

Many of these programs are not effective at addressing key transportation challenges such as increasing congestion and growing freight demand because federal goals and roles are unclear, many programs lack links to needs or performance, and the programs in some areas do not employ the best tools and approaches to ensure effective investment decisions. For example, most highway funds are distributed through formulas that have only an indirect relationship to needs and no relationship to performance or outcomes.

We have called for a fundamental re-examination of the Nation's surface transportation policies. We identified a number of principles that could help drive reexamination of federal surface transportation programs and an assessment of options for restructuring the federal surface transportation program. These principles include: (1) ensuring goals are well defined and focused on the federal interest, (2) ensuring the federal role in achieving each goal is clearly defined, (3) ensuring accountability for results by entities receiving federal funds, (4) employing the best tools and approaches to emphasize return on targeted federal investment, and (5) ensuring fiscal sustainability.

With the sustainability and performance issues of current programs, it is an opportune time for Congress to more clearly define the federal role in transportation and improve progress toward specific, nationally-defined outcomes. Given the scope of needed transformation, it may be necessary to shift policies and programs incrementally or on a pilot basis to gain practical lessons for a coherent, sustainable, and effective national program and financing structure to best serve the Nation for the 21st century.

[3] GAO, *Surface Transportation: Restructured Federal Approach Needed for More Focused, Performance-Based, and Sustainable Programs,* GAO–08–400 (Washington, D.C.: March 6, 2008).

Appendix 2:

Additional Material for the Record

STATEMENT OF LAWRENCE H. ORCUTT
CHIEF, DIVISION OF RESEARCH AND INNOVATION
CALIFORNIA DEPARTMENT OF TRANSPORTATION

This testimony is intended to address the following four questions posed to the Division of Research and Innovation, California Department of Transportation (Caltrans):

1. *How has the federal investment in R&D through the UTCs, NCHRP, SHRP II, etc. impacted current infrastructure construction practice?*
2. *What barriers prevent adoption of new techniques or applications?*
3. *How can the Federal Government ensure that State, county, and city decision-makers make informed decisions (i.e., LTAP)?*
4. *Is the current workforce capable of implementing advanced highway technologies?*

INTRODUCTION

Mr. Chairman, Members of the Subcommittee:

My name is Lawrence Orcutt. I am the Chief of the Division of Research and Innovation for the California Department of Transportation, also known as Caltrans. Thank you for the opportunity to provide you with this written testimony.

The Division of Research and Innovation (DRI) receives $10–15 million per year from the Federal Highway Administration (FHWA) to fund the State Planning and Research Program, Part 2. In addition, in 2008 Caltrans was notified of receiving $10–15 million in federal grants through various competitive processes that include Safe Trip-21: Connected Traveler (Research and Innovative Technology Administration), Vehicle Assist and Automation (sponsored by Federal Transit Administration), Augmented Speed Enforcement (sponsored by the Rural Safety Initiative-FHWA), and a Truck Parking Initiative grant to fund a project along the Interstate 5 (I–5) Corridor (sponsored by FHWA).

I serve on the Transportation Research Board's (TRB) Strategic Highway Research Program 2 (SHRP 2) Safety Technical Coordinating Committee, and I am the Co-Chair for the TRB Technology Transfer Committee. I also serve on the Research and Technology Coordinating Committee (RTCC) that serves as an independent advisor to FHWA and other research organizations on national and federal highway research that has been supported by FHWA.

Innovation is one of the four core values that guide and shape Caltrans, and staff is empowered to seek creative solutions and take intelligent risks. Caltrans has the largest and one of the most vigorous research programs in the Nation. Mr. Randell H. Iwasaki, Chief Deputy Director for Caltrans, provided testimony to your subcommittee in June 2008 about some of the nationally significant infrastructure-related technologies that Caltrans has developed such as, long-life pavement rehabilitation strategies, and rapid rehabilitation strategies (Construction Analysis for Pavement Rehabilitation Strategies). I will be providing more detailed information about these two innovations later in my testimony.

Caltrans has been focused on deploying research results to achieve true innovation so that research becomes reality. Through the guidance of the Caltrans Research and Deployment Steering Committee and by establishing a deployment group that is responsible for developing and implementing research deployment strategies, Caltrans has become a leader in transportation research deployment. Examples of some of the challenges and solutions to research deployment are included in my testimony.

One of the most significant issues facing California and the Nation is the need to develop and implement transportation innovations. In the *Safe, Accountable, Flexible, Efficient Transportation Equity Act—A Legacy for Users* (SAFETEA–LU), Congress recognized the importance of innovation per the Principles for Research based on Title V:

> "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)."

In the *Research and Technology Coordinating Committee, TRB Special Report 295* it is recommended that:

> "Adequate resources should be provided to FHWA to support a robust program for dissemination of research results to states, local governments, and private vendors."

Congress had the excellent foresight to require an implementation report for SHRP 2. "As part of SHRP 2 authorization, Congress requested that a report be delivered in early 2009 concerning promising results from the research and how they could be implemented most effectively. In response to this request, the TRB's report *Implementing the Results of the Second Strategic Highway Research Program: Saving Lives, Reducing Congestion, Improving Quality of Life* outlines what it will take to implement the results of the program and reap the benefits it promises."

The recommendations listed in the report are very consistent with the Caltrans focus on deploying research results to achieve innovation: "A SHRP 2 implementation program should be established and stable and predictable funding should be provided over several years to support SHRP 2 implementation activities."

The legislative recommendations from the American Association of State Highway and Transportation Officials (AASHTO) developed by the Standing Committee on Research also requests resources for research deployment:

> *"Legislative Recommendations Summary: Initiation of a new Research Deployment Program, funded at $5 million annually.*
>
> Policy Issue Discussion/Background:
>
> Research products are difficult to deploy into practice. Many reasons contribute to this, and many are documented in the NCHRP Report 442, *Systems Approach to Evaluating Innovations for Integration into Highway Practice.* One of the most significant reasons hindering the deployment of a research product is a lack of a focused national program with resources to identify and share the most successful research deployments.
>
> A program should be established that facilitates the deployment of successful research products. This program should be multi-modal and conducted under the guidance of stakeholders who are the ultimate users of the research. The program would develop and implement project deployment plans, communications, and demonstration activities. The program should be able to advise and assist stakeholders with unique implementation problems, such as intellectual property, feasibility studies, cost benefit analysis, and ease of implementation."

The Federal Investment in Highway Research, 2006–2009: Strengths and Weaknesses—Special Report 295 makes an excellent argument for implementing innovation:

> "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 draw-down 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. "

QUESTION 1. How has the federal investment in R&D through the UTCs, NCHRP, SHRP II, etc. impacted current infrastructure construction practice?

OVERVIEW

The California Department of Transportation (Caltrans) built and oversees a 78,000 lane-kilometers (lane-km, or one lane, one kilometer) State highway system. Much of that system needs repair. Rebuilding our transportation infrastructure affects all Californians as well as our national economy and global commerce. Much of our problem focuses on meeting the challenge of how to rebuild deteriorating highways economically, safely, and with minimal impacts and inconvenience to the public.

Cutting-edge pavement research at Caltrans and the University of California has been helping find ways to rebuild our highways. Pavement research methods and findings have potential use on other projects. For example, results from traffic stud-

ies in work zones are available for research and deployment of Intelligent Transportation Systems (ITS). Also, results may help improve pavements at ports and railheads. The state-of-the-art research tools are also adaptable to local agencies to use in improving city streets and county roads. In this way, results from Caltrans research are better able to produce benefits for all Californians and all Americans.

BACKGROUND LONG LIFE PAVEMENT REHABILITATION STRATEGIES (LLPRS)

The three examples I will describe, all stem from the Caltrans Long-Life Pavement Rehabilitation Strategies (LLPRS) Program which began in 1998. The goal of the LLPRS program is to rebuild approximately 2,800 lane-km of high-volume urban freeway with pavements that are designed to last more than 30 years with minimal maintenance. LLPRS also addresses the State's need for cost-effective approaches for rebuilding the aging pavements in its urban highway networks. The LLPRS program will reduce the need for future repair projects and ultimately save public resources for future generations of road users.

LLPRS candidate projects were selected from among highways that experience minimum volume demands of 150,000 Average Daily Traffic or 15,000 Average Daily Truck Traffic, and that have poor structural pavement condition and ride quality. Most LLPRS candidate sections are Portland Cement Concrete (PCC) pavements on Interstate freeways in urban networks, 80 percent of which are within the Los Angeles Basin, and 15 percent of which are in the San Francisco Bay Area.

Caltrans has been working with the Partnered Pavement Research Center (at the University of California, Berkeley) since 1994 using the Heavy Vehicle Simulator (HVS) and Accelerated Pavement Testing to develop new pavement products for infrastructure improvements. In 2005, Caltrans approved an issue memo titled, "Adoption of Mechanistic-Empirical (ME) Pavement Design Method," which calls for the adoption of ME pavement design methodology to replace existing pavement design methods which have been in place since the early 1960s. Since 2000, the University of California Pavement Research Center (UCPRC) has been supporting the Caltrans effort to adopt ME pavement design by using a wide array of tools, including HVS full-scale pavement tests. This work is under the technical guidance of the Caltrans Pavement Standards Team. One of the Team's tasks is to develop and calibrate ME flexible pavement design and models for new pavements and rehabilitation. These models have been incorporated into a draft software program called *CalME*. The validation and calibration of the models in *CalME* was first performed using performance data from HVS tests completed by the UCPRC between 1995 and 2004. Calibration of *CalME* models also has been achieved using WesTrack performance data.

The following are three Caltrans LLPRS projects:

1. LLPRS Pilot Project: Interstate 10 Concrete Rehabilitation in Pomona

In February 2000, a 20-lane-km rehabilitation project on Interstate 10 near Los Angeles, California, was successfully completed. Fast setting hydraulic cement concrete was applied because it reached traffic opening strength in only four hours after its placement. The project required one weekend closure to complete 2.8 lane-km and repeated seven and ten-hour nighttime closures for the remaining distance. The rehabilitation project consisted of replacing the existing 230 millimeter concrete slab with new concrete, dowels, and tie bars. The contractor used a concurrent working method in which demolition and concrete paving occurred simultaneously and only a single lane was removed and replaced.

The delivery and discharge of concrete controlled the overall progress. The 55-hour weekend closure proceeded at a rate 54 percent faster than the average of nighttime closures, as measured by number of slabs replaced per hour. A comprehensive traffic management strategy helped to reduce the volume of traffic during the weekend closure and minimize the traffic delay through the construction work zone.

This "proof of concept" LLPRS project, which used concrete material, was followed by another project using asphalt materials.

2. LLPRS Demonstration Project: Interstate 710 Asphalt Concrete Rehabilitation in Long Beach

Caltrans successfully rebuilt a 4.4-km stretch of Interstate 710 in Long Beach, California, by adopting a fast-track construction approach that included around-the-clock (24/7) operations. The project proved that fast-track rehabilitation with 55-hour weekend closures is effective to drastically shorten overall construction time and lessen the negative effects of construction in an urban area. This eased

congestion for the public, as well as freight moving to and from the ports of Long Beach (the second busiest port in the United States) and Los Angeles.

The project proved that asphalt concrete pavement designed to provide a 30+ year design life can be constructed in a series of weekend closures even on the most heavily loaded truck route in the state. This long-life asphalt concrete pavement rehabilitation project occurred during the summer of 2003. On this project, either 230 millimeters of asphalt concrete overlay or 325 millimeters of full-depth asphalt concrete replacement were applied during eight 55-hour weekend closures. After five years of monitoring, the pavement is performing as predicted by research and pavement tests conducted for Caltrans by the UCPRC.

3. LLPRS Implementation Project: Interstate 15 Concrete Rehabilitation in Devore

Fast-track rehabilitation and reconstruction innovations have been researched and deployed in California. One example is the heavily traveled Interstate 15 corridor in Devore, California. A 4.5-km stretch of badly damaged concrete truck lanes was rebuilt in only two 210-hour (about nine days), extended closures using counter-flow traffic and 24-hour operations. The same project would have taken ten months using traditional nighttime closures.

Compared to traditional ten-hour nighttime closures, the extended closure had about 80 percent less total closure time, about 30 percent less road user cost due to traffic delay, and about 25 percent less Caltrans cost (about $6 million savings) for construction and traffic control.

Specific innovations adopted for this groundbreaking "Rapid Rehab" project include the following:

- **Automated Work Zone Information Systems** to update travelers with real-time travel information
- **Quickchange Movable Barrier** system with a dynamic lane configuration to minimize traffic disruption
- **Incentive/disincentive provisions** to encourage the contractor to complete the closures on time
- **Multifaceted outreach program and web-based information systems** for disseminating project updates and getting input from the public
- **Mix design of rapid strength concrete** to enable the project to be opened to traffic 12 hours after placement.

RAPID REHAB

One significant R&D product that is changing planning and management of highway construction across the country, specifically pavement rehabilitation projects, is Rapid Rehab. Rapid Rehab, also known as *Construction Analysis for Pavement Rehabilitation Strategies,* or CA4PRS, is a software package that was developed by the UCPRC with funding from DRI. CA4PRS aids engineers and contractors in selecting economical highway rehabilitation strategies that minimize disruptions to drivers and to the surrounding community. It identifies optimal construction management strategies that balance construction schedules with traveler inconvenience while minimizing agency costs by considering "what if" scenarios for variables such as construction time windows, number of lanes to be closed, material selection, and site access for construction vehicles (16).

Rapid Rehab Development, Testing, and Implementation Progress

CA4PRS was developed outside of the normal Caltrans Information Technology (CIT) development process using a Transportation Pooled Fund project with the States of Washington, Minnesota, and Texas participating in the pooled fund effort.

CA4PRS was first tested in 1999 in a construction project along a stretch of Interstate 10 near Pomona, east of Los Angeles, California. Data from that project validated CA4PRS simulated production rates and impacts on traffic. Before the work began, the contractor's estimate for a 55-hour weekend production rate was 3.5 lane-km. CA4PRS' estimate was 2.9 lane-km. Actual performance came to 2.8 lane-km (17).

The second major construction project was on Interstate 710 near Long Beach in Southern California in 2002. The original construction plan called for ten 55-hour weekend closures. However, encouraged by an incentive provision of $100,000 for each weekend closure eliminated, the contractor used CA4PRS and finished the job in eight consecutive closures instead of ten and claimed a $200,000 bonus (18).

The third major project was in 2004 along a 4.5-km stretch of Interstate 15 near Devore in Southern California. Original construction schedule called for 10-month nighttime-only closures. However, using CA4PRS proposed scenario, this badly damaged concrete stretch was rebuilt in two single-roadbed continuous closures (also called "extended closures") totaling 210 hours, using counter-flow traffic (opposite direction to the main traffic flow) and 24-hour-per-day construction operations (17).

The AASHTO Technology Implementation Group in 2006 designated CA4PRS as a "priority technology" because CA4PRS proved to be a valuable time and money saving innovation.

In 2007, CA4PRS was nominated and earned the International Road Federation Global Road Achievement Award for the Research Category. CA4PRS is also included on the FHWA Priority Market-Ready Technology list. During a recent ceremony with the Director of Caltrans, the question was asked, "Why aren't we using this tool on all of our projects?" Caltrans is working to make CA4PRS part of the standard design practices for all projects.

At the national level, Caltrans has been working with FHWA to assist other State Departments of Transportation in the purchase of the licensing rights through the *Highways for Life Program.* The University of California has established a cost of $150,000 for all states to be allowed exclusive rights to use CA4PRS. The current cost for a state to purchase a CA4PRS enterprise license is $5,000, which is relatively inexpensive.

Conclusion

Through partnering with University of California researchers, Caltrans used innovative technologies to begin rebuilding California's infrastructure. These examples show pavement improvements being made in California that both improve how pavements are designed and built, and also help to manage the construction impacts to traffic by considering work windows that allow contractors get the work done quicker, cheaper, and with better quality. The overall construction cost savings total more than $20 million for the LLPRS program using the new technologies developed by this research program. Rebuilding America's infrastructure will require new methods and technologies similar to those developed in California using federal research funding to develop products that will improve our transportation products and services.

QUESTION 2. What barriers prevent adoption of new techniques or applications?

INTRODUCTION

In the transportation world of the 21st century, many challenges are created by inadequate resources needed to address today's massive transportation problems of congestion, failing infrastructure and environmental impacts of transportation, most notably worsening air quality and climate change. Innovation should, and could lead to improving the performance, efficiency, and quality of the transportation system as well as reducing their environmental impacts.

Innovation is much needed to manage the enormity and complexity of transportation system. As noted in the TRB Special Report 261, *"complexity of the transportation challenges underscores the need for new ways of looking at problems and for innovative solutions, offering significant research opportunities in all facets of the highway sector"* (1).

COMMON BARRIERS TO INNOVATION

Different types of innovations face different obstacles. The more radical or disruptive an innovation is, the more challenges will accompany its acceptance and implementation. A thorough literature search (particularly the 2001 TRB Special Report 261) (1) helped the department to identify six major barriers to innovation in transportation as summarized below.

1. System Diversity and Complexity

The United States Transportation system is diverse, decentralized, and multifaceted. Conflicting public and private sector incentives add to such complexity (1). Fragmentation, disagreement among public works constituencies, and competition among public works categories for scarce resources have combined to constrain innovation (7).

2. Intellectual Property and Procurement Restrictions

The public sector procurement practices impose constraints on innovation (1). Public sector procurement activity is driven by low-bid process based on speci-

fications and procedures established to satisfy the need for open competition and accountability (7). Competitive bidding requirements represent a core problem because often certain innovations are offered by a single company. Conflict between open public bidding processes and private Intellectual Property (IP) rights can hamper deployment of innovative products (9). Excluding evaluation contractors from implementation contracts can limit competition at the deployment stage (8).

3. Risk Aversion

There is notable low tolerance for risk in the public sector (1). Public sector decision-makers work in an environment that does not reward risk taking. If public officials are uneducated about or unfamiliar with the potential of innovative technology or uncertain of its merits, they are reluctant to adopt it (7).

4. Resistance or Inability to Change

Organizations limit and resist change (1). "When optimal resolution of a product or process performance problem demands a very different set of knowledge than a firm has accumulated, it may very well stumble" (10). Lack of training and unskilled employees often inhibits technological change (8).

5. Lack of Profit Motives

Public sector innovation is not subject to the profit motive that stimulates commercial innovation (7). Disruptive technologies are "initially embraced by the least-profitable customers in a market" (10). Companies that let customers identify only new products that promise greater profitability and growth "are rarely able to build a case for investing in disruptive technologies until it is too late" (10).

6. Lack of Product Evaluation Criteria

It is often difficult to characterize and predict system and component performance of new innovative products (1). New product evaluation guidelines are slow to develop and are often under-resourced (8). Evaluation requirements are sometimes unclear or not defined (9). At the Caltrans it is particularly difficult to get business cases for Information Technology products approved through the extensive and cumbersome Feasibility Study Report process imposed by other regulatory agencies (8).

THREE MAJOR CALIFORNIA CASE STUDIES

Recently, Caltrans completed research and development of three technological innovations the implementation of which covers a wide spectrum of barriers in encountered in new transportation technologies.

I. Sensys™ is a revolutionary traffic sensing innovation that combines latest communications in roads and highways technologies that was implemented in an evolutionary manner.

II. Rapid Rehab (also known as *Construction Analysis for Pavement Rehabilitation Strategies,* CA4PRS), is a strategic and tactical planning, and control software innovation that is being implemented in an evolutionary fashion.

III. Balsi Beam is an evolutionary safety hardware innovation that needed revolutionary approach to implementation.

Although these innovations promised significant return on investment, deployment of each faced numerous and significant challenges that delayed implementation.

I. SENSYS™ CASE STUDY

Sensys™ is a compact, self-contained, easy-to-install, highly reliable, low cost wireless traffic sensor system that can replace traditional, more expensive inductive loops. The Sensys concept originated through the Partners for Advanced Transit and Highways (PATH) Program, at the University of California, Berkeley (UC–Berkeley) through a special research program in 2002 dedicated to exploring new ideas. Through Caltrans' DRI, the program provided up to $25,000 for one-year research proposals strictly intended to test or demonstrate new ideas and concepts.

The $25,000 Sensys proposal was to investigate the potential use of a new wireless detector that could collect similar traffic data collected by wired inductive loops that have been in use since 1960. The research proposed to investigate the use of micro electro-mechanical systems (MEMS) acoustic sensors, a prototype of which was developed earlier in the Department of Electrical Engineering and Computer Science at UC–Berkeley under a previously sponsored Defense Advanced Research

Project Agency (DARPA) project. Researchers proposed to test how well the MEMS sensor network would detect traffic in urban streets and parking lots and determine how effectively these sensors can operate in an urban traffic environment, and how much spatial and temporal resolution can be achieved (11).

The Sensys research proposal was approved and Caltrans, which allowed the researchers to explore and test the concept within one year, provided, seed money. During the research, the researchers switched from the initial detection technology (acoustical sensors) to magneto-resistive sensor. They also redesigned the system's protocol to increase communications efficiency and reduce energy consumption (12). The first Sensys prototype was ready for testing in 2003.

Sensys*TM* Roadblocks

Two of the main barriers that the implementation of the new Sensys system faced emerged at the testing stage. There was no funding allocated for testing and there were no criteria with which to evaluate its effectiveness. Other roadblocks faced by Caltrans include:

1. **Lack of Funding to Explore Brand New Concepts**

   To mitigate this barrier, DRI created a small ($25,000) and limited (one-year) research grants to investigate and test new ideas.

2. **Lack of Functional Requirements, Specifications, and Evaluation Criteria**

   To mitigate this barrier, DRI commissioned the California Center for Innovative Transportation (CCIT) at UC–Berkeley to perform an evaluation and that also performed a supplemental evaluation using comparable criteria.

3. **Lack of Provider Credibility**

   To mitigate this barrier, DRI assured end-users that Sensys was a reliable product backed not only by the manufacture but also approved by Caltrans.

4. **Resistance to Change and Risk Aversion**

   To mitigate this barrier, proactive communication was pursued through reports and informal discussions. DRI recruited champions at Caltrans' Division of Traffic Operations who sanctioned the testing.

5. **Sole-sourcing Contracts**

   To mitigate this barrier, DRI had relied on performance-based specifications.

Lessons Learned

Caltrans has learned several important lessons in this case.

1. **Logical Evaluation Criteria must be established in a Timely Fashion to Evaluate New Products.** Customer-approved key performance indicators must be identified and performance must be measured with reasonable resources. It was learned that, in order to establish credibility, testing performance standards for new products should be as rigorous as or more rigorous than performance standards for existing products.

2. **Using a Systems Engineering Approach is Necessary.** Using principles of systems engineering, functional requirements should have been specified and used instead of promotional product descriptions. In all cases, a company trying to meet the client's requirements must clearly understand the process for getting the product approved for use by the client (12).

3. **Intellectual Property (IP) can be Handled through the University System.** Intellectual property was not an issue with this innovation because the IP was handled through the University of California's IP licensing process. Nonetheless, this required a substantial effort by Caltrans to get the approval of the California Department of General Services to allow the University to own the IP developed by the University research that was funded by Caltrans.

4. **Innovation needs Champions.** The importance of innovation champions was a critical factor for the successful deployment of Sensys. Professor Varaiya, inventor of Sensys at UC–Berkeley, believes that acceptance of Sensys in California by Caltrans will establish confidence in Sensys and pave the way for other markets to deploy the product (15).

II. RAPID REHAB (CA4PRS) CASE STUDY

Rapid Rehab is described previously under Question 1 as part of the LLPRS program.

CA4PRS Roadblocks

The AASHTO Technology Implementation Group in 2006 designated CA4PRS as a "priority technology." Despite this and the fact that CA4PRS proved to be a valuable time and money saving innovation, it had its share of roadblocks. CA4PRs was developed outside of the normal Caltrans Information Technology (IT) development process using a Transportation Pooled Fund project with the States of Washington, Minnesota, and Texas participating in the pooled fund effort.

1. **Compliance with Caltrans IT Standards.** In order for CA4PRS to be accepted and allowed by Caltrans IT to become standard Caltrans software (and for Caltrans users to install it on their computers), an extensive benefit-cost analysis justifying the acquisition of the software for Caltrans had to be conducted and an extensive and cumbersome Feasibility Study Report (FSR) had to be completed. Completing the FSR for CA4PRS was extremely time-consuming, complicated, difficult, and frustrating process.

   Soon after the CA4PRS FSR was completed and after CA4PRS was incorporated into Caltrans Technology Standards list, a new deployment roadblock emerged. CA4PRS software needs to be installed on each engineer's computer individually. According to Caltrans IT protocols, individual installation of software requires the work to be performed by Caltrans IT staff. Caltrans' IT staff was not able to perform the installation work in a timely manner for the many users. As a result, many engineers gave up on using CA4PRS altogether.

2. **Need to Learn How to Market New Technologies.** Marketing of technology is critical for its success because often the information is available, but it requires too much effort to find. Marketing successful results of research by going out to the customers is a proactive approach that Caltrans has used to "push" this technology out to users. Caltrans has learned that producing a report that resides on a web page or in a library is not an effective way to deploy innovation.

3. **Resistance to Change and Breakdown in Bottom-up Communications.** Public institutions prefer stability and routine and are resistant to change. Caltrans had to be proactive in pushing the new technology. DRI used champions at staff and management levels throughout all stages of deployment to demonstrate the merit of this software. Briefings were provided to key decision-makers to support this innovation.

4. **Lack of Profit Motive.** It was necessary to demonstrate the concrete benefits of Rapid Rehab to Caltrans staff as well as private contractors. Establishing the savings in support costs is very important to Capital Outlay Support managers, and this information helped make decisions that supported the use of CA4PRS. Construction and traveler delay cost and savings were documented and shown to benefit Caltrans, the contractors, and the general public.

5. **Risk Aversion and the Need to Establish Credibility for New Products.** Seeking national and international recognition for innovative research is a strategy that DRI has used to build credibility for CA4PRS within Caltrans at management and staff levels. In 2007, CA4PRS was nominated and earned the International Road Federation Global Road Achievement Award for the Research Category. CA4PRS is also included on the FHWA Priority Market-Ready Technology list. DRI used CA4PRS in pilot studies that demonstrated its success. DRI won credibility for CA4PRS through winning national and international recognition.

6.• **Software Licensing Issues.** The University of California has established a cost of $150,000 for all states to be allowed exclusive rights to use CA4PRS. The current cost for a state to purchase a CA4PRS enterprise license is $5,000, which is relatively inexpensive. Nonetheless, many states were unable to get the approval from their own IT departments to acquire the software for reasons similar to the Caltrans experience. To alleviate the financial burden that other states may have in acquiring CA4PRS, Caltrans took the initiative and has been working with FHWA to assist other State DOTs in the purchase of the licensing rights through the *Highways for Life Program.*

7. **Need for User Training.** Finally, lack of training is an impediment to using CA4PRS. Therefore, Caltrans, in cooperation with UC–Berkeley, has established a training curriculum. So far over 700 people have been trained to use CA4PRS. This includes approximately 100 users from other states.

Lessons Learned

The most important lesson learned includes the needs to do each of the following:

1. **Be flexible and resourceful.** Although the FSR was difficult to do, DRI used it to as a way to document the benefits and costs of CA4PRS.
2. **Manage product licensing.**
3. **Demonstrate the value of innovation.**
4. **Have innovation champions.**
5. **Minimize implementation cost.** Caltrans used *Highways for Life Program* to help other states purchase CA4PRS.
6. **Train users professionally.** It was learned that without a curriculum and training plan, this innovation would not be used.

III. BALSI BEAM CASE STUDY

Protecting the safety of construction and maintenance field crews and motorists on roadways has long been a top priority for Caltrans. More than 40,000 people are injured each year in the United States of America as a result of motor vehicle crashes in work zones. Fatalities from work zone crashes have increased by more than 50 percent between 1999 and 2004 (19). In 2004, the cost of a fatality was estimated to be $1,011,000. The cost of a critical injury was estimated to be $858,000 (20).

Balsi Beam is an innovative mobile work zone protection system that was envisioned by Caltrans Division of Maintenance staff. The Balsi Beam is named after Mark Balsi, a Caltrans landscape worker who suffered major injuries when he was working along Interstate 280 in Santa Clara County, California in January 2001.

The Balsi Beam system is basically a tractor-trailer combination, with a specialized trailer that extends into a thirty-foot long work space in between the rear axles and tractor, shielded on one side with two steel beams" (21). The trailer provides an extendable steel barrier to protect workers on traffic-exposed flank of a work zone.

The Balsi Beam was designed and built by Caltrans' Division of Equipment. The Caltrans bridge crews utilized the Balsi Beam to protect their workers. The Balsi Beam would not be deployed today without the support of the bridge crew from Caltrans district staff Marysville, California.

Balsi Beam Roadblocks

The deployment of Balsi Beam has faced several technical, logistical, and institutional roadblocks that included the following:

1. **Lack of an Established Evaluation Criteria and Customers' Uncertainty about the Effectiveness of Balsi Beam.** It is difficult to get maintenance crews to use a new product like the Balsi Beam. In the opinion of the inventor, Balsi Beam is not ready for national deployment because it is still a prototype. In her opinion, Balsi Beam will prove its effectiveness when it is actually hit and saves lives (22).
2. **Customers' Lack of Familiarity with Balsi Beam Capabilities.** The complex logistics of introducing a new tool into existing processes at Caltrans made the deployment of this innovation difficult. Demonstrations by the crew using the Balsi Beam helped get the word out to the maintenance community. Having champions at all levels to support the Balsi Beam is critical for the success of implementing this innovation. Training needs to be developed by maintenance personnel as hands-on training for crews to be able to operate the Balsi Beam.
3. **Lack of a Business Case for Commercializing Balsi Beam.** Balsi Beam has strong business (and safety) case but documenting such an innovation case for commercialization was a new process for Caltrans. Documenting the business case for the Balsi Beam was essential for getting additional resources to purchase additional units through the Budget Change Proposal process at Caltrans. Documenting the business case not only yielded a solid and presentable business case, but also during the process itself, stronger links were established between champions at all levels for this innovative system from regular highway maintenance workers to the Chief for the Division of Maintenance at Caltrans, District Director for District 3 (in Sacramento), and Caltrans Chief Deputy Director. This made the case stronger to implement the Balsi Beam. Establishing the business case using worker safety data and in-field evaluations helped to overcome the institutional issues. DRI commissioned CCIT to perform an evaluation. Finally,

DRI funded research at UC–Davis to perform benefit-cost analysis and risk evaluation study.

A consultant was hired to help DRI establish a process to sell the licenses to vendors to produce units for other states. Two goals of commercializing the Balsi Beam were to improve the product design and to reduce the costs and time to produce the units.

4. **Legal Restrictions.** One way for Caltrans to share this innovation with other states would have been to "gift" the license to other states or venders. However, California law prohibits Caltrans from doing so. Article XVI § 6 of California Constitution prohibits any public agency from making "any gift of any public money or thing of value to any individual, municipal or other corporation whatever" (23). As a result, DRI has developed licenses to allow other states to purchase the right to use Balsi Beam through license agreements. DRI will be issuing an RFP to sell Balsi Beam licenses to multiple qualified vendors.

5. **High Capital Cost.** A major obstacle for getting the approval to deploy additional Balsi Beam units has been its high capital cost. The capital cost of the original prototype unit was $257,000. Capital cost for a new, fully operational unit is estimated to be as high as $600,000–700,000. Increases in the price of steel, complex system requirements, and potential liabilities are behind the cost increases. High capital cost has become a barrier to deploying Balsi Beam at Caltrans and to marketing it to other State DOTs. DRI is using commercialization to reduce capital cost by improving the design and optimizing manufacturing procedures as well as mass-producing the units to domestic and international customers. Concerned about its high cost, the California Department of Finance asked Caltrans to evaluate other less expensive mobile work zone protection devices. Caltrans will purchase an additional three Balsi Beams units and three ArmorGuard™ units. This study suggests that one way to reduce the high capital cost is to optimize Balsi Beam design and its manufacturing processes. Another way is to mass-produce the system, which spreads the fixed manufacturing costs over larger number of units by marketing it to other State agencies and overseas.

6. **Intellectual Property Constraints.** The patent and resulting Intellectual Property license for the Balsi Beam is an important discussion point that relates to implementing innovation. Almost all states have competitive bidding requirements to assure that they get the lowest price for the products they buy. CCIT conducted a study to analyze problems related to intellectual property and licensing of the Balsi Beam and concluded that Caltrans may have hampered the marketing of Balsi Beam by patenting it (12). This same study concluded that if a patent or licensed product requires exclusive, non-competitive bid, government entities might not be able to purchase the product because of the restrictions placed on non-competitive bids.

7. **Uncertainty about a Fair Market Value for Balsi Beam.** Uncertainty in determining a fair market value for Balsi Beam has been a financial stumbling block facing the implementation of this innovation. An agreement with the State of New York was held up for about one year waiting for the license to be developed and approved. In an effort to solve this problem, DRI commissioned CCIT in 2007 to conduct a study to estimate a market value for Balsi Beam license. CCIT concluded that a fair market value for the license would be $2.6 million. The study further assumed that there is demand for 136 units that could be marketed eventually. Thus, the license cost per unit would $19,000 per unit (12). Fair market value is critical for establishing that Caltrans gets a reasonable compensation for the Intellectual Property and for complying with the State Constitution that prevents gifts of public resources.

Lessons Learned

This case study illustrates the importance of several lessons learned including the need for all of the following:

1. **Creating champions at all levels of the organization from the crew level to top management.** Getting to this stage in the deployment of innovation has taken considerable time and dedication on part of champions at all levels in the organization.

2. **Carefully Managing Intellectual Property Rights.** Intellectual Property was a significant issue with the deployment of the Balsi Beam. It is different than the other two case studies because Caltrans owns the patent for the Balsi Beam.

Developing standard license agreements for use by other states and providing a market assessment were effective in overcoming the IP roadblocks. Caltrans is very close to issuing RFP to sell the licenses to vendors who will allow other potential customers to purchase Balsi Beam through commercial channels.

3. **Optimizing Manufacturing and Production of Balsi Beam.** Commercialization should optimize Balsi Beam design and manufacturing process and lower production cost. Mass production is also expected to lower unit cost.

4. **Marketing.** Marketing the Balsi Beam across the country has helped to gain credibility within California by proving that this technology is unique for the purpose of obtaining resources to purchase additional units. In June 2004, Caltrans sent the Balsi Beam across the Nation on a multi-state tour with the final destination being a demonstration for the AASHTO Standing Committee on Maintenance. Caltrans also marketed the Balsi Beam through many FHWA publications and by adding the Balsi Beam to the AASHTO Technology Implementation Group (TIG).

QUESTION 3. How can the Federal Government ensure that State, county, and city decision-makers make informed decisions (i.e., Local Technical Assistance Program, LTAP)?

Need to Train Next Generation Workforce

Over the next 10 years, nearly half the current transportation workforce will be eligible to retire—it's even more crucial than ever that we provide technical assistance and training programs. Tomorrow's decision-makers are likely today's young professionals. If they stop learning when they leave college, their training may be 20 years behind them by the time they are leading their agency. As technology and processes change, we need to ensure today's decision-makers are using today's tools, not what they learned in school 20 years ago.

LTAP Centers (the California center and 58 other centers across the country) already support the Federal Government objectives by getting training and information out to State, regional, local agencies in the following ways:

- Over the past 10 years, LTAP/TTAP centers have provided training to over 200,000 State DOT employees, helping to increase their knowledge and proficiency. More than half of this training is focused on Highway and Worker Safety.
- Each year more than 40,000 DOT staff use the LTAP/TTAP technical newsletters as a source of timely transportation related information.
- LTAP Centers are assisting in the Strategic Highway Safety Improvement Plan development process through their participation on many statewide advisory committees including Roadway Safety, Bike/Pedestrian, Work Zone Safety and Driver Behavior committees.
- Partnerships between State DOTs, the Federal Highway Administration, and the Local Technical Assistance Program have developed Safety Circuit Rider programs to help reduce the number of fatalities on rural roads.
- LTAP Centers are administering their State High Risk Rural Road Programs, including conducting the field reviews for local agencies.
- LTAP Centers are conducting the Safe Routes to School Educational Outreach programs.
- LTAP Center staff has coordinated national, regional, and statewide transportation conferences including the Transportation Asset Management Conference, the AASHTO Research Advisory Committee Meetings, Winter Maintenance Symposiums, Pavement Preservation Conferences, Rail Corridor Safety Conferences, and many others.
- Partnerships with State DOTs on new local road safety programs have helped to provide training, technical assistance and funding for local road improvement projects.
- State Transportation Librarians, working closely with LTAP Librarians, have created customized search tools using Google that include all State DOTs and all university transportation center libraries and provided materials to State and local agencies that those employees would not otherwise have access to.
- LTAP Centers are vital for delivering critical training to county engineers, highway superintendents and local road professionals in each state. Over the past 10 years, over 1.5 million local transportation professionals attended the LTAP/TTAP training.

LTAP Accomplishments and Training Statistics

"It would be hard to find a program in the Federal Government that touches as many people and fosters such success as LTAP and TTAP" says Joe Toole, former FHWA's Associate Administrator for the Office of Professional and Corporate Development and now Associate Administrator for FHWA's Office of Safety.

Over the past 10 years, LTAP Centers have:

- Conducted more than 60,000 training events,
- Provided more than nine million hours of training,
- Reached over 1.5 transportation professionals/practitioners in those classrooms, nearly half of all training content relates to highway and worker safety,
- Distributed over two million technical publications, and
- Saved local transportation agencies an estimated $8 for every $1 LTAP spent on information and training.

National Cooperative Highway Research Program

The National Cooperative Highway Research Program (NCHRP) was created as a means to conduct research in acute problem areas that affect highway planning, design, construction, operation, and maintenance nationwide. NCHRP is a voluntary program created by agreement between AASHTO, FHWA, and member States and administered by the TRB.

Caltrans values the research produced through the NCHRP program. Caltrans contributes $3.5 million each year to NCHRP. In 2008, 54 projects were selected for funding of which 37 were a high priority for Caltrans. Of the 171 projects selected over the past three years, Caltrans has over 50 members serving on project panels guiding the research. The strength of the NCHRP research projects is in how they are developed and supported, usually by TRB or AASHTO committees, and how the research is pursued through panels that represent the users/customers to make sure the research is meaningful. This model is very similar to how the SHRP 2 was developed through direct involvement from transportation stakeholders and practitioners. A recent TRB project *Communicating the Value of Research* objective to develop a guide for successfully communicating the value of transportation research projects and programs is a good example of the type of research that is pursued at the request of the transportation community.

QUESTION 4. Is the current workforce capable of implementing advanced highway technologies?

The challenge of implementing advanced highway technologies is more an institutional issue. The employees of today are very capable of taking on the new challenges of advance highway technologies. What they are lacking are the tools to bring new technologies into their environments to make changes that will improve the products and services that are provided to the transportation system customers.

In order for the workforce to implement innovations they need to have the "right stuff" to overcome the many institutional and organizational barriers. One basic requirement that most advanced technologies have difficulty overcoming is to establish a business case that can be approved through the financial institutions. Providing product specifications and training are requirements that often are not met. The innovation system is designed to create new ideas, not to implement them. At Caltrans, we have dedicated resources to deploying research results by forming a four-member deployment branch. We have also established the California Center for Innovative Transportation to assist with deployment of research products and services.

Innovation Survey

Transportation innovation information can help provide insights into what our current staff thinks about innovation and what we should do to encourage them to innovate. DRI conducted a pilot survey in an attempt to help answer the following research innovation questions. The following survey was sent to 150 transportation research professionals in California, research executives in the other 49 State DOTs, and some in Canada:

1. Should focus be on sustaining (evolutionary) or disrupting (revolutionary) innovation?
2. What are the most common roadblocks facing the implementation of innovation in transportation?
3. What are most common enablers of the innovation process?

4. Prioritize the importance of innovation in safety, performance, cost-effectiveness, quality, and environmental protection.
5. How can we facilitate the process of implementing innovation at Caltrans and other State DOTs?

Survey Instrument

The survey consisted of ten questions used to test our assumptions "hypothesis" regarding the existence of the above barriers and enablers. Respondents completed 109 "usable" surveys. The survey asked respondents the following:

- Rate the importance of each roadblock and enabler.
- State if they prefer sustaining or disruptive technologies.
- Prioritize which innovations, safety, performance, cost-effectiveness, quality, and environmental protection, are most important.
- Provide their suggestions for improving the innovation process.

Survey Results

1. About 79 percent of respondents indicated that innovation is "very important," 20 percent indicated it is "important."
2. About 62 percent of respondents thought "sustaining" (evolutionary) technologies are more important than "disruptive" (revolutionary) technologies. However, 73 percent of academic respondents believed the other way around.
3. Safety was the top priority for non-academic respondents with an average score of 4.1/5.0.
4. Academic researchers indicated they are most interested in performance innovations, followed by quality.
5. About 63 percent of respondents considered themselves innovation champions.
6. About 42 percent of respondents are decision-makers.
7. About 40 percent of respondents are potential implementers of technological innovations.
8. *"Resistance to Change"* was voted by both Caltrans practitioners and academic researchers as the most serious roadblock to innovation (researchers scored it 4.8/5.0, Caltrans participants scored it 4.6/5.0).
9. Innovation enablers "Product matches user needs" received a score of 4.6/5.0; "User/customer participation" received a score of 4.5/5.0; and "Successful pilot projects" received a score of 4.4/5.0.
10. Both Caltrans practitioners and academic researchers view "lack of political will to take on challenge" as the most serious institutional barrier to innovation, with researchers thinking it is more serious and rating this barrier 4.7 on average as compared with Caltrans group, who rated it 4.3 on average.

IMPROVING TRANSPORTATION INNOVATION IMPLEMENTATION

1. Establish clear direction and procedures for the innovation process

A vast number of respondent comments focused on the need to establish clear direction and procedures for the innovation process, including clear objectives and precise performance measures to evaluate success.

One respondent stressed the importance to define what is "new" and what is "innovative." Another said clear procedures should be created for implementations and marketing, and some respondents recommended to make pilot projects part of the implementation process. Frustration with bureaucracy was evident. The innovation process should be streamlined so that there are fewer barriers holding up innovation. "The FSR [Feasibility Study Report required for implementation of innovations at Caltrans] process and requirements are mind-boggling and in need of streamlining as well." Executive leaders must "institutionalize" the culture of encouraging innovation by integrating it into work plans and incorporating it into the regular performance evaluations of the organization and its managers. One respondent's experience is that most innovations stop at the recommendations level in government and there are not good implementation plans to carry out the recommendations make them permanent or institutional. The same respondent further cautioned that "Too often things are attached to a per-

son and when that person moves on and so does the innovation." The implementation of innovation should be mandated in order to carry innovation to fruition.

2. Improve communications

One respondent emphasized "Communicate, communicate, and communicate." Make sure that everyone with an interest in the potential innovation gets a chance to provide input and to question. A university research executive suggested connecting the organization [say Caltrans] more closely with researchers and innovators. A project manager would mandate customer participation in project progress and meetings.

3. Secure executive sponsorship and management support

There was a universal consensus that strong management support for innovation is indispensable. "There is no substitute for leadership with vision and practical, focused follow-through," one respondent wrote. Innovation begins with executive-level commitment and development of a work environment that embraces innovation. Upper management support and encouragement is required. Innovation needs strong executive support & successful pilots/demos. There is a need for strong executive mandate and adequate funding of demonstration programs. While executive-level support is important, they need to leave the implementation to the experts. Leaders should lead, not manage. Finally, top leadership has to make innovation a priority and then hold people accountable.

4. Empower people and find champions for each innovative idea/project

Innovation champions are needed in the innovation policy and procedures area. Otherwise, innovations will fall flat or will not reach full potential. Many respondents suggested that research staff "needs to be empowered to accomplish innovation." It is necessary to have champions at high-levels in order to create a culture for innovation in an organization as well as product-level champions to overcome resistance to change. A university professor and a director of a university transportation center said: "Give people some freedom to try new things". A Caltrans project manager suggested giving ownership of each innovation project to a small team with management backing. One respondent pointed out the role of the individual in innovation and cautioned that, "if the person who is championing the change is not liked in the organization, the change may be overlooked."

5. Create incentives for innovators

Many respondents argued for increasing opportunities for innovative ideas. Both university researchers and project managers advocated creating incentives. "More ideas portend higher probability of innovation which may be implemented," said a university researcher. A senior electronics engineer would reward innovators and reward those in management who are willing to take reasonable risk when the potential advance is significant. A senior transportation engineer would encourage more innovative research work by staff by reducing administrative workload demands.

6. Demonstrate the benefits of innovation

Many respondents emphasized the importance of ensuring that end-users have clear understanding of the advantage of innovation. The benefits of the concept must be proven to satisfy the real user needs. Innovation advocates and end-users must have clear understanding of the problem and value added by innovation. The importance of an innovation must be clarified up front to all stakeholders. Case studies should be used to show how other State agencies have implemented an innovation and show how it has improved their business.

7. Manage risk and change

Surprisingly, many respondents with executive authority confronted the need to take reasonable risk head on. One asked to "demystify risk" because sometimes "it is riskier not to act." Another said one must "accept certain amount of risk to compensate for high payoff." One acknowledged that the core issue is the "risk-averse culture," the general lack of positive reinforcement to try something new, and the "penalties" if you break the mold and fail. One executive cautioned, however, to be realistic and not expect the organization to always absorb the cost/effort to innovate. One respondent believed that people, users, and even institutions that normally are reluctant to change would eventually welcome "good" changes that make life easier.

CONCLUSIONS AND RECOMMENDATIONS

Respondents recommended seven major actions to develop a workforce that can implement innovations that will make new or advanced technologies a commonplace reality:

1. Establish clear direction and procedures for the innovation process,
2. Improve communications,
3. Secure executive sponsorship and management support,
4. Empower employees and find champions for each innovation,
5. Create incentives for innovators,
6. Demonstrate the benefits of innovation, and
7. Manage risk and change.

Finally, the research showed that "resistance to change" and "lack of political will" are among the most serious barriers to innovation. The highest-rated enabler of innovation was "product matched user need." It was also evident that innovation, whether disruptive or sustaining, requires champions of innovation at all levels of the organization to be successful. It was evident that managing risk and change is critical for the success of innovation. In the public sector, most failures are highly publicized and criticized. A single innovation failure can outstand, outtalk, and overshadow dozens of successful ones. Therefore, creating the ability to take calculated reasonable risks is required at all public agencies in the transportation sector.

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STATEMENT OF THE AMERICAN SOCIETY OF CIVIL ENGINEERS

An Overview of Transportation Research and Development: Priorities for Reauthorization

The American Society of Civil Engineers (ASCE)[1] is pleased to submit this Statement for the Record of the February 12 hearing held by the United States House of Representatives, Subcommittee on Technology and Innovation, Committee on Science and Technology: *An Overview of Transportation Research and Development: Priorities for Reauthorization.*

America's surface transportation system is broken. ASCE's 2009 *Report Card for America's Infrastructure,* released in January, graded the Nation's *Roads* a D-; *Bridges* a C; *Transit* a D; and *Rail* a grade of C-.

Among the key findings are the following. In 2007, 41,059 people were killed in motor vehicle crashes and 2,491,000 were injured. Motor vehicle crashes cost the U.S. $230 billion per year—$819 for each resident in medical costs, lost productivity and travel delays. Americans spend 4.2 billion hours a year stuck in traffic at a cost of $78.2 billion a year—$710 per motorist. Roadway conditions are a significant factor in about one-third of traffic fatalities and poor road conditions cost U.S. motorists $67 billion a year in repairs and operating costs—$333 per motorist. One-third of America's major roads are in poor or mediocre condition and 36 percent of the Nation's major urban highways are congested.

More than 26 percent of the Nation's bridges are either structurally deficient or functionally obsolete and the number of deficient bridges in urban areas is on the rise. While demand for public transit is increasing, only about half of American households have access to bus or rail transit and only 25 percent consider it to be a good option. Because freight and passenger rail generally share the same network, any significant increase in passenger rail demand will exacerbate freight railroad capacity challenges.

To compete in the global economy, improve our quality of life, and raise our standard of living, we must rebuild and update America's surface transportation infrastructure. America's 21st century surface transportation system must be founded on a new paradigm based on a comprehensive, holistic, multi-modal approach utilizing integrated, effective, inter-modal, sustainable, cost effective solutions. Only then will America have a surface transportation system that is unparalleled in its safety, security, efficiency and effectiveness.

As Congress works to develop the 2009 Authorization of the Surface Transportation Program, it must remain cognizant that it can no longer focus only on the movement of cars and trucks from one place to another. Rather, the new paradigm must be based on moving people, goods and services across the country. This new vision must be inter-modal and deal with the possible effects of climate change; land use, sustainability, and the anticipated changes in the population's demographics, particularly age and urbanization.

ASCE supports the vision of a national inter-modal transportation system which is economically efficient, environmentally sound, provides the foundation for U.S. businesses to compete globally and moves people and freight in an efficient manner. Developing and deploying new technologies and cutting-edge solutions will require input from stakeholders in the public, private, and academic sectors, and accomplishing a truly inter-modal system will require partnerships among Federal, State, local and regional government authorities as well as citizen groups and the private sector.

Research and technology (R&T) are critical to achieving transportation goals in: infrastructure performance and preservation; safety; quality of life; economic prosperity; environmental impacts; and sustainability and security . . . and technology transfer activities are critical to the successful implementation of research results. While we understand that in the current economic environment it may be difficult to increase surface transportation research and development funding, at a minimum, current R&T funding levels must be maintained and public-private partnerships, where appropriate, should be fostered.

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[1] ASCE was founded in 1852 and is the country's oldest national civil engineering organization. It represents more than 146,000 civil engineers individually in private practice, government, industry, and academia who are dedicated to the advancement of the science and profession of civil engineering. ASCE is a non-profit educational and professional society organized under Part 1.501(c) (3) of the Internal Revenue Code.

The Highway Trust Fund (HTF) has been an essential source of funding for surface transportation research and technology for decades, and research results have led to many benefits including: materials that improved the performance of pavements and structures; design methods that reduce scour (and the consequent threat of collapse) of bridges; intelligent transportation systems technologies that improve safety and reduce travel delay; methods and materials that radically improve our ability to keep roads safely open in severe winter weather; innovative management approaches that reduce environmental impacts and improve the cultural aspects of transportation facilities; and many more.

One way to reduce the investment gap, that is, the difference between HTF revenues and the funding needed to improve the surface transportation system, is through research, as research outcomes can improve the performance and durability of our transportation infrastructure, resulting in reduced operations and maintenance costs and less frequent replacement of infrastructure elements. The Exploratory Research Program, funded in SAFETEA–LU, has the potential to be the lead program in providing improved materials, designs, and processes that can transform the performance of our surface transportation infrastructure.

The ability of the HTF to continue to serve as a major funding source for transportation R&T is dependent upon the continued capability of the Highway Trust Fund revenue sources to generate adequate levels of funding. The latest projections indicate that Highway Trust Fund revenues will be insufficient to continue the 2009 SAFETEA–LU authorized levels of funding in 2010. The result will be not only reduced investment in highway and transit infrastructure, but also reduced investment in research. To avoid reduced investment, Congress will need to address this problem by September 30, 2009. While in the short-term, an increase in user fees is clearly necessary, our national surface transportation policy must—in the longer-term—move toward a system that more directly aligns fees that a user is charged with the benefits that the user derives. Appropriate policy research can help identify solutions to the funding issue and what methods and technologies are best to provide revenue to the HTF. This type of research needs to be funded in the new authorization.

Other research programs that can continue to contribute to the improvement of the highway system include the Federal Highway Administration's (FHWA) program, the National Cooperative Highway Research Program (NCHRP) and State department of transportation programs funded largely through State Planning and Research (SPR) funds. In the transit area, the main programs are those of the Federal Transit Administration (FTA) and the Transit Cooperative Research Program (TCRP). ASCE believes that the University Transportation Centers (UTC) program provides valuable research across most transportation modes.

Designated programs and earmarks in SAFETEA–LU resulted in an over designation of funding in the research title. As a result, the FHWA has no discretionary research funding, causing some research products and services previously provided by FHWA to either be absorbed by State programs or to be discontinued altogether. Some of the earmarks also placed additional burdens on State research programs when these programs were identified as sources of matching funds for the earmarks. Therefore, as we go forward, we recommend that there be minimal earmarking and that free and open competition among non-federal entities performing research utilizing federal funds be promoted.

Within the context of the general principles set out above, ASCE supports the following actions regarding specific R&T programs:

- The research and technology portion of the State Planning and Research (SPR) program should be maintained to help support state-specific activities while continuing to encourage the states to pool these resources to address matters of more general concern.
- University research should continue to be supported through the University Transportation Centers (UTC) program using a competitive selection process that guarantees quality participants and fairness in the allocation of funds.
- The Federal Highway Administration's (FHWA) program should be strengthened by giving it sufficient funding and flexibility to implement the recommendations of TRB Special Report 261, *The Federal Role in Highway Research and Technology,* to focus on fundamental, long-term research; to perform research on emerging national issues and on areas not addressed by others; to engage stakeholders more consistently in their program; and to employ open competition, merit review, and systematic evaluation of outcomes.
- A continuation of the Strategic Highway Research Program SHRP II beyond the life of SAFETEA–LU, ensuring that critical research will be continued in key areas of surface transportation.

- The Federal Transit Administration's (FTA) research program should be given sufficient funding and flexibility to work with its stakeholders to develop and pursue national transit research priorities.
- The new Research and Innovative Technology Administration (RITA) should have a well-defined scope and responsibility and appropriate funding, in addition to currently authorized research funding, so that it may supplement and support the R&T programs of the modal administrations.

We also encourage the Subcommittee to review the findings and recommendations of TRB Special Report 295, *"The Federal Investment in Highway Research 2006–2009, Strengths and Weaknesses."*

While the Federal Government plays a relatively minor role in the ownership and operations of the Nation's highways, it plays a critical and indispensable role in the research and innovation process, providing about two-thirds of the total amount spent on highway research and technology projects. It also plays a major role in training and technology transfer, and has traditionally been the sole source for higher-risk, potentially higher pay-off research.

To bolster the U.S. Department of Transportation's (DOT) capabilities to improve research, development, technology coordination and evaluation, in 2004, Congress created DOT's Research and Innovative Technology Administration (RITA), to coordinate and review the Department's programs for purposes of reducing research duplication, enhancing opportunities for joint efforts and ensuring that research, development and technology activities are meeting their objectives. In 2006, the U.S. Government Accountability Office (GAO) reported that while RITA had made progress toward these ends, more needed to be done. Specifically, GAO noted that RITA has not yet developed an overall strategy, evaluation plan, or performance measures which delineate how its activities ensure the effectiveness of the Department's research, development, technology investment. As a cost-effective coordinated research, development and technology program is vital to creating a world class, 21st century surface transportation program, we urge Congress to continue to monitor RITA's progress towards achieving these goals to ensure that the public receives a maximum return on every dollar invested.

Rebuilding America's transportation infrastructure is a critical part of rebuilding our economy. And there can be little doubt that a highly focused and well coordinated R&T surface transportation investment program is necessary if we are to build a surface transportation system that is unparalleled in its safety, security, efficiency and effectiveness, one which provides long-term benefits and reinforces the economic foundation of our nation.

ASCE looks forward to working with the Committee to create a strong transportation research program in the next surface transportation authorization bill.