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SUSTAINABLE, ENERGY-EFFICIENT TRANSPORTATION INFRASTRUCTURE

HEARING

BEFORE THE

SUBCOMMITTEE ON TECHNOLOGY AND INNOVATION

COMMITTEE ON SCIENCE AND TECHNOLOGY

HOUSE OF REPRESENTATIVES

ONE HUNDRED TENTH CONGRESS

SECOND SESSION

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CONTENTS

June 24, 2008

Page

Witness List 2
Hearing Charter 3

Opening Statements

Statement by Representative David Wu, Chairman, Subcommittee on Technology and Innovation, Committee on Science and Technology, U.S. House of Representatives 7
Written Statement 8
Statement by Representative Phil Gingrey, Ranking Minority Member, Subcommittee on Technology and Innovation, Committee on Science and Technology, U.S. House of Representatives 9
Written Statement 10
Prepared Statement by Representative Laura Richardson, Member, Subcommittee on Technology and Innovation, Committee on Science and Technology, U.S. House of Representatives 11

Witnesses:

Mr. Paul R. Brubaker, Administrator, Research and Innovative Technology Administration, U.S. Department of Transportation
Oral Statement 12
Written Statement 13
Biography 20
Mr. Randell H. Iwasaki, Chief Deputy Director, California Department of Transportation
Oral Statement 21
Written Statement 23
Biography 34
Dr. Robert L. Bertini, P.E., Director, Oregon Transportation Research and Education Consortium (OTREC); Associate Professor, Portland State University
Oral Statement 34
Written Statement 37
Biography 59
Mr. Gerald F. Voigt, P.E., President and CEO, American Concrete Pavement Association
Oral Statement 60
Written Statement 62
Biography 68
Dr. Christopher M. Poe, P.E., Assistant Agency Director; Senior Research Engineer, Research and Implementation Division–Dallas, Houston, Texas Transportation Institute, Texas A&M University System
Oral Statement 70
Written Statement 72
Biography 78

Discussion 79

Page

Appendix 1: Answers to Post-Hearing Questions

Mr. Paul R. Brubaker, Administrator, Research and Innovative Technology Administration, U.S. Department of Transportation 96
Mr. Randell H. Iwasaki, Chief Deputy Director, California Department of Transportation 101
Dr. Robert L. Bertini, P.E., Director, Oregon Transportation Research and Education Consortium (OTREC); Associate Professor, Portland State University 106
Mr. Gerald F. Voigt, P.E., President and CEO, American Concrete Pavement Association 112
Dr. Christopher M. Poe, P.E., Assistant Agency Director; Senior Research Engineer, Research and Implementation Division–Dallas, Houston, Texas Transportation Institute, Texas A&M University System 116

Appendix 2: Additional Material for the Record

Statement by the Arizona Department of Transportation 120
Statement by Mike Acott, President, National Asphalt Pavement Association (NAPA) 125

SUSTAINABLE, ENERGY-EFFICIENT TRANSPORTATION INFRASTRUCTURE

TUESDAY, JUNE 24, 2008

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 [Chairman of the Subcommittee] presiding.

BART GORDON, TENNESSEE
CHAIRMAN

RALPH M. HALL, TEXAS
RANKING MEMBER

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Subcommittee on Technology and Innovation

Hearing on:

Sustainable, Energy-Efficient Transportation Infrastructure

Tuesday, June 24, 2008
10:00 a.m. – 12:00 p.m.
2318 Rayburn House Office Building

Witnesses

Mr. Paul Brubaker
Administrator
Research and Innovative Technology Administration
U.S. Department of Transportation

Mr. Randell Iwasaki
Chief Deputy Director
California Department of Transportation

Dr. Robert Bertini, P.E.
Director
Oregon Transportation Research and Education Consortium

Mr. Gerald Voigt, P.E.
President and CEO
American Concrete Pavement Association

Dr. Christopher Poe, P.E.
Assistant Agency Director
Director of the Center on Tolling Research
Texas Transportation Institute

HEARING CHARTER

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

Sustainable, Energy-Efficient Transportation Infrastructure

TUESDAY, JUNE 24, 2008
10:00 A.M.—12:00 P.M.
2318 RAYBURN HOUSE OFFICE BUILDING

I. Purpose

On Tuesday, June 24, 2008, the Subcommittee on Technology and Innovation will hold a hearing to review ongoing federal, State, academic, and industry research and development activities related to reducing life cycle energy consumption, reducing fuel use and promoting sustainability for surface transportation infrastructure. The hearing will also address technical, regulatory, social, and financial challenges to implementing new measures and integrating new materials and technologies into existing transportation networks.

II. Witnesses

Mr. Paul Brubaker is the Administrator of the Research and Innovative Technology Administration (RITA) of the U.S. Department of Transportation.

Mr. Randell Iwasaki is the Chief Deputy Director of the California Department of Transportation (Caltrans).

Dr. Robert Bertini, P.E., is the Director of the Oregon Transportation Research and Education Consortium (OTREC).

Mr. Gerald Voigt, P.E., is the President and CEO of the American Concrete Pavement Association.

Dr. Christopher Poe, P.E., is the Assistant Agency Director and Director of the Center on Tolling Research at the Texas Transportation Institute.

III. Brief Overview

- The surface transportation sector is a major contributor to energy use and pollution, accounting for 33 percent of carbon emissions in the U.S. annually. In addition to energy use and pollution from vehicles, infrastructure construction, maintenance, and destruction have high fuel costs and require significant materials manufacturing. Transportation infrastructure also is a factor in heat, noise, and water pollution.
- Materials and technologies currently exist to combat pollution and energy waste from transportation infrastructure. Recycled or high performance pavement materials reduce manufacturing and maintenance needs and can also cut fuel use by reducing friction. Sophisticated traffic management and data collection technologies reduce congestion, which resulted in 2.9 billion gallons of wasted fuel in 2007, according to the Texas Transportation Institute.
- Many State and local governments are beginning to adopt innovative surface transportation infrastructure materials and technologies reduce energy costs and promote sustainability, but widespread implementation remains slow. Some impediments include lack of performance data, high costs, lack of trained engineers and planners, and industry reluctance to embrace new construction techniques and materials. Additionally, new materials and technologies must be integrated with existing transportation systems, requiring cooperation between researchers and planners.
- Research, development, testing, and evaluation (RDT&E) carried out by federal and State agencies, academia, and industry is helping advance knowledge in the field of innovative surface transportation materials and technologies, but additional technology transfer and education efforts are needed

to engage policy-makers and the public. Strong partnerships between the research and user communities are vital to ensure that R&D efforts are tied to user needs and that demonstration projects prove the effectiveness of various technologies and materials.

IV. Issues and Concerns

What research and development efforts are needed to address current challenges in the surface transportation sector? How should the research community determine R&D priorities? What data collection needs currently exist, and how do researchers measure whether new materials and technologies have the desired impact of reducing energy use and promoting sustainability? Researchers have established a strong link between surface transportation infrastructure and a host of negative environmental impacts, including wasted fuel, urban heat island effects, carbon emissions, noise pollution, and demand on virgin materials for pavement. The R&D community addressing these challenges is diverse, ranging from federal agencies such the U.S. Department of Transportation's Federal Highway Administration (FHWA) and Research and Innovative Technology Administration (RITA) and the Environmental Protection Agency, universities, and industry. While entities such as the Transportation Research Board exist to help bridge gaps between the research and user communities, the R&D community further benefits from formal and informal connections to their immediate communities in order to understand users' research priorities. Additionally, data collection helps frame the environmental, economic, and safety challenges and influences research priorities by identifying the areas of greatest need.

What are the roles of the Federal Government, State agencies, academia, and industry in technology transfer? How should these entities help policy-makers find a balance between environmental impact and safety, cost, and efficiency? Because transportation infrastructure needs vary by region, technology transfer is most effective when it involves partnerships between local experts and policy-makers. Many universities involved in transportation research convene formal and informal meetings to discuss how available technologies might be integrated into transportation networks. The Federal Government also engages in technology transfer activities through partnerships, training, and demonstration projects. FHWA offers courses through the National Highway Institute, some of which cover innovative technologies. FHWA and the EPA also participate in the Green Highways Partnership, which coordinates outreach and education efforts and demonstration projects to promote use of environmentally friendly materials and technologies. However, acceptance and use of new transportation technologies remains slow. Decisions on the use of innovative technologies are made by State or local transportation officials who may or may not have access to data on their efficacy and cost.

What standards development activities are needed in both materials and intelligent transportation systems? What is the impact of the lack of standards? Stakeholders have engaged in some standards development activities for pavement materials and intelligent transportation systems, but the community has identified a need for further efforts. In the materials field, the expanded use of recycled materials and industrial byproducts in pavement to cut landfill waste requires characterization of products (such as fly ash, slag, or even construction waste like drywall) that may not be uniform in size, shape, or composition. The National Institute of Standards and Technology (NIST) has done some work in characterization and hosts a virtual lab to allow researchers to test their mixture of recycled materials via computer simulation To meet users' performance requirements, manufacturers need standards that specify the percentage of each type of recycled material that can be safely incorporated into cement. For data collection and traffic management systems, end-users have identified a need for technical standards that allow inter-operability of systems across jurisdictions to ensure that the benefits of these technologies are seen region-wide.

V. Background

Environmental Challenges in Surface Transportation

The surface transportation sector is a major contributor to energy use and pollution. Vehicle use, construction, maintenance, and destruction all result in significant energy costs, and the production of pavement materials uses valuable natural resources. Transportation infrastructure can also contribute to noise and heat pollution, increasing its environmental impact. Currently, the U.S. Department of Energy

estimates that the transportation sector accounts for 33 percent of carbon emissions in the United States annually.

The United States consumes approximately 128 million tons of cement annually, with a significant share being used for transportation infrastructure. Though the industry has effectively cut energy use and carbon emissions over the last few decades, the scope of cement manufacturing means that the environmental impact remains noteworthy, accounting for 1.5 percent of carbon emissions. According to a report by the American Concrete Pavement Association, this translates to 52,800 tons of carbon dioxide emitted for the construction of a typical 100 kilometer highway. In addition, the construction of infrastructure also carries considerable fuel costs, ranging from nearly 2000 to over 10,000 gallons of fuel per lane-mile, depending on the material used for pavement.

Vehicle use also results in fuel use and emissions, especially in congested areas. The Texas Transportation Institute estimated that traffic congestion in the United States in 2.9 billion gallons of wasted fuel in 2007. In a study of 85 urban areas with serious congestion problems, TTI also found that travel delays that result in idling, and thus fuel waste and extra emissions, have grown since 1982.

Research and development activities

Research and development activities to combat the negative environmental impacts of surface transportation have been ongoing in the U.S. for several decades, with contributions from federal agencies, academia (especially U.S. DOT-funded University Transportation Centers), and industry. State transportation agencies also participate in data collection activities to help frame challenges and determine the efficacy of various measures. Current research covers traffic management and data collection activities through the use of intelligent transportation systems, materials characterization, design, and manufacturing research, and urban planning and transportation system design studies.

Specific research activities addressing energy efficiency and sustainability range from intelligent transportation system (ITS) design and data collection technologies to paving materials design. ITS technologies help reduce fuel consumption and emissions by managing traffic flow to cut congestion and keep vehicles moving smoothly. Specific projects include traffic signal timing, highway on-ramp management, truck scales embedded in travel lanes, and other traffic management tools. Additionally, ITS technology can be used for data collection to identify problem areas or determine the effectiveness of traffic management technologies. Many of these technologies also have further safety benefits in addition to ensuring smoother traffic flow by helping avoid collisions.

Materials research focuses on promoting sustainability and reducing energy use in the manufacturing process by incorporating recycled materials into paving materials or by designing high performance paving materials that reduce friction and require less maintenance. Industrial byproducts such as fly ash from coal power plants promote sustainability and energy savings by reducing the need for producing new materials while also cutting landfill waste. Academic and industry researchers are working to determine the types of materials that can be safely incorporated into cement, such fiberglass or drywall. They are also studying the maximum percentage of the mix that these byproducts can comprise.

Extending the life cycle of pavement is another important goal for researchers working to improve energy efficiency in the transportation structure. Doing so reduces maintenance and construction needs, thus cutting energy costs. Researchers address this challenge through multiple approaches, including developing pervious pavements to reduce erosion or designing stronger pavements that are less vulnerable to cracking and potholes. Some of the smoother high performance pavements also help cut fuel use by reducing friction, especially for large vehicles. A study by the National Research Council of Canada found that fuel consumption by fully loaded trucks can be reduced by one to six percent when traveling on smooth pavement.

Finally, some materials research efforts also address heat pollution. Dark pavement absorbs heat from the sun and has been found to raise ambient temperatures in urban areas by 9°F and increase demand for energy for air conditioning. Lighter colored pavements reflect sunlight, thus reducing the urban heat island effect.

Technology transfer and implementation issues

Technology transfer in transportation infrastructure typically faces particular challenges related to regulations, cost, education and training, and industry reluctance to embrace new construction techniques. The Federal Government, academia, and industry all play a role in demonstrating the effectiveness of new technologies, training engineers on their use, and helping meet regulatory requirements.

A lack of standards is a key impediment to the implementation of pavements using recycled materials and intelligent transportation systems. For pavements, State and local regulatory performance requirements related to the mix of materials comprising cement mean that byproducts must be characterized to understand their effect on the strength and performance of the pavement. Because there are not standards for the size, composition, or other characteristics of byproducts such as fly ash, manufacturers and researchers have a difficult time proving the performance of their materials from batch to batch. Technical standards for intelligent transportation systems (ITS) are also a key requirement prior to implementation. Especially in dense areas, such as the DC area, where multiple local governments oversee a broad transportation system, ITS technology must be inter-operable to ensure that the benefits are seen region wide.

The cost of technologies and materials also prevents their manufacture and use. Concrete manufacturers must locate and ship byproducts to be incorporated into their mixes, increasing initial capital costs. Additionally, engineers and architects require further training for new materials, resulting in additional expenditures. Similarly, end-users may pay more initially for innovative materials and technologies for managing traffic. Researchers and the Federal Government can help promote technology transfer in the face of cost concerns by providing further information on costs over the life cycle of the infrastructure, rather than initial costs. Life cycle costs are typically reduced through the use of innovative materials and technology.

Demonstration projects play an invaluable role in encouraging implementation of new materials and technologies. The Federal Government funds some local demonstrations of new technologies, which prove to engineers and policy-makers that new technologies can be effective in spite of training needs and high initial costs. Specifically, the U.S. Environmental Protection Agency (EPA) and Federal Highway Administration (FHWA) partner with State governments and industry on the Green Highway Partnership to demonstrate environmentally-friendly highway construction methods. University Transportation Centers also work with local agencies to demonstrate technologies suited to their region's specific needs.

Chairman WU. This hearing will now to order.

I appreciate everyone's patience this morning and thank you very, very much for being here. I would like to welcome everyone. Right now, I can think of very few topics that are of greater interest to the American public than the pocketbook impact of refueling our cars and still trying to hold within each household's budget. According to the Department of Energy, the average price of gasoline in the United States as of yesterday was $4.08 per gallon at the pump. At the gas station closest to here, the number that strikes me is the number that is north of $4.50. One thing we all agree on is that we must take action to help reduce the costs of transportation overall for families across this nation.

Thus far, the national focus has been on cutting or restraining the rise of the cost of fuel. However, any of the proposed solutions will not have a palpable impact for years to come but there are important steps that many cities and states are already taking to reduce fuel consumption and promote sustainability through changes in this transportation infrastructure which includes roads and freeways, networks of stoplights, public transportation systems and overall urban planning and design. Around the country, researchers in academia, industry, State and federal agencies have been working on developing innovative materials and technologies that reduce the life cycle energy costs of transportation infrastructure and promote sustainability. Pavements that incorporate waste materials that would otherwise be landfilled, traffic signal timing systems that cut congestion and monitoring devices that can warn drivers to take alternate routes around traffic jams are just a few of the examples of innovations in transportation infrastructure and technology that can help protect our environment.

The potential benefits of these innovative materials and technologies are impressive. Currently, the surface transportation sector accounts for 33 percent of carbon emissions in the United States. Additionally, according to the Texas Transportation Institute, congestion alone accounted for 2.9 billion gallons of wasted fuel in 2007. The Federal Highway Administration estimates that five percent of that congestion is due to poorly timed traffic signals. Intelligent transportation systems can eliminate congestion due to poor signal timing. That is a potential fuel savings of 145 million gallons of fuel per year.

What is even more striking is that many of the technologies we need to bring about these fuel savings already exist. So why isn't every community in America using them? I am very interested to hear our witnesses' thoughts on why policy-makers opt not to use innovative materials and technologies as part of their transportation systems, and what the Federal Government can do to help spur technology transfer.

I am proud that in Portland, Oregon, and in the First Congressional District, which I am pleased to represent, we have been leaders in using energy-efficient and sustainable transportation infrastructure.

With technologies such as transit signal priorities that reduce idling by buses by linking on-board computers to traffic lights, ramp meters that cut congestion on our freeways and real-time traffic information so that drivers can avoid backups, the State and

local departments of transportation in Oregon have worked effectively to identify and implement innovative solutions to important transportation challenges. These efforts are coordinated regionally, not just city by city, so that energy savings benefit taxpayers and gasoline purchasers and other fuel purchasers throughout the area.

Dr. Robert Bertini, who is Director of the Oregon Transportation Research and Education Consortium, will tell us more about how the research and policy communities collaborate to make these projects a reality.

Soon the Congress will be considering the next surface transportation reauthorization, and the Committee on Science and Technology plans to play an important role in defining our transportation research priorities for the future. Sustainability and energy efficiency are no longer just buzzwords in the transportation community.

They are crucial components of a working national transportation infrastructure. Building more roads alone is not the answer. We must use our resources carefully and wisely, and that requires a commitment to reducing the creation of new materials and finding simple innovative ways to conserve fuel. I am confident that our panel today will give us some solid ideas for moving forward on a sustainable energy-efficient transportation policy.

[The prepared statement of Chairman Wu follows:]

PREPARED STATEMENT OF CHAIRMAN DAVID WU

This hearing will come to order. I'd like to welcome everyone to this morning's hearing. I can think of few topics that are of greater interest to the American public than the impact of filling up our cars on the household budget. According to the Department of Energy, the average price of gas in the U.S. as of yesterday was $4.08 per gallon at the pump. One thing we all agree on is that we must take action to help reduce the cost of transportation for families across the country.

Thus far, the national focus has been on cutting the cost of fuel. However, any of the proposed solutions will not have a measurable impact for years. But there are important steps that many cities and states are already taking to reduce fuel consumption and promote sustainability through changes to the transportation infrastructure, which includes roads, freeways, networks of stoplights, public transportation systems, and overall city planning.

Around the country, researchers in academia, industry, and federal agencies have been working on developing innovative materials and technologies that reduce the life cycle energy cost of transportation infrastructure and promote sustainability. Pavements that incorporate waste materials that would otherwise be landfilled, traffic signal timing systems that cut congestion, and monitoring devices that can warn drivers to take alternate route around traffic jams are just a few of the examples of innovations in transportation infrastructure and technology that help protect the environment.

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Chairman WU. Now I would like to recognize my colleague and friend, the Ranking Member from Georgia, Dr. Gingrey, for an opening statement. Dr. Gingrey.

Mr. GINGREY. Good morning, Mr. Chairman, and good morning to our distinguished panel of witnesses. I want to first thank you for holding this hearing today and this hearing that touches the lives of so many Americans on a daily basis. I am pleased to work with you as we continue this subcommittee's efforts to improve our nation's transportation infrastructure through innovative research and development activities that will hopefully result in a windfall of cost savings for our nation.

While the importance of our roads and highways to our economy and our way of life are self-evident, I would like to take a moment to document for the Subcommittee the extent of their impact. There are approximately four million miles of roads in this country and Americans drive approximately four trillion miles per year. Furthermore, there are over 200 million cars and light trucks on the road and a further eight million trucks on the roads supporting our businesses, so overall transportation-related activities currently account for 10 percent of our gross domestic product.

To support all this traffic, government expenditures on our highways are approximately $140 billion a year. Unfortunately, even with this constant influx of revenue, our infrastructure cannot support our growing traffic needs.

According to the Urban Mobility Report published by Dr. Poe's Texas Transportation Institute, TTI, drivers in the Atlanta metropolitan area spend an average of 60 hours per year stuck in traffic and they waste approximately 44 gallons of fuel in the process. This is my hometown, by the way. With gas prices currently at $4.08 per gallon, as the Chairman said, for regular gasoline, this equates to almost $200 per driver that is wasted when families are struggling to pay for rising energy costs.

Metropolitan Atlanta has similar congestion to Washington, D.C., and San Francisco, and only Los Angeles has a greater congestion problem. Congestion, as we know, it is not limited to our major cities. Nationally, TTI estimates that congestion on our nation's roads resulted in 2.9 billion gallons of wasted fuel in 2007 and a $78 billion drain on our economy.

Congestion aside, our transportation infrastructure accounts for a significant portion of our total energy consumption. Civilian transportation consumes nearly nine million barrels of petroleum per day for gasoline, twice the amount of industrial uses. With oil prices now at about $135 per barrel, the total cost is a staggering $1.2 billion per day.

Despite the numerous challenges presented by our transportation infrastructure, researchers across America are working right now on reducing our energy consumption and easing our congestion problems. Our panel will describe many technologies that can improve the condition and sustainability of our highways both in the short- and long-term.

The priority of research and development in the transportation sector has lagged behind construction and rehabilitation. The challenges that now face our transportation infrastructure will require innovative design and technologies. So I am eager to hear the panel's thoughts on how effective R&D activities have been in the past and how R&D should be included, as David just mentioned, the next transportation bill.

Chairman Wu, again thank you for holding this hearing. It couldn't be more timely. I look forward to the panel and their testimony, and I yield back the balance of my time.

[The prepared statement of Mr. Gingrey follows:]

PREPARED STATEMENT OF REPRESENTATIVE PHIL GINGREY

Good morning Mr. Chairman. I want to first thank you for holding this hearing today that touches the lives of so many Americans on a daily basis. I am pleased to work with you as we continue this subcommittee's efforts to improve our nation's transportation infrastructure through innovative research and development activities that will hopefully result in a windfall of cost savings for our nation.

While the importance of our roads and highways to our economy and way of life are self-evident, I would like to take a moment to document for the Subcommittee the extent of their impact. There are approximately four million miles of roads in this country and Americans drive approximately four trillion miles per year. Furthermore, there are over 200 million cars and light trucks on the road, and a further eight million trucks on the roads supporting our businesses. Overall, transportation related activities currently account for 10 percent of our GDP.

To support all this traffic, government expenditures on our highways are approximately $140 billion annually. Unfortunately, even with this constant influx of revenues, our infrastructure cannot support our growing traffic needs.

According to the Urban Mobility Report published by Dr. Poe's Texas Transportation Institute (TTI), drivers in the Atlanta Metropolitan area spend an average of 60 hours per year stuck in traffic and waste approximately 44 gallons of fuel in the process. With gas prices currently at $4.07 per gallon for regular gas, this equates to almost $200 per driver that is wasted when families are struggling to pay for the rising energy costs.

Metropolitan Atlanta has similar congestion to the Washington, DC and San Francisco areas, and only Los Angeles has a greater congestion problem. Congestion—as we know—is not limited to our major cities. Nationally, TTI estimates that congestion on our nation's roads resulted in 2.9 billion gallons of wasted fuel in 2007 and a $78 billion drain on the U.S. economy.

Congestion aside, our transportation infrastructure accounts for a significant portion of our total energy consumption. Civilian transportation consumes nearly nine million barrels of petroleum per day for gasoline, twice the amount of industrial uses. With oil prices at $135 per barrel the total cost is a staggering $1.2 billion per day.

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Chairman Wu, again, thank you for holding this hearing and I yield back the balance of my time.

Chairman WU. Thank you, Dr. Gingrey.

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 Ms. Richardson follows:]

PREPARED STATEMENT OF REPRESENTATIVE LAURA RICHARDSON

Thank you Chairman Wu for holding this very important hearing today, and our witnesses for their appearance. The purpose of today's hearing is to examine current efforts in transportation infrastructure research that will reduce energy consumption and improve energy efficiency.

Fact of the matter is highway construction and maintenance consumes a lot of energy. From the amount of fuel that is consumed by cement trucks and other construction related vehicles, to the cars that waste fuel sitting idly in traffic due to lane closures as a result of highway construction, plenty of energy is consumed on a daily basis.

In my home State of California, where there are more registered vehicles than there are registered drivers; and where we have been dealing with traffic congestion and the environmental impacts for years, the heads of the State DOT (Department of Transportation) have already begun to tackle this issue.

Indeed, one of the individuals testifying today is Mr. Randell Iwasaki, Chief Deputy Director of the California Department of Transportation. Under his leadership the State of California has pursued a number of projects to address energy efficiency through our transportation infrastructure. This includes the use of old tires in rubberized asphalt, the installation of LED red lights saving the State taxpayers more than $2 million a year in power costs, and conversion of the Caltrans equipment fleet to clean burning fuels.

Furthermore, under Executive Order S–3–05, which established climate change emission reduction targets for the state, Caltrans has embarked on an effort to lower fuel consumption, and reduce greenhouse gas emissions (GHG) by implementing several programs. The Intelligent Transportation Systems manages traffic flow; the Cold Foam Recycle Project (which won an award from Green Technology) recycles in-place materials on high speed, high traffic volume roadways, and Waste Tires which as mentioned earlier, establishes a variety of uses for waste tire products including shredded waste tires which are used as lightweight fill for embankments.

Likewise the State of California uses environmentally friendly cement, in addition to establishing the Long-life Pavement Rehabilitation Strategies program. The purpose of this program is to reduce the need for future repairs on our highways, by building highways that last as long as thirty years with minimal maintenance.

With the rise in gas prices, coupled with overall rise in the cost of living, the research being done at the University Transportation Centers across the country is vital to the sustainability of our national economy.

I look forward to a productive discussion, Mr. Chairman I yield back my time.

Chairman WU. I am delighted to have such an expert group of witnesses before the Subcommittee today to discuss this very, very important and timely topic. Mr. Paul Brubaker is the Administrator of the Research and Innovative Technology Administration of the U.S. Department of Transportation. Mr. Randell Iwasaki is the Chief Deputy Director of the California Department of Transportation. My good friend, Dr. Robert Bertini, I especially welcome here in Washington, is the Director of the Oregon Transportation Research and Education Consortium, a university transportation center comprised of researchers from Portland State University, Oregon State University, the University of Oregon and the Oregon

Institute of Technology. Next we have Mr. Gerald Voigt, President and CEO of the American Concrete Pavement Association, and Dr. Christopher Poe, Assistant Director and Director of the Center on Tolling Research at the Texas Transportation Institute.

As our witnesses already know, your spoken testimony should be timed for about five minutes. Your written testimony will be taken into the record in its entirety, and after your testimony, Members of the Committee will have five minutes for each round to ask questions, and we will begin with Administrator Brubaker. Please proceed.

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

Mr. BRUBAKER. Thank you, Chairman Wu, Dr. Gingrey, distinguished Members of the Committee. I have the privilege of representing the Research and Innovative Technology Administration at the United States Department of Transportation. Our job at RITA is to coordinate research across all the various modes, and one of the things that we are interested in doing is to make sure that we have mechanisms in place to ensure the appropriate level of investment across the Department in a variety of different areas, particularly those materials that can reduce life cycle energy costs and ensure sustainability for our transportation infrastructure.

Mr. Chairman, our theme for the Research and Innovative Technology Administration is something we like to say, our tag line, if you will, our bumper sticker is, "Innovation for a Nation on the Move," and the key there is to ensure that we continue to be on the move, and the points you raised in your opening statement about intelligent transportation systems and the ability to reduce fuel consumption just by keeping traffic moving is a really excellent one and it is one that we have devoted significant amount of research dollars into and we have got a number of university transportation centers across the country including those at Portland State and those at Georgia Tech that are engaged in—as well as other areas in the country that are engaged in that type of research to ensure that we are developing modern technology, the latest technology, taking advantage of commercial developments as well as researching ways that we can integrate existing and future technologies including things like nanotechnology to ensure that those developments are incorporated into the infrastructure over time. That is on the intelligent transportation system side.

We also are conducting significant research into recycled materials and those innovative materials and methods that can significantly reduce life cycle energy costs and make use of recycled materials. We have got a number of efforts underway, particularly those that we are working with industrial and commercial waste products trying to figure out the best way to use waste material and industrial byproducts to achieve this objective, and one example is that we currently see over 71 million tons of pulverized coal byproducts, also known as fly ash, produced in the United States and only about 39 percent of that fly ash is recycled or used for other purposes. Most of what is currently produced winds up in landfills, which as we know, is a very environmentally unfriendly option. So

pavements made with fly ash offer the potential for providing lower costs and in fact more durable pavement and we are very interested in that type of research and we are going to do that and support that through the Department.

Recycled tire fibers are also another technology that show great potential, and today, as we know, most old automobile tires wind up in landfills or they get incinerated which, is again, not exactly a very environmentally friendly option, and what we are supporting right now based on our experience with rubberized asphalt, we are supporting the use of recycled materials and trying to use recycled rubber to see if the performance that we experience with our rubberized asphalt projects using virgin synthetic fibers has the same durability and quality as that made with the virgin synthetic fibers.

Also, we are looking at nanotechnology, like I mentioned, another cutting-edge innovation that may show some promise in reducing long-term energy consumption and dramatically increasing the sustainability. For example, at the Missouri University of Science and Technology in Rolla, Missouri, they are conducting a field test of bridge decking made with fiber-reinforced composites. What that is going to do, it eliminates the need for steel rebar, which obviously is energy intensive to produce that rebar for reinforcement, but it also can significantly extend the life of the bridge, cutting down on replacement costs and the need to conduct repair of the bridge decking. Georgia Tech has some self-consolidating concretes that is going to reduce the maintenance costs and improve the durability and longer life of bridge structure. Federal Highway Administration is involved in a demonstration project for advanced material called ultra high performance concrete, and we view those as pretty critical developments.

There are also some challenges though, which you asked us to address in the letter of invitation, and we view those in two particular areas. One is standards development: are there sufficient standards that exist to encourage the use of sustainable products and high-energy-efficient products, both in the construction and the repair of these materials, and then the second is the procurement process itself, is the procurement process—and as you know, most of the actual implementation is done at the State and local level—is the procurement process supportive in requiring these sustainable products, and those are the two areas that we see as the most significant challenges.

So that concludes my testimony and I would be delighted to answer any questions.

[The prepared statement of Mr. Brubaker follows:]

PREPARED STATEMENT OF PAUL R. BRUBAKER

Thank you, Chairman Wu, Ranking Member Gingrey, and distinguished Members of the Subcommittee. I have the privilege of serving as the Administrator for the Department of Transportation's (DOT) Research and Innovative Technology Administration (RITA), and I am grateful to have the opportunity to come before you today to testify on RITA's role in coordinating and facilitating research into fuel efficiency and sustainability in our transportation infrastructure.

With his signature on the *Federal-Aid Highway Act of 1956,* President Dwight D. Eisenhower committed the U.S. Government to investing in the development of a transportation system that would revolutionize the American economy and way of life for decades to come. However, no one could have anticipated the sheer volume

of passenger and freight movement that the transportation infrastructure must support yearly. Our roads handled nearly three trillion vehicle miles in 2005 alone—a 74 percent increase from 1990. As America's economy and population continues to grow, it will push even greater demand on our highways, interstates and roads in the decades to come. A safe, reliable, and sustainable transportation system is key to our nation's continued prosperity.

New construction, operational improvements, and routine maintenance of our transportation infrastructure have an enormous cost, and are straining federal, State and local resources. America has 162,373 miles of National and Interstate Highways, with nearly one-third needing extensive upgrades. Innovative, sustainable materials and systems provide us with the opportunity to construct new bridges and overpasses, expand capacity and make necessary operational improvements, with less resources and better long-term durability. Various factors, such as lagging national and State materials standards, technical barriers and budgetary constraints, have impeded the progress of the development and use of innovative materials, coatings, and planning processes that can increase the sustainability of our transportation infrastructure. It is clearly in our nation's best interest to have a transportation infrastructure that supports greater fuel efficiency, and is more sustainable. The Department of Transportation is committed to collaborating with stakeholders in government, industry and the academic community to overcome these challenges.

Today, I will be discussing current research and programmatic activities of RITA and the University Transportation Centers (UTC) program within the areas of energy efficiency and infrastructure sustainability; the processes that guide our priorities in these areas; and the challenges to the research, development and national deployment of innovative materials and technologies.

Research and Development Activities in Energy Efficiency and Infrastructure Sustainability

Since its creation in 2004, RITA has sought to effectively prioritize transportation research programs, identify innovation gaps, and coordinate research and technology efforts within the Department, and throughout the transportation community. While there are challenges to effectively promoting both the research and development, and widespread deployment of more energy efficient and sustainable materials and technologies, there has been a lot of progress as well. The Secretary of Transportation's seven priorities for national transportation have driven Departmental research and development in the areas of energy efficiency and sustainability—specifically by focusing on Reduced Congestion, Energy Independence and Environmental Sustainability.

Under the guidance of these priorities, the Federal Highway Administration's Turner-Fairbank Highway Research Center (TFHRC), ,and the University Transportation Centers, have made great progress in researching and developing innovative materials and technologies that offer the potential for increasing the sustainability of our transportation infrastructure.

University Transportation Centers

First, I would like to discuss a few of the University Transportation Center (UTC) research and development activities in the areas of energy efficiency and sustainability. The UTC Program is a great example of an effective partnership that brings together State transportation agencies and private sector stakeholders with the academic community to find solutions to pressing transportation challenges. UTCs are mandated to address regional issues that impact their states, and bridge the institutional divide—providing outstanding opportunities for technology transfer and deployment.

DOT seeks to tap into the vast pool of expertise, and existing research portfolios, of our nation's academic community by funding UTC transportation research—including energy efficiency and sustainability.

There are several great examples of the important work UTCs are engaged in:

- The Missouri University of Science and Technology at Rolla conducted a field test of a bridge deck made with fiber reinforced composites. Using composites precludes the use of steel bars as reinforcement, which will significantly extend the service life of the bridge, and eliminate the need to replace steel reinforcements at some point in the future. Missouri S&T is involved in numerous projects to study fiber reinforced composites, and their potential for upgrading aging bridges.
- The University Transportation Center for Materials in Sustainable Transportation Infrastructure (MiSTI) at Michigan Technological University conducts

research in the areas of recycled and beneficial use materials in transportation infrastructure. For example, Portland cement production is a significant contributor to total global greenhouse emissions. Reducing Portland cement consumption is the simplest way to reduce this greenhouse gas production. MiSTI is researching new methods of constructing concrete highways and bridges using less Portland cement, which will greatly reduce the environmental impacts of Portland cement production.

- University of California–Davis' Institute of Transportation Studies is evaluating modified binder mixes, comparing overlays with mixes using a new process for rubberizing asphalt binders. The results were extremely promising. Caltrans is reviewing the results and the recommendation to move to pilot projects and how to incorporate results. This research should lead to more use of rubberized asphalt, and longer lives for pavement maintenance and rehabilitation overlays, which will save money and reduce use of crushed stone.
- At the Georgia Institute of Technology, research has developed three acceptable mixtures for self-consolidating concretes for use in precast bridge girders. The use of these self-consolidating concretes will result in better quality bridge girders which require less construction labor and time on site, significantly reducing project costs. The improved materials properties will also result in more reliable, longer-lived bridge spans with reduced maintenance and repair costs.

U.S. DOT

Departmentally, there has been very good progress in pushing innovative materials technologies as well. Turner-Fairbank Highway Research Center is conducting research into developing methods for using more fly ash, a by product of coal combustion, in concrete mixtures for road paving. Fly ash is typically land-filled after it is produced, and using more of it in concrete mixtures recycles fly ash with little environmental impact. Pavements made with fly ash offer the potential for providing lower-cost, more durable pavement, which uses less energy to manufacture. Turner-Fairbank is also working on testing procedures, construction guidelines, and supportive software applications to promote greater use of fly ash in paving applications.

While Turner-Fairbank is exploring ways to use more fly ash in concrete mixtures, the FHWA is involved in a demonstration project for an advanced concrete material called Ultra High Performance Concrete (UHPC). This project is a part of the President's National Nanotechnology Initiative, and has broad energy efficiency and sustainability implications for transportation construction and maintenance. UHPC is composed of a special mixture of minerals and fibers that is lightweight, impermeable and resistant to freezing. This material offers the potential to reduce energy consumption across the life cycle, as it is a precast concrete that can be constructed away from the worksite, and subsequently transported—reducing the impact on driving costs, reducing congestion created by construction projects, and lowering maintenance costs. In 2006, the first highway bridge built in North America with UHPC was opened in Wapello County, Iowa—this bridge was the result of a collaboration of FHWA, Iowa DOT, the Iowa State University Bridge Engineering Center, and private industry.

Partnerships such as this, and other collaborative relationships, are essential to our success in effectively facilitating research and development, and deploying research results in these areas. The multi-state, multi-agency, public-private makeup of our national transportation infrastructure necessitates cooperative research in order for us to be successful innovators.

Coordinating the U.S. DOT Research, Development and Technology Portfolio

While there have been very good outcomes from RITA's current research and development activities and investments, we are actively seeking to improve these processes. The U.S. DOT, through RITA, is instituting a new, Research Planning and Investment Coordination (RPIC) process for coordinating, facilitating and reviewing the Department's research and development programs and activities. It will allow the Department to:

- Align research investments with National transportation goals;
- Track performance and net benefits of Departmental RD&T dollars invested;
- Create visibility and transparency for all directed and discretionary research funding;

- Identify potential redundancies and eliminate unnecessary duplication; and
- Leverage available research resources including those within the U.S. DOT, at the UTCs, in the State DOTs, and in the private sector.

The goal is to achieve greater transparency and bring into one database all of the RD&T data that are currently scattered among many agencies, as recommended in the GAO report *Transportation Research: Opportunities for Improving the Oversight of DOT's Research Programs and User Satisfaction with Transportation.*[1] When completed, the database will allow policy-makers, researchers, and other users to search for RD&T information by research topic, funding level, grant description, contractor, State, and more. It will be a critical tool for coordinating research investments, and for sharing knowledge.

Additionally, we believe strongly in promoting *Communities of Interest (COI)* among the Department's modal administrations, external partners and relevant transportation stakeholders. COI allow agencies, organizations, institutions and individuals to exchange information and resources through multiple knowledge systems. COI offer an excellent opportunity for organic peer review and collaboration, expanding the pool of expertise readily available to enhance progress across priority RD&T areas.

The Department's plan for achieving a safe, sustainable and more efficient transportation system, *Transportation Vision 2030,* defined an initial list of seven priority, multi-modal *Communities of Interest (COI)* that have a significant impact on the future of energy efficiency and sustainability:

- Multi-modal policy and transportation systems research;
- Environmental stewardship and energy independence;
- Physical infrastructure;
- Surveillance infrastructure;
- Human factors research and applications;
- Materials; and
- Intelligent Transportation Systems.

Modal RD&T Collaboration within the U.S. DOT

While each administration has unique, mission-related research areas and topics it must pursue, the *Communities of Interest* model will ensure that priority cross-cutting areas will be addressed through collaborative processes, encouraging better knowledge sharing and leveraging of RD&T dollars. Specifically, Communities of Interest *in Physical Infrastructure and Materials* are driving cross-cutting research and development activities in energy efficiency and sustainability across U.S. DOT modal offices.

Intermodal research working groups and online forums are being established on these topics to cultivate ongoing collaboration among Departmental operating administrations, University Transportation Centers (UTCs), and U.S. DOT Centers of Excellence. *Communities of Interest* will help to ensure that related research is coordinated, fostering technology transfer through more effective sharing of outcomes and products.

Facilitating RD&T with External Partners

The U.S. DOT engages in cooperative research with stakeholders across the transportation sector, including other federal agencies, State and local governments, the academic community, industry, and not-for-profit institutions. RITA has been working to build closer ties between individual UTCs and U.S. DOT programs to ensure that UTC research is targeted toward the critical transportation challenges as mandated.

The National Surface Transportation Policy and Revenue Commission recommended that "funding of RD&T . . . be subject to careful planning and review by the transportation industry."[2] The RD&T planning team has reviewed the strategic research documents of key stakeholders and will continue to work with them to ensure consistent and substantive input into the research investment planning process. By providing greater visibility and transparency into the U.S. DOT's research programs, the U.S. DOT seeks to foster greater collaboration and leveraging

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[1] Government Accountability Office, "Transportation Research: Opportunities for Improving the Oversight of DOT's Research Programs and User Satisfaction with Transportation," August 2006, *http://www.gao.gov/new.items/d06917.pdf*

[2] *Transportation for Tomorrow: Report of the National Surface Transportation Policy and Revenue Study Commission,* p. 31, *http://www.transportationfortomorrow.org/final_report/*

of resources with State and local governments, the Transportation Research Board (TRB), and other relevant entities.

Challenges to the Broad Deployment of Effective Technologies

The Department's primary role in facilitating the broad deployment of innovative technologies is to provide the necessary support to demonstrate the viability of emerging technologies, and to establish the regulatory framework, standards and architectures to safely and effectively integrate new technologies into the transportation infrastructure.

The Department does not do this in a vacuum—across all of the modal administrations, U.S. DOT experts serve on over 300 technical committees of 48 Standards Developing Organizations (SDOs), seeking to ensure that new technologies and applications may be deployed to enhance transportation safety, security and mobility. These standards become the basis for DOT safety regulations and planning guidance. U.S. DOT experts also serve on countless research panels and technical exchange committees to enable implementation of significant technological and operational innovations.

Many current construction and operational standards, and State transportation agency contracting procedures do not adequately support or incentivize greater use of innovative materials. Our friends at NIST are currently reevaluating existing standards and best practices, and developing standards for new materials, high-performance and adaptive concrete technologies, to determine how standards and specifications can be revised to reflect national priorities for the use of innovative materials in construction and maintenance.

More difficult is encouraging the deployment of incremental improvements in operational concepts, procedures and technology that do not rise to the level of a standard. In many ways, these smaller steps, often the result of U.S. DOT or State DOT research, are just as crucial to improving safety and efficiency. However, due to their incremental nature, sharing information on these advances across the many levels of government, multiple systems operators, and the contractor and consulting engineering community is difficult. This is where RITA's development of *Communities of Interest* is vital in expanding our processes for knowledge sharing, technology transfer and research implementation. Under the *COI* model, every project is required to have a mechanism for technology transfer and deployment by including State, institutional and industry stakeholders in the planning process.

The multi-state, multi-agency, public-private makeup of America's transportation infrastructure, its providers and users, requires strong institutional arrangements and partnerships to ensure successful cooperation when planning, evaluating or implementing research results. State and local DOTs, transit agencies, port authorities, railroads, trucking firms, carriers and shippers need to be aware of research results, implementing contracting and internal operating practices that encourage the use of new research and technology, as so much of the implementation of transportation infrastructure research is conducted at those levels of government, often through cooperation with the private sector. We believe that Public-Private Partnerships offer a practical, effective vehicle for overcoming many of these barriers.

Conclusion

RITA has made great strides in our young life towards coordinating DOT transportation research priorities, and we are working towards a national transportation research strategy and strategic plan. Innovative materials and Intelligent Transportation Systems will be two of the key priority areas we will address as we continue to advance in this direction.

Examples of Current U.S. DOT and UTC Research and Development Activities with Energy Efficiency and Sustainability Applications

U.S. DOT Activities

Development Of Portland Cement Concrete Pavement (PCCP) Mixtures Containing High Fly Ash Contents
FHWA/Office of Infrastructure R&D, Pavement Materials & Construction Team

Verify, integrate, and refine software, guidance and test procedures to facilitate the use of high fly ash content concrete mixtures for highway paving. The products

of this research will contribute to both greater use of fly ash in highway paving applications and improved performance of the pavement.

Greatly Increased Use of Fly Ash in Hydraulic Cement Concrete (HCC) for Pavement Layers and Transportation Structures
FHWA/Office of Infrastructure R&D, Pavement Materials & Construction Team and Contractor(s) to be Identified (Solicitation in Process)

To more than double the use of fly ash in HCC and halve the use of Portland cement. The high payoffs are decreases in energy content of the cementitious phase, amount of CO_2 given off, and amount of fly ash land-filled—also elimination of the need for more cement production and imports and the productive use of an otherwise wasted material. Once technology is in place, initial costs may be lowered in those areas where fly ash haul distances are less than Portland cement and due to energy and disposal savings. Extended service life is also a realistic objective due to the recognized quality of fly ash in making concrete better—with less permeability, porosity, and microcracking, and the potential capability to heal due to extended hydration reactions.

Recycled Materials Resource Center
University of New Hampshire

Expand the extent of use of industrial byproduct materials in highway construction through training, technology transfer, and research to support agency use of recycled materials.

Warm Mix Asphalt
FHWA/Office of Pavement Technology with support from the Office of Infrastructure R&D

Efforts to implement high priority findings from the international scan completed last year and field demonstration projects to better understand the use and benefits of the technology. Warm mix asphalt technology will allow for increased levels of recycled asphalt materials in the production of hot mix asphalt.

Use of Reclaimed Asphalt Pavement
FHWA/Office of Pavement Technology

Advancement of increased usage of recycled asphalt (RAP) in asphalt mix design. These efforts are focusing on support efforts with states to use much higher levels of RAP (> 25 percent) in hot mix asphalt applications. FHWA has helped in sponsoring workshops with industry, we have formed an Expert Task Group that has worked hard to conduct demonstration/pilot projects, and we have conducted on site support of high RAP mixes through the use of our mobile lab.

In-Place Pavement Recycling
FHWA/Office of Pavement Technology with support from the Resource Center

FHWA recently supported a workshop in Utah on in-place pavement recycling and we are working with industry and State representatives to update training and design references on the use of this technology.

Use of Industrial Byproducts
FHWA/Office of Infrastructure R&D with Recycled Materials Resource Center (Designated Program)

FHWA in partnership with EPA recently helped support a workshop in Denver on the use of industrial byproducts as a material resource to design and produce pavements.

Green Highways Partnership
FHWA/Office of Pavement Technology

FHWA has continued to support the Mid-Atlantic Green Highway Partnership which includes the use of Recycled/Re-Use Materials as a major theme within the partnership. This partnership has encouraged the delivery of pilot projects using recycled materials on a few highway projects in the Mid-Atlantic area.

UTC Activities

University Transportation Centers across the Nation engage in a wide variety of research projects. Here is a sampling from some of these centers.

Fibers from Recycled Tires as Reinforcement in Hot Mix Asphalt
Texas Transportation Institute (Texas A&M University)

High-quality long-lasting hot mix asphalt (HMA) pavements are essential to the sustainability of the U.S. economy. Previous research and construction projects have demonstrated that virgin synthetic fibers can provide excellent reinforcing aids in asphalt paving mixtures. Fibers from scrap tires offer an excellent low-cost alternative supplement to virgin fibers. As no good use has been found for these byproduct fibers from the tire grinding process, they are currently being disposed of in landfills or, in some cases, incinerated.

The proposed researchers have successfully incorporated virgin synthetic fibers into HMA and demonstrated the benefits in the laboratory and even in the field, on a limited basis. Virgin fibers can improve the resistance of HMA to cracking and rutting. This promising work needs to be continued to determine the value of using fibers from the tire recycling process in HMA. Equipment is available to incorporate fibers into HMA.

A laboratory study will be developed and implemented to examine the utility of byproduct tire fibers in HMA for paving purposes. Researchers will incorporate the waste fibers into HMA, prepare and test HMA specimens in the laboratory, evaluate the benefits of fibers in different types of HMA. If tire fibers appear beneficial in HMA, the researchers will recommend modifications to materials specifications and field construction guidelines that can be used by State departments of transportation and other highway specifying agencies. This project may lead to additional research for TTI if the use of byproduct tire fibers in HMA appears promising.

Use of Recycled Materials in Bicycle and Pedestrian Trails
Texas Transportation Institute (Texas A&M University)

The proposed research will investigate the feasibility and benefits of paving bicycle/pedestrian trails with recycled material. The proposed study will also perform field tests of paving bicycle/pedestrian trails with recycled material. A preferred mix of recycled materials will be used in a test section of an off-road bicycle trail and then evaluated by the researchers and trail users.

The proposed research would include site-identification, planning and coordination of a field experiment. Minimal lab testing would be required to establish and characterize the mix design for the materials chosen for evaluation. Field test sections will be evaluated for bicyclist/pedestrian satisfaction, constructability, cost, performance, environmental impact, and aesthetics.

The increased use of byproducts in construction applications will provide numerous environmental and economic benefits. Positive environmental effects include reduced sold waste and reduced use of natural resources. Positive economic benefits should include (a) reduced construction costs; (b) creation of alternate materials for non-existent, poor, or depleting aggregate resources; (c) savings in energy prices versus disposal; (d) creation of new jobs through new manufacturing and marketing opportunities; and (e) extension of creative rationale to other byproducts.

Implementation of a System for Evaluating Waste/Recycled Materials in Transportation Projects
Texas Transportation Institute (Texas A&M University)

Enormous quantities of waste materials are generated every year in Texas and recycling these waste materials is necessary to preserve the country's natural resources. A waste and recycled material evaluation system has already been developed which takes into account technical, economic, societal, and environmental aspects of waste and recycled material utilization in roadbase.

Under this research project, the evaluation system will be field tested and implemented in various administrative levels including one or two TxDOT districts and one or two city of county projects. This will help reduce the volume of waste and recycled materials going into landfills by permitting reuse in transportation projects. The implementation will also help reduce the energy required to produce virgin aggregate involved in more than 110 million tons of recycled aggregate base for AC and PCC pavements in addition to several other environment related benefits.

RFID Applications in Transportation Operation and Intelligent Transportation Systems (ITS)
Oregon Transportation Research and Education Consortium (Portland State University)

It is anticipated that great applications of Radio Frequency Identification (RFID) technologies in transportation operations are foreseen in next few years. The lower cost producing and the long-lasting energy supply enables RFID technology with potential applications in many areas including transportation and logistics. Under the RFID equipped vehicle and highway system, almost all components (vehicles, highways, traffic signals, signs, symbols, pavement markers, etc.) can be provided with

the long-lasting and cheap RFID tags or labels. RFID system typically includes an RFID device containing data, an antenna transmitting signals, a Radio Frequency (RF) transceiver generating signals, and a reader receiving RF transmissions. This research is intended to investigate the potential RFID applications in transportation operations through literature review and survey; and identify the possibility of incorporating RFID into the Intelligent Transportation System (ITS).

Evaluation of Traffic Simulation Models for Supporting ITS Development Oregon Transportation Research and Education Consortium (Portland State University)

The deployment of various ITS facilities will likely change the functions and structures of the existing urban transportation network components. The continuing expansion of ITS user service definitions is adding more and more travel and traffic control elements to the already complex network configurations. The dynamic interactions between the traffic control and management components and the traffic flows are becoming more complicated than ever before. In this context, the use of a traffic simulation model is becoming the most cost-effective way to analyze the complicated ITS networks. Many traffic simulation models are available for analyzing operations and management. While each type of traffic simulation model seems to have its own merit and shortcomings, there is a need to comprehensively evaluate and document all of the existing models and identify those models that are most suitable for application to different ITS network and development scenarios.

BIOGRAPHY FOR PAUL R. BRUBAKER

Paul Brubaker was nominated by President George W. Bush to serve as Administrator of the U.S. Department of Transportation's (DOT) Research and Innovative Technology Administration (RITA) on June 18, 2007. He was confirmed by the U.S. Senate on August 3, 2007, and was sworn into office on August 8, 2007.

As RITA Administrator, Mr. Brubaker leads the agency responsible for coordinating and reviewing DOT's roughly $1 billion investment in research, development and technology, and is charged with advancing technologies that will improve the Nation's transportation system. RITA oversees the Bureau of Transportation Statistics, Volpe Center, Intelligent Transportation Systems program, Transportation Safety Institute, and numerous cross-modal research initiatives.

Mr. Brubaker previously served as CEO of Procentrix, a firm that helps organizations plan, manage and achieve measurable performance improvement through the effective use of process and technology. His diverse background and expertise positioned him with the ability to empower public sector transformation and drive new models for government efficiency. Prior to this role, Mr. Brubaker served as Executive Vice President and Chief Marketing Officer of SI International, one of the Nation's fastest growing government contractors.

Mr. Brubaker previously served as Deputy Assistant Secretary and Deputy Chief Information Officer at the U.S. Department of Defense (DOD) where he was the Department's second highest-ranking technology official and supervised DOD's $50 billion annual Information Technology expenditure. He drove the transformation of many of DOD's business and war-fighting processes including personnel, logistics, finance and command and control, and supervised the Department's electronic business activity including implementation of paperless contracting initiatives, travel process management and electronic mail. He was awarded the Distinguished Public Service Medal (with bronze palm) for his efforts on behalf of the Department.

Before serving at DOD, Mr. Brubaker held various executive positions within the public and private sectors, including Vice President of Strategic Programs for Litton PRC, Vice President of Business Development for Federal Data Corporation, and in senior positions within the U.S. Senate and General Accounting Office. While serving as Republican Staff Director of the Senate Subcommittee on Oversight of Government Management, Mr. Brubaker was the principal staff architect of the Clinger Cohen Act while working for then-Senator William S. Cohen (R–Maine).

He has also won numerous awards including the Association for Information Resource Management's (AFFIRM) Government Executive Leadership Award in 2000. He was named to Federal Computer Week's Federal 100 in 1996 and 2002, and was appointed to the board of the Virginia Innovative Technology Authority in 1998 where he served as chairman from 2001 to 2003. He recently ended terms as Chairman of the Technical Committee of the Armed Force Communications and Electronics Association (AFCEA) and President of its D.C. Chapter.

Mr. Brubaker holds a B.A. from Youngstown State University and a M.P.A. from Kent State University, and is very active with the Churchill Centre. He lives with his family in Oakton, Virginia.

Mr. WILSON. [Presiding] Thank you. Are there any questions? Pardon me. I recognize Mr. Iwasaki.

STATEMENT OF MR. RANDELL H. IWASAKI, CHIEF DEPUTY DIRECTOR, CALIFORNIA DEPARTMENT OF TRANSPORTATION

Mr. IWASAKI. I think I need more than five minutes, though. Would that be okay? All right. Thank you.

Good morning, Members of the Subcommittee. My name is Randy Iwasaki and I am the Chief Deputy Director at the California Department of Transportation and I am just going to get right into it.

Government works the best when we have definite clear-cut goals. In California, we have AB–32, the *California Global Warning Solutions Act of 2006,* and then Governor Schwarzenegger signed an executive order which established climate change emission reduction targets for the state. We have to go back to 1990 levels by 2020. So we have goals.

Proposition 1B generated $19.925 billion for congestion relief in California. We have to take congestion levels down, delay levels down to below today's level by 2016. So we have goals not only on our climate change, on carbon reduction but also on congestion.

So I want to get right into it. Some of the innovative materials that we are looking at—and by the way, our budget is about $14 billion at Caltrans. Less than 20 percent of that is federal. So we are a state that helps ourselves. In the area of materials, I am the technical coordinating committee chair of the Strategic Highway Research Program, SHRP 2, we call it, and I am in the renewal section. We are looking at getting in, getting out and staying out, basically rapid rehabilitation, minimize disruption and create longer-life facilities. In the area of materials—and by the way, what Congress can do is, it was set up at $450 million. It was cut to $150 million, and besides renewal, there is congestion—or there is capacity, reliability and safety as well, research in that area. When we talk about materials, we are looking at longer lasting. We are looking at recycling. We are actually doing recycling projects in California. Rubberized asphalt concrete, Administrator Brubaker talked about that. Thirty percent of our program, asphalt concrete rehabilitation, is done with asphalt rubber. We are looking at warm asphalt. You don't have to heat it as high so therefore you don't burn as much fuel.

And we recently received an EPA award for environmentally friendly concrete and cement, and you wonder what is that. Well, on the San Francisco-Oakland Bay Bridge in the foundations, we poured concrete that had 50 percent fly ash in it. So in California, probably anywhere else, when you manufacture cement, one pound of cement equals one pound of CO_2. It is a little bit less but for practical purposes it is one for one. And so two percent of our greenhouse gas emissions are cement manufacturing and so we are trying to reduce the amount of cement but still get the same strength and durability because the last thing you want is your facility to wear out faster and have to redo it sooner because you are just going to spend money there. The last thing in the area of materials is, we need to get in, get out, we need to do it rapidly. Get

the facility in the hands of the traveling public sooner so we are doing it very, very quickly.

We are looking at fuels. We are the first State agency, the major buyer of low-sulfur diesel in California five or six years ago. People wonder why are you buying that expensive fuel. Well, today they know because all fuel sold in California that is diesel is low sulfur and so we started that program. Hydrogen—we are going to build a hydrogen fueling facility in our Shop 7 in Los Angeles, the equipment shop. E85—we are building facilities throughout California. How you can help us is, we need one standard specification for the hardware that doesn't fluctuate and we get into conflict with the fire marshal.

In the area of technology, there is so much technology out there that is hard to explain but the problem is integrating it into the transportation system. So I will talk about LED lights. It is a simple technology. We started working on that 15 years ago because our controller box would kick out because of the heat. Today many, many states use LEDs. It is a lower draw. It is an energy saving. It is sustainable. We are proud to say that we are the recipient, the only recipient so far of the Safe Trip 21 effort. It is along the lines of VII, Vehicle Infrastructure Integration program, where cars talk to cars, cars talk to the infrastructure. One of these days, those cars are going to refuse to crash, refuse to run off the road, but in order to expedite that program, we applied for a Safe Trip 21 grant and that is where the communication technology is not imbedded in the car but it is actually in consumer mobile devices. You know them as cell phones. And so we are going to take 10,000 cell phones and run through the Bay area and we are going to get arterial information, probe information so that you can take your trip faster, not shortest distance but quickest time. What does that mean? You are in your car less, you burn less fuel. We think that has a lot of potential. Travel information—we are beefing up our 511 systems. We want people to have up-to-date information to make mode choices, put people in other modes of transportation. And lastly on the technology, we just opened a system-wide adaptive ramp metering where we have 35-mile-an-hour mainline flows and we adjust each meter along the 210 in Los Angeles to maximize throughput and then we are looking at electronic tolling.

You wonder how does California do it. We opened up right-of-way for deployment. When the ITS World Congress came to San Francisco in 2005, we did a call for submissions with the private sector. It is like a three-legged stool for deployment of technologies: academia, government and the private sector. We don't build anything in State government, but when the ITS World Congress came to Sacramento, we opened up our right-of-way. We have some great, great partnerships there and it morphed into the ultra-successful innovative mobility showcase where you could touch ITS. We have two test beds for mobility, one on Interstate 80 near Berkeley, the other one on the I-405 near UC–Irvine. We fully fund our UTCs. We have five in the state. We partner with the Transportation Research Board, AASHTO, ITS America, U.S. Department of Transportation, Federal Highway Administration and others. We have joint research programs with other nations. We do mobility re-

search for the last 20 years with France. We do material research with Denmark. We do seismic research with Taiwan and Japan.

States should probably play in the deployment of technology because we need the overarching standards. We don't want the widget or the product not to work when you cross State lines or county lines. We have to have inter-operability. Some of the impediments are on the federal side when it is a federally over-sighted project. If we have a new mix design, it takes time to get those approvals. At the end of the day, the states are responsible for our rehabilitation projects, so if something happens, they don't come back to the Federal Highway Administration. They come back to the states. The non-competitive bid—we have patent laws in the United States that allow the private sector to develop new widgets, new technology, but when you try to deploy them on a project, you have to go through a PIF process, that's a public interest forum. It takes time. And so we are trained not go through the PIF process, but how do you get innovation if you don't go through the PIF process.

I think since I am red now, and I have so much to say, demo projects, you know, back in 1970, then-Governor Ron Reagan flipped a switch on the first transportation management center in Los Angeles. Today transportation management centers are spread throughout the United States. We need deployment. We need demo projects. AASHTO sponsors a number of scans that go throughout the Nation as well as internationally to look at technology and how they deploy those technologies so we don't have to reinvent the wheel. We use our strategic plan at Caltrans to help guide our research program.

The last thing I would say is, we need people to maintain, operate, design and build these systems. That is where the UTCs come into play. They teach the next generation of leaders. We need to get people in trades. So thank you very much for your time.

[The prepared statement of Mr. Iwasaki follows:]

PREPARED STATEMENT OF RANDELL H. IWASAKI

Mr. Chairman, Members of the Subcommittee:

My name is Randell Iwasaki. I am the Chief Deputy Director of the California Department of Transportation, also known as Caltrans. I would like to thank you for the invitation to testify before you today.

As Chief Deputy Director of Caltrans, I am responsible for a budget of 14 billion dollars, an organization of more than 23,000 employees, and a transportation system that includes 52,000 lane-miles of State highways, two of the five largest transit systems in the Nation, three Amtrak routes, and the two busiest ports in the United States.

I serve as the Chair of the Intelligent Transportation Society of America's Board of Directors. I am also a member of the Intelligent Transportation Systems (ITS) Advisory Committee, which is providing executive-level advice and guidance for U.S. Department of Transportation (DOT) Secretary Mary Peters' Five-Year ITS Program Plan.

As you know, all State departments of transportation belong to the American Association of State Highway and Transportation Officials, or AASHTO. I have been a member of the AASHTO Standing Committee on Research since 1999. This committee represents the Association's interests in all research activities for all transportation modes. The Committee makes reports and recommendations on the $35 million National Cooperative Highway Research Program (NCHRP) and other activities to the AASHTO Board of Directors. I am also a founding member of the AASHTO Technology Implementation Group (TIG) that provides leadership for promoting and supporting rapid implementation of selected technologies.

With regard to the Transportation Research Board (TRB) Strategic Highway Research Program (SHRP 2), I am Chair of the Technical Coordinating Committee for Renewal.

I was recently a member of the Committee on Climate Change and U.S. Transportation for TRB's Special Report 290: *Potential Impacts of Climate Change on U.S. Transportation.*

California is growing rapidly, and by 2020, its population is expected to increase from 37 million to 44 million people; about one out of every eight Americans now lives in California. We have more registered vehicles (24 million) than we have licensed drivers (22 million), so vehicle travel is an important part of our culture, and by 2020, annual vehicle miles traveled will increase by 38 percent to 475 billion miles. Trade volumes through our ports will also more than double by 2020. Responding to this growth is a high priority for the state. Our objectives are to protect the existing investment, fuel the economy, enhance the quality of life for our citizens, and protect our environment. Achieving these objectives will require a substantial effort.

The need for the benefits that we receive from new materials and technologies could not be more apparent anywhere than it is here in California. Each year, our state suffers a societal cost of more than $46 billion in terms of car crashes and traffic congestion. Car crashes annually cause more than 4,000 deaths, 300,000 serious injuries, and the associated level of property damage. Traffic congestion leads to a loss of economic productivity, wasted fuel, and disrupted goods movement, the cost of which continues to rise. We sincerely believe that new materials and technologies will help us significantly improve safety and reduce traffic congestion, and we are committed to investigating the benefits of implementing them.

On June 1, 2005, Governor Schwarzenegger signed Executive Order (EO) S–3–05, which established climate change emission reduction targets for the State. The Climate Action Team (CAT) was created to coordinate the statewide effort. Assembly Bill (AB) 32: *California Global Warming Solutions Act of 2006* further established the first-in-the-world comprehensive program of regulatory and market mechanisms to achieve quantifiable and cost-effective reductions of greenhouse gases (GHG), and required the reduction of GHG emissions to 1990 levels by 2020. Caltrans is a member of the CAT, and we are committed to working with the California Air Resources Board to implement transportation strategies that will help reduce GHG emissions. The Caltrans' Climate Action Program was developed to promote clean and energy efficient transportation and provide guidance for incorporating innovative solutions into its business operations. Furthermore, Governor Arnold Schwarzenegger's Strategic Growth Plan, a ten-year mobility investment program, targets a significant decrease in traffic congestion below today's level by 2016. Therefore, Caltrans' approach to lowering fuel consumption and GHG from transportation is to:

1) Reduce congestion and improve efficiency of transportation systems through smart land use, operational improvements, and Intelligent Transportation Systems. These are objectives of the State Strategic Growth Plan; and
2) Institutionalize energy efficiency and GHG emission reduction measures and technology into planning, project development, operations, and maintenance of transportation facilities, fleets, buildings, and equipment.

Innovation is one of the four core values that guide and shape the department, and staff is empowered to seek creative solutions and take intelligent risks. Caltrans has the largest and most vigorous research division of a State DOT in the Nation. We have ongoing studies that address the potential impacts of climate change and State legislation that mandates the consideration of environmental impacts in State decision-making and project development. We use innovative technologies for traffic management systems. We also have programs to develop alternative fuels, green pavement, fleet vehicle greening, smart parking, and many other projects that help to improve mobility and sustain a high quality of life in California.

Questions:

1) What innovative materials and technologies are currently available to State and local transportation departments, and how do you decide which materials and technologies to use in California? Who are your resources for information on technical capabilities and engineering and design, and how would you rate their technology transfer efforts? How are new materials and technologies integrated into existing transportation networks, especially across multiple regions and jurisdictions?

Caltrans encourages the use of innovative solutions. We have instituted a Green Highway Program to guide us in using environmentally friendly and recycled products and technologies. Caltrans' environmentally friendly business practices include using innovative materials, waste tires, pavement recycling, office waste recycling, and many other applications. Here are a few highlights from this program:

- **Cold Foam Recycle—**Caltrans' Interstate 80 Cold Foam Recycle Project won an award from Green Technology, a nonprofit organization that works with federal and State officials on environmental solutions. The project was the first in California and the United States to recycle in-place materials on a high-speed, high-traffic volume roadway (Traffic counts range from 30,000 to 60,000 vehicles/day).

  The innovative aspect of the project was three-fold: First, the recycling methodology used 100 percent of the existing in-place asphalt concrete on a high-volume, high-speed interstate. This was done in a single pass, allowing for the free flow of traffic through the construction zone. This method reduced construction zone congestion and idling motors at traffic standstills, therefore lowering non-construction vehicle emissions. Second, trucks were not needed to haul away the existing milled asphalt concrete or bring in new replacement hot mix asphalt. Third, the modern computer-driven all-in-one recycler eliminated the need for the following three high-horsepower diesel engines: paver, pickup machine and breakdown roller. This saved additional fuel and further reduced the emissions as compared to conventional construction methodology. The Cold Foam technology has been used successfully in over 10 projects statewide, and more projects are anticipated in 2008/2009.

- **Waste Tires—**Caltrans has established a variety of uses for waste tire products. They include rubberized asphalt concrete as a pavement alternative and shredded waste tires, which are used as lightweight fill for embankments.

- **Environmentally Friendly Cement—**Carbon dioxide (CO2) is a major by-product in the production of cement (0.86 ton of CO_2 per ton of cement in California, where cement plants are among the most efficient in the world). California's production of cement accounts for two percent (two percent) of the state's total CO_2 emission. Caltrans, the Air Resources Board, the California Environmental Protection Agency, and our concrete industry are international leaders in efforts to reduce GHG from cement production and concrete cement usage. Our goal is to stretch the amount of cement used in concrete and to reduce the energy necessary for production. We are focused on concrete that meets our materials quality requirements as we strive to meet the goals of State statue AB 32 (similar to the Kyoto Treaty).

  Specifically, Caltrans and our industry have been looking into ways to reduce the amount of carbon in concrete mixes by using more supplementary cementitious materials (SCM) and by limiting the amount of cement in concrete mixes. For example, we are reducing the amount of cement in the mix by allowing up to five percent (limestone and 25 percent fly ash. The percent of fly ash may be increased to 50 percent. Last year Caltrans won an award from the EPA for building the new San Francisco Oakland Bay Bridge with concrete that had 50 percent of the cement replaced with SCM. We are investigating using different fuels to produce cement so there are less GHG emissions.

  Caltrans is also studying the adoption of a GHG emission standard to assure that cement imported to California has at most the same cement intensity (so that it is as GHG friendly) as cement produced in California. To accomplish this objective, we are looking into the amount of GHG from shipping material by different modes of transportation including ship, train and truck.

- **Caltrans Vehicle Fleet Greening Program—**This program began as a five-year plan in August 2000 to reduce emissions from the Caltrans fleet, ahead of future regulations, and set an example for the use of emerging, clean air technologies. Today, Caltrans continues to promote an efficient fleet mix and use of efficient, low emission vehicles to reduce our use of petroleum, and our emissions of air pollutants and greenhouse gases. Through a combination of regulatory compliance, State purchasing policies, and innovative demonstrations, we have implemented hybrid passenger vehicles; solar-powered equipment; propane-fueled vehicles; low dust street sweepers, diesel particulate filters on heavy-duty, diesel-powered vehicles; hydrogen demonstration

vehicles; and an E–85 fuel ethanol demonstration project. We are also pioneers in the use of low-sulfur diesel and bio-diesel in our vehicle fleet.

- **California Hydrogen Highway Network (CaH2Net)—**Created as part of Executive Order S–7–04 issued by Governor Arnold Schwarzenegger, the mission of the program is to assure that infrastructure is in place to enable fuel cells and other hydrogen vehicle technologies to be used by consumers as they reach commercial readiness. Working in partnership with other components of California's environmental and energy programs, the CaH2Net can help achieve more stable and sustainable energy usage, and increase the number of zero emission vehicles (ZEVs) on California's roads. We are also currently installing a hydrogen fuelling facility in one of our equipment shops in the Los Angeles area.
- **Long-life Pavement Rehabilitation Strategies (LLPRS)—**The goal is to rebuild high volume urban freeways with pavements that are designed to last more than thirty years with minimal maintenance. The program will reduce the need for future repair projects and ultimately save public resources and help preserve the environment 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 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. Pilot projects include the I–10 concrete rehabilitation in Pomona, I–710 asphalt concrete rehabilitation in Long Beach, and I–15 concrete rehabilitation in Devore.
- **Rapid Rehab: Construction Analysis for Pavement Rehabilitation Strategies (CA4PRS)—**By reducing highway construction time and its impact on traffic, CA4PRS is a schedule and traffic analysis tool that helps designers select effective, economical rehabilitation strategies. The software's scheduling module estimates highway project duration, incorporating alternative strategies for pavement designs, lane-closure tactics, and contractor logistics. On the I–15 Devore reconstruction project, CA4PRS software justified implementing the one-roadbed continuous (24/7) closure scenario, which saved $6 million in construction costs and $2 million in road user delay costs. The project was completed in 18 days by closing down one direction of traffic and reconstructing the freeway. This project would normally have taken 10 months to complete with nighttime closures. CA4PRS is funded through a Federal Highway Administration (FHWA) pooled-fund, multi-state consortium (California, Minnesota, Texas, and Washington), CA4PRS was developed by the University of California Pavement Research Center through the UC–Berkeley Institute of Transportation Studies. FHWA formally endorsed CA4PRS as a *"Priority, Market-Ready Technologies and Innovations"* product in 2008 for nationwide deployment. Over 700 people have been trained on the use of this software product.
- **Caltrans Stormwater Management Program—**The program received a Green Technology Leadership Award in the transportation category for its pioneering integrated approach to incorporate protection and treatment of stormwater. The approach starts with project planning, design and construction, and includes ongoing efforts in operations and roadside maintenance. Through the corporate business cycle, practices are continually being evaluated and improved.

Our resources for information on technical capabilities and engineering come from many areas, including academia, Federal, State and local governments, private industry, and from other nations. Caltrans has established excellent working partnerships with our research community. Here are some of the partners we work closely with:

- Advanced Highway Maintenance and Construction Technology (AHMCT), University of California, Davis,
- California Partners for Advanced Transit and Highways (PATH), University of California, Berkeley,
- California Center for Innovative Transportation (CCIT)—As part of the Institute of Transportation Studies at UC–Berkeley, (Its focus is technology transfer efforts),

- Partnered Pavement Research Center—UC–Berkeley and UC–Davis,
- Western Transportation Institute (WTI), Montana State University-Bozeman (MSU),
- University Transportation Centers:
  - The University of California Transportation Center (UCTC) at UC–Berkeley,
  - The Mineta Transportation Institute at California State University, San Jose,
  - The METRANS University Transportation Center at the University of Southern California,
  - The Sustainable Transportation Center at the University of California, Davis,
  - The Leonard University Transportation Center at California State University, San Bernardino,
- U.S. Department of Transportation, including the FHWA, the Federal Transit, Administration (FTA), and the Federal Motor Carrier Administration (FMCSA),
- Transportation Research Board (TRB),
- American Association of State Highway and Transportation Officials (AASHTO), and
- International Partners:
  - France—Mobility Research,
  - Denmark—Pavement Research,
  - Japan/Taiwan—Seismic Research,
  - Holland—Sustainable Transportation Research,

Caltrans is committed to the research and timely deployment of new and innovative materials and technologies, which includes the development of policies that promote sustainability and reduce energy consumption and impacts to the environment. At the same time, there are industry standards that we must follow to be in compliance with federal and State regulations for types of materials used, construction standards, and the like. These policies support our commitment to safety and reliability of the State transportation system. For example, in our pavement unit, a Pavement Standards Team (PST) evaluates pavement design, construction, and maintenance practices and procedures and, as appropriate, develops standard special provisions in a collaborative manner within Caltrans and with FHWA and industry associations. Many times, when changes are deemed necessary or when innovative changes need to be evaluated, pilot programs are initiated. Pilot programs typically require the construction of pilot projects to evaluate the proposed changes; especially, if the change involves an improved maintenance or construction practice, validating enhancements to pavement performance and/or life; and changes in material properties or sampling and testing. Pilot programs and pilot projects require prior approval from PST before they are initiated.

2) What are the biggest impediments to the use of new infrastructure-related materials and technologies? How can the Federal Government, academia, and industry contribute to overcoming these barriers? What role do technology demonstration projects play, and has California undertaken any specific demonstration projects? How are the results of these demonstrations disseminated?

Based on our extensive experience with transportation innovation, here are some of the primary impediments to the use of new infrastructure-related materials and technologies:

- Insufficient resources for implementation,
- Resistance to change at multiple levels within the implementing agency,
- Restrictive legal requirements, such as ownership and use of intellectual property, and indemnification,
- Difficulty in operating and maintaining cutting-edge technologies (lack of workforce with the necessary job skills),
- Procurement challenges due to non-competitive bid (sole source) situations with technologies that are only available from one source,
- Lack of executive-level sponsorship within the implementing agency,

- Challenges with getting federal approval to use new materials and technologies when they have not been educated on them ("Public Interest Finding" process),
- Lack of performance requirements and guidelines for implementing the new idea,
- Risk-averse cultures within the implementing agency, and
- Lack of clear performance measures that determine success.

Here are some of the ways to overcome these barriers to the use of new infrastructure-related materials and technologies:

- Develop products that meet the user's needs,
- Strengthen management commitment to using the product,
- Provide funding to enable State DOTs to meet with cutting-edge technology leaders to share experiences and to learn from them,
- Develop products with user participation,
- Provide sufficient resources to fund complete development of the product, and
- Use pilot projects to demonstrate the benefits of the product.

The Federal Government can help by providing national leadership, serving as a repository for information on best practices, and providing the higher level of resources that are needed for taking a product from research to deployment. Academia is our primary partner for performing research on new infrastructure-related materials and technologies. We then work with the private sector to commercialize these products so they Caltrans and others can use them.

Technology demonstration projects play a key role in addressing the impediments to the use of new infrastructure-related materials and technologies. For example, they enable an implementing agency to deploy a new product on a limited scale to measure and evaluate its benefits. If the results of the evaluation are promising, it becomes much easier for the agency to overcome institutional resistance to change, to gain executive-level support, and to address a risk-averse culture. Another key aspect in the success of a technology demonstration project is to include the end-user of the product in its development and execution. When users play an active role in the project, they can become a champion for it among their peers, making it easier to overcome resistance to change.

As a leader in the field of transportation innovation, Caltrans has participated in many technology demonstration projects. Here are a few of the notable examples:

- **Vehicle-Infrastructure Integration (VII)—**Caltrans is working with ten other State DOTs, members of the auto industry, and the U.S. DOT in a cooperative effort whose outcome will be a new approach to transportation, whereby auto manufacturers and transportation agencies would build systems that communicate wirelessly with one another to:
  1. Enable the implementation of cooperative safety features that prevent vehicle crashes,
  2. Provide unprecedented levels of reliable traveler information, and
  3. Give transportation managers full knowledge of the real-time operating conditions on the Nation's roadway network.
- **SAFE TRIP–21—**Caltrans is working with the U.S. DOT on a program closely related to VII. Instead of emphasizing communications equipment that is deeply embedded within a car, it explores the use of consumer mobile devices, such as cell phones that drivers typically carry with them when they travel, as the communications medium for collecting traffic data from cars and sending traveler information to drivers. Our project is a successful public-private partnership that includes several industry giants, such as Nokia, NAVTEQ, and Nissan.
- **Cooperative Intersection Collision Avoidance Systems—**This project is also closely related to VII. It uses the wireless communications technology developed under VII to enable an application that warns distracted or inattentive drivers before they run a red light, thereby avoiding many of the serious crashes that occur at intersections.
- **On-board Driver Monitoring System—**Caltrans is working with the Federal Motor Carrier Safety Administration on this project to develop equipment that monitors the performance of commercial truck drivers and warns them

of unsafe driver behavior. It can also detect the onset of drowsiness and advise the driver to take a break.

- **Travel Times on Changeable Message Signs (CMS)—**This project provides information on current traffic conditions to drivers while they are commuting. Trip time is the most practical information that commuters can use to assess traffic and adjust their routes. The CMS displays information about downstream corridor delays, traffic incidents, and estimated travel times. Displaying accurate travel times on CMS helps commuters assess traffic, alleviates driver stress, and allows drivers to make better route decisions. Knowing the driving times to popular destinations, travelers may choose a less-congested route or a different form of transportation.
- **Integrated Corridor Management—**Caltrans is working with the FHWA and two regional transportation agencies (San Francisco and San Diego) on ways to integrate both operations and traveler information for different roads (arterials and highways) and different modes (cars, commercial trucks, buses, and commuter rail) along strategic transportation corridors. When implemented, travelers can make more efficient decisions on mode and route choice, saving them time and money.
- **System-Wide Adaptive Ramp Metering (SWARM)—**Along Interstate 210 in the Los Angeles Region, Caltrans has implemented a ramp metering algorithm that substantially reduces the amount of traffic congestion along the corridor. Based on the success of this demonstration, the SWARM algorithm will be implemented along several other strategic corridors in the near future.
- **Caltrans Automated Warning System (CAWS)—**This technology has been deployed in the Central Valley of California to detect and automatically inform drivers of foggy and other reduced visibility conditions. It is now being expanded to other regions that are prone to foggy conditions.
- **Electronic Toll Collection (ETC)—**The California State Legislature passed a law requiring standardization of the technologies for electronic toll collection, and Caltrans and its regional partners have implemented this technology on toll bridges and toll roads throughout California. ETC enables tolls to be collected without requiring the driver to wait in line to pay a toll collector, reducing the exhaust emissions created by idling vehicles.
- **Traffic Signal Synchronization—**Caltrans is working with the City of Los Angeles' Department of Transportation to coordinate and synchronize traffic signals on city streets with those on adjacent State highway routes. This effort will result in a substantial reduction in traffic delay for users of both roadways.
- **Light Emitting Diode (LED) Traffic Signals—**Caltrans was one of the first public agencies to adopt LED technology for traffic signal lights, instead of the traditional incandescent light fixtures. This change results in a considerable reduction in electric power usage, in addition to the longer life of LED technology and their ability to operate with battery-backup during power outages.
- **Bus Forward Collision Warning Systems—**Caltrans worked with the San Mateo Transit District to develop and implement a system to warn bus drivers of possible dangers ahead in time for them to avoid a crash. This technology is now available to all transit operators as an option when they purchase a new transit bus.
- **Bus Rapid Transit—**This project developed methods for operating buses on priority right-of-way to make bus transit perform like rubber-tired light-rail systems, but with the flexibility to operate on existing roadways. Some of the technologies used include bus precision docking, automated lane-guidance, and adaptive transit signal priority.
- **Efficient Deployment of Advanced Public Transportation Systems (EDAPTS)—**Caltrans worked with a small rural transit district in San Luis Obispo to develop technologies that reduce life cycle costs, promote easy system expansion, and contain adjustable levels of complexity and function. EDAPTS uses a modular approach characterized by common connections, standard communications interfaces, and off-the-shelf hardware coupled with open-source software. EDAPTS will be shared with other similar transit agencies to improve their operations.

- **Shakecast—**After an earthquake, this software decision support tool uses Google Earth maps and data available from multiple sources to estimate and prioritize the likelihood of damage to transportation infrastructure in the vicinity of the earthquake. The tool enables Caltrans to send its inspection crews to check out the structures most likely to have been damaged first, so that they can be re-opened as quickly as possible.
- **National Automated Highway Systems Consortium—**Caltrans was a core member of this consortium that was tasked with developing and demonstrating automated highways, where cars would travel under the control (steering, throttle, and brakes) of computers embedded in the car, instead of being operated by a driver. The objective of the project was to improve safety, since human drivers cause a large percentage of vehicle crashes, and to increase mobility, since more vehicles can be safely packed onto the existing roadway if humans are not driving them. Despite a successful demonstration in San Diego in 1997, the USDOT terminated funding for the project due to changing priorities.

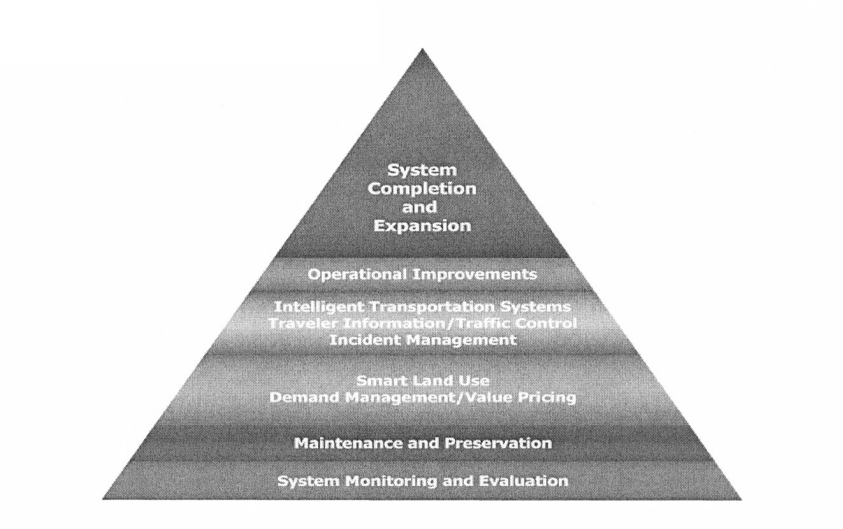
There are many ways to disseminate the results from a technology demonstration project. At a minimum, the sponsors of these projects require that a final report is prepared, delivered, and circulated to other states. In many cases, however, Caltrans does much more to spread the word on successful projects. All of our research reports are available on our web site, which also includes contact information for key staff that have additional knowledge about the project. They are also accessible in the TRB Transportation Research Information System. We have also conducted video teleconferences on select projects using the FHWA's facilities to reach out to our colleagues in other states. We are currently experimenting with Webinars as an additional mechanism for sharing the results of our work. Caltrans has used their video conference facilities to host the "research connection" where researchers provide their research findings directly to Caltrans practitioners. UCTC and PATH conduct an annual conference to share research results with Caltrans and local government agencies. Finally, much of our research is conducted in partnership with university research centers, and we encourage the academic researchers to write and publish papers documenting their work for industry-related events, such as TRB's Annual Meeting.

3) What are your priorities for research and development of new technologies? Is the research community doing an adequate job of responding to the short and long-term needs identified by the user community?

Caltrans ties its research to the Department's Strategic Goals through the Strategic Research Plan. The Strategic Goals are:

- **Safety—**Provide the safest transportation system in the Nation for users and workers.
- **Mobility—**Maximize transportation system performance and accessibility.
- **Delivery—**Efficiently deliver quality transportation projects and services.
- **Stewardship—**Preserve and enhance California's resources and assets.
- **Service—**Promote quality service through an excellent workforce.

The research priorities are also tied to the Strategic Growth Plan (SGP) unveiled by Governor Schwarzenegger in January 2006. Central to this plan was a proposed 10-year investment of $222 billion into the state's infrastructure including $107 billion in transportation investment. Caltrans developed a "Strategic Growth Plan Pyramid" as a dynamic illustration of the transportation elements of the State SGP:



As part of the Strategic Research Plan, a list of strategic research questions was developed to guide prioritization and selection of transportation research projects and ensure that all research projects supported by Caltrans are in alignment with Caltrans' Mission, Goals, and Objectives.

1. **Data—**How can we improve/enhance data collection and interpretation across modes?
2. **Travel Demand Management (Real-Time)—**What are the most effective real-time strategies to influence travel demand?
3. **Travel Demand Management (System Elements)—**What transportation system elements and land use options are most effective in reducing travel demand by enhancing choices?
4. **Integrated Corridor Management—**How can we optimize movement through a corridor?
5. **Goods Movement—**How can we improve goods movement throughout the State to generate jobs, increase mobility and relieve traffic congestion, improve air quality and protect public health, enhance public and port safety and improve California's quality of life?
6. **Design/Construction—**What design features and construction standards can be utilized to improve highway safety?
7. **Proactive Safety—**What can Caltrans do to mitigate collisions?
8. **Climate Change—**How can Strategic Growth Planning be advanced through addressing climate change adaptations and mitigations?
9. **Transportation Infrastructure** (e.g., Pavement, Structures, Maintenance Stations, Office Buildings, and others not listed)—How can we optimize the performance of our transportation infrastructure?

Research roadmaps were developed to identify all research projects and activities needed over time and their expected research outcomes. Research roadmaps facilitate programming research activities and provide guidance to partnering with other organizations with common research needs.

A Research and Deployment Steering Committee (RDSC) comprised of Deputy Directors and District Directors sets the Department-wide research priorities. The RDSC approves all research proposals and projects included in the program. Research projects are selected and programmed annually, using an integrated RFP (Request For Proposals) process. A short turn-around (quarterly) process responds to projects that require approval outside the annual cycle.

Caltrans research project selection process emphasizes customer participation throughout the research process and customer ownership of the research products. In addition to the RDSC, research committees were established in various levels to get the customers involved in the research selection, management, and deployment process.

Caltrans has established excellent working partnerships with the research community. In keeping with its Strategic Plan, Caltrans works with its research partners to create deployable research products. This applied-research approach results in a safer, more efficient and better-built transportation system that serves the short- and long-term needs of the traveling public. Four ways that Caltrans partners with the research community are:

- The Research and Technology Advisory Panel Executive Committee,
- University-Contracted Research,
- The University Transportation Centers (UTCs), and
- Educational opportunities.

The Research and Technology Advisory Panel Executive Committee (RTAP) is an external academic advisory committee created by Caltrans, in cooperation with leadership at the California Business, Transportation and Housing Agency. This committee is comprised of influential members of the academic research community and key State decision-makers. The RTAP advises Caltrans on critical long-term transportation research needs and helps to identify and evaluate critical long-term trends and research needs the department might otherwise overlook.

Caltrans contracts with universities for the bulk of its research. Much of this research is conducted through partnerships with university-based research institutes. These institutes include the following:

- Advanced Highway Maintenance and Construction Technology (AHMCT)—This partnership with University of California, Davis, develops work zone concept vehicles and equipment for Caltrans. So far, 16 concept vehicles and 18 pieces of equipment or software have been developed.
- California Partners for Advanced Transit and Highways (PATH)—This partnership with University of California, Berkeley, emphasizes research in new technologies that offer potentially large improvements in traffic operations, transportation safety, transportation policy, and transit operations.
- California Center for Innovative Transportation (CCIT)—As part of the Institute of Transportation Studies at UC–Berkeley, this organization's goal is to "accelerate the implementation of research results and the deployment of technical solutions by practitioners to enable a safer, cleaner and more efficient surface transportation system."
- Partnered Pavement Research Center—The key objectives of this research group are to optimize pavement performance, lower life cycle cost, increase service life, and increase highway safety through smoother pavement and more efficient maintenance and construction.
- Western Transportation Institute (WTI)—Established by the Montana and California Departments of Transportation in cooperation with Montana State University–Bozeman, this UTC focuses on "real transportation challenges facing rural America."

Caltrans maintains a close relationship with California's federally funded University Transportation Centers, as well as those from other states. The five California UTCs are:

- The University of California Transportation Center at UC–Berkeley,
- The Mineta Transportation Institute (MTI) at California State University, San Jose,
- The METRANS University Transportation Center at the University of Southern California,
- The Sustainable Transportation Center at the University of California, Davis, and
- The Leonard University Transportation Center at California State University, San Bernardino.

Again, this partnership ensures that the research we support provides products that are more practical than theoretical.

Last but not least, Caltrans supports educational opportunities for graduate students to develop advanced skills that focus on the most significant "real-world"

transportation issues and problems. By partnering with the UTCs and other university researcher programs, Caltrans recognizes the long-term benefits of supporting high quality education and graduate training for transportation professionals and future transportation researchers. Garrett Morgan competition is held annually through MTI to encourage young middle school students to pursue science and engineering degrees.

In all of the above examples, Caltrans strives to nurture a dynamic ongoing relationship with the transportation research community to be a catalyst for applied transportation solutions. This helps to ensure that its strategic research program is continually responsive to the changing transportation demands of California citizens and of the Nation.

Since much of our research has common interest across the country, Caltrans is very active in research and the national level. We conduct partnered research with other states and the FHWA through the FHWA Pooled Fund Program. We have a long history of partnered research with the FHWA and FTA through the ITS Program and the Turner-Fairbank Highway Research Center. Caltrans pays special attention to research conducted the TRB, especially its cooperative research programs and the Strategic Highway Research Program (SHRP 2).

Research and development of innovative methods and technologies can contribute significantly to the sustainability of highway transportation. The second Strategic Highway Research Program, authorized by Congress in SAFETEA–LU, is addressing the sustainability of the highway transportation system from several perspectives. The "Capacity" portion of SHRP 2 is developing a new approach to transportation planning and development of highway projects. This approach, called the Collaborative Decision-Making Framework (CDMF), will more effectively integrate engineering, economic, social, and environmental considerations into highway planning and development. The research focuses both on the institutional and process aspects and on developing more robust economic inputs and scientific data regarding environmental impacts. Earlier stages of the CDMF focus on assessing the suitability of different strategies (including different transportation modes) for addressing local needs. Later stages focus on improving the environmental, social, and economic impacts of new highway capacity. Specific projects focus on greenhouse gases, ecology, conservation, smart growth, economic impacts, and highway operations.

The "Renewal" portion of SHRP 2 is focused on renewing aging infrastructure more rapidly, with less disruption to users, and producing longer-lived facilities that will require less maintenance and cause less user disruption in the future. This research is addressing an array of tactics for speeding up delivery of highway renewal projects: performing more work off site and bringing completed portions of the facilities (modular bridges or pavements) to the site for quick installation; rapid techniques for work that must be completed on-site; non-destructive testing and evaluation technologies; and improved communication and collaboration methods to reduce the delays that arise when railroads and utilities cross or abut highway rights-of-way. Specific research projects address the use of recycled materials in rapid highway renewal, development of performance specifications to promote use of these and other materials, and techniques for encouraging innovation through better allocation and mitigation of risks.

The "Reliability" portion of SHRP 2 addresses congestion caused by non-recurring events such as crashes, work zones, inclement weather, and special events. Approximately half of highway delay is due to non-recurring events; this delay leads to significant waste of fuel and contributes to poor air quality. SHRP 2 research addresses data needs and performance measures for improved travel time reliability; institutional structures and training for improving highway operations related to reliability and incident management; innovative approaches for the future; and integration of reliability factors into highway programming, planning, and design processes. This last set of projects will produce the scientific and technical material needed to modify planning models and design standards to reflect the impacts of better highway operations, specifically in terms in incident management and other ways of improving travel time reliability. The planning portion of the work will be carried out in concert with the SHRP 2 Capacity work described above.

SHRP 2 also has a significant focus on highway safety. SHRP 2 will study the interaction among driver behavior, vehicle and roadway characteristics, and environment to understand safety risk factors, identify crash surrogates, and provide the basis for improved safety countermeasures. This "naturalistic driving study" will involve instrumenting vehicles of 4,000 volunteers in several areas of the country. While primarily focused on safety, the data gathered in this study show promise for other applications. SHRP 2 will soon start a project to look at the feasibility of using these data to study driver behavior from an operational point of view to develop more efficient designs and operational strategies.

SHRP 2 research will be completed over the next few years and be ready for field demonstrations. The ultimate success of this research, in terms of improved environmental, social, and economic sustainability of highway transportation, will depend on widespread deployment. Funding to support SHRP 2 implementation activities in the next authorization will bring the promise of this research to fruition. Additional information on SHRP 2 can be found on the programs web page: *http://www.trb.org/shrp2/*.

In conclusion, Caltrans has the need for research to solve our transportation problems, the plans and the research projects to develop solutions, and the partnerships to leverage resources and expertise. We are active locally, nationally, and internationally as leaders in the pursuit of safer, more efficient, and "greener" transportation systems.

BIOGRAPHY FOR RANDELL H. IWASAKI

Randell "Randy" Iwasaki is the Chief Deputy Director of the California Department of Transportation (Caltrans).

Iwasaki manages the day-to-day operation of the Department, including an operating budget of $14 billion and almost 23,000 employees.

A licensed civil engineer, Iwasaki has been with Caltrans for almost 25 years serving in a number of high profile engineering and management positions.

From July 2004 to November 2004, Iwasaki was appointed as the Department's Interim Director where he was responsible for California's State transportation system, including more than 50,000 lane miles of State highways stretching from Mexico to Oregon and from the Pacific Ocean to Nevada and Arizona.

During his Caltrans career, Iwasaki has spearheaded a number of transportation engineering innovations ill California including the use of old tires in rubberized asphalt, the installation of LED red lights saving the State taxpayers more than $2 million a year in power costs, and conversion of the Caltrans equipment fleet to clean burning fuels.

Iwasaki also serves on a number of national transportation panels. The panels include co-chairing an effort to encourage development and application of quiet pavement technologies to reduce highway noise in the United States. He is also the Technology Coordinating Committee Chair for the renewal portion of the Strategic Highway Research Program and most recently appointed the Chairman of ITS America.

Iwasaki earned his Bachelor's degree in Engineering from California Polytechnic State University, San Luis Obispo, and a Master's in Engineering from California State University, Fresno.

Mr. WILSON. Thank you, Mr. Iwasaki.

The Chair now recognizes Dr. Bertini.

STATEMENT OF DR. ROBERT L. BERTINI, P.E., DIRECTOR, OREGON TRANSPORTATION RESEARCH AND EDUCATION CONSORTIUM (OTREC); ASSOCIATE PROFESSOR, PORTLAND STATE UNIVERSITY

Dr. BERTINI. Thank you very much, Representative Wilson. Good morning, Chairman Wu and Members of the Subcommittee. Thank you for this opportunity.

Approximately two-thirds of our ongoing research at OTREC addresses energy efficiency and sustainability by aiming to improve the operation of the multi-modal transportation system. Increasing efficiency means improving safety, reducing congestion and encouraging more energy-efficient travel. When the total amount of travel time or number of trips is reduced, there is always an accompanying benefit in reduced fuel consumption, energy use, emissions and other externalities such as noise, accident exposure and contribution to urban heat islands. Public transit also benefits by reduced travel times and increased reliability. Projects from the Intelligent Transportation Systems, or ITS, toolbox include new pricing and tolling strategies, integrated corridor management, inci-

dent management, ramp metering, measuring arterial performance and improved traffic signal coordination using adaptive systems. Also at OTREC, a joint project with the University of Minnesota is examining how drivers value travel time reliability, which is important for implementing advanced traveler information systems.

How do we determine the potential environmental impact of a given technology? Typically, an evaluation will include standard performance metrics such as travel time and reliability, emissions and noise, number of trips, mode choice, and fuel and energy consumption. We use national resources such as the U.S. DOT's ITS benefits database and the Intelligent Transportation Systems Deployment Analysis System, or ITAS. For a successful evaluation, there are several critical ingredients based on my experience: Strong partnerships with transportation agencies and industry, careful identification of the problem to be addressed by the technology, a freely available data source, preferably as part of the technology deployment itself, the ability to measure performance both before and after deployment, early involvement by the evaluator, use of a test bed and technology transfer before and after and during the evaluation.

We still have many research needs in order to improve the energy efficiency and sustainability of the transportation system. Our focus at OTREC is shifting toward efficient and sustainable operation of the transportation system, which requires new financing systems with energy efficiency and sustainability goals——

Mr. WILSON. Dr. Bertini.

Dr. BERTINI. Yes?

Mr. WILSON. Sorry to interrupt you but we are going to have to suspend the hearing for just a minute. We have votes to do and I have got two minutes to get over there. Mr. Wu should be back in just a few minutes. I apologize. I apologize to everybody but we need to vote. Excuse me.

[Recess.]

Chairman WU. It is somewhat interesting and ironic that in the midst of discussing time, motion and traffic management, we are doing that sort of on a different scale, a small, minor scale such as we deal with here. This is not quite the equivalent of a bus going sideways on a narrow transportation corridor but let us just say that this is not uncommon but just a change in traffic flow to which we are adjusting.

Dr. Bertini, I understand—we made a valiant attempt to keep the flow going and choreograph something up here on the dais. My understanding is that there may be some further unexpected changes or not-planned-for changes as we go. With the cooperation of the Minority Members, my understanding is that whether Minority Members are present or not, that we are good to go with further testimony and probably with some of the questions, and we will just see what happens on the House Floor as we proceed. My apologies to the witnesses and the attendees. This is the process of checks and balances that protects our liberties. An efficient government would more effectively take away your liberties, our liberties, so it is friction that allows us to travel, isn't it? With that, Dr. Bertini, let us reset the clock a little bit and be more generous with your time. Please proceed.

Dr. BERTINI. Thank you very much, Chairman Wu. I was beginning to talk about our future research needs and I had mentioned the need for a new financing system with energy efficiency and sustainability goals. Mr. Iwasaki talked about how we respond well to very specific goals. I also believe we need to pursue full and aggressive implementation of ITS-based congestion management strategies including ramp metering, speed harmonization and traveler information, in addition, a robust, high-quality and secure data collection infrastructure, ideally built upon Oregon's open data sharing philosophy and including a mix of public and private sources. Better management of arterials for all modes requires modern traffic signal systems, communications and data collection, accurate, timely and customized traveler information. A clearinghouse for obtaining freight data will be needed for managing freight transport. Green performance measures that can be generated and compared across different geographic areas and across all modes, standard traveler information graphics to replace text-based dynamic message signs, solving legal and institutional issues for automated enforcement, and serious exploration of liability issues following the lead of the European Union and Japan related to technology deployment.

Now, there are many challenges impeding the use of innovative technologies in transportation. Some examples include the incomplete shift to an operations environment in transportation agencies, finance and funding, human resources in a multidisciplinary world, legacy systems and system integration, communications infrastructure, data quality, reliability and availability, the need for collaboration and the need for objective and continuing evaluation.

There are many actions that can be taken by Federal, State and local governments in order to break down barriers to the application of innovative technologies. Several examples include encouragement of regional collaboration across modes and jurisdictional boundaries, include the private sector and academia, encourage public-private partnerships for data sharing and communications, funding and incentives for green operations, reward data sharing, continuing education and mentorship from transportation professionals, as I mentioned earlier, green performance measurement and evaluation, and expansion of the rural infrastructure.

Now, regarding technology transfer, industry and academia play important roles in the implementation of technology solutions, and through collaboration such as with the UTC program under RITA's leadership, universities can work with transportation agencies and industry to provide unbiased, rigorous evaluations that complete the feedback loop in the project development cycle. In the ITS field, academia can play an important role in the collection, storage and maintenance of data archives.

Now, OTREC has been in operation for about 18 months and our technology transfer efforts have been successful so far and we hope that will continue. In order to accomplish that, we have about 30 external public and private matching partners who have a vested interest in the success of the research that we are pursuing. External partners serve on our advisory board and assist with the peer review of our projects. We believe that these efforts will help get the results into the hands of those who can implement them in the

transportation field. In addition, our educational programs are preparing future transportation professionals and providing opportunities for working professionals to seek additional education and training. Our website, publications, videos, podcasts that are available through iTunes, by the way, our online seminars, short courses and conferences. We even have a Facebook page for those of you younger generation. They all contribute towards the important technology transfer.

Our theme of healthy communities, integration of land use and transportation and advanced technology is guiding us along with our agency and industry partners to develop research and education programs to solve transportation problems and strengthen the transportation workforce. Our research is being developed through a collaborative process and the important component of peer review.

Thank you for this opportunity and I look forward to working with you to make a more sustainable and intelligent future.

[The prepared statement of Dr. Bertini follows:]

PREPARED STATEMENT OF ROBERT L. BERTINI

Good morning Chairman Wu, Vice Chairman Mitchell, Ranking Member Gingrey and Members of the Subcommittee. I would like to begin by thanking you for this opportunity to share our views and perspectives on our ongoing research and development activities related to reducing life cycle energy consumption and promoting sustainability for surface transportation infrastructure. On behalf of my colleagues in academia, government and industry, we appreciate this chance to address the technical, regulatory, social and financial challenges to implementing new measures and integrating new technologies into existing transportation networks.

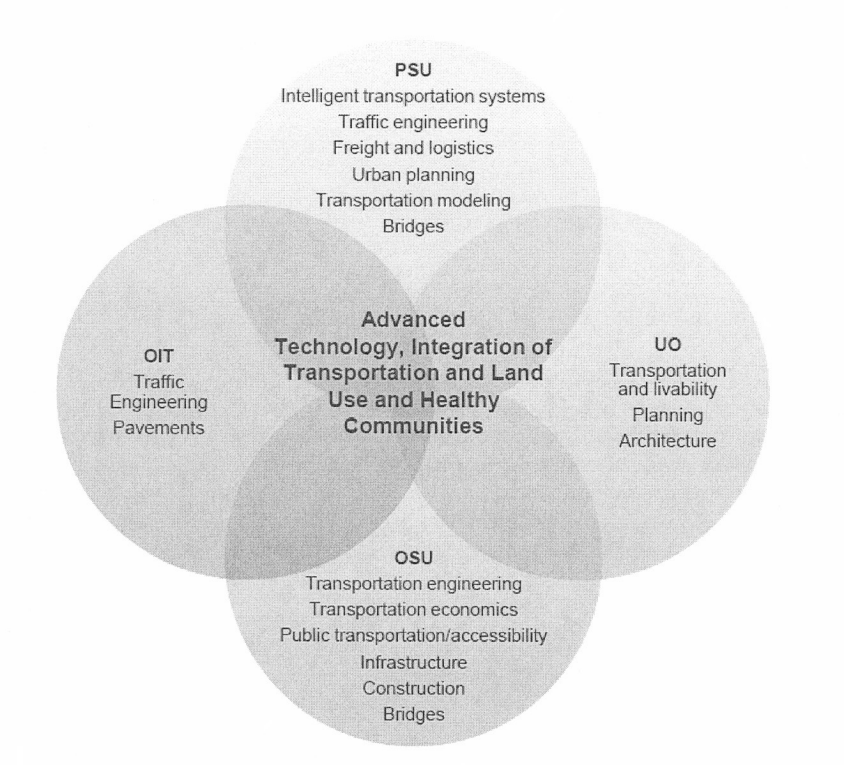
My name is Robert Bertini and I am the Director of the Oregon Transportation Research and Education Consortium (OTREC) and an Associate Professor of Civil and Environmental Engineering and Urban Studies and Planning at Portland State University, in Portland, Oregon.

1. OTREC Background

OTREC is dedicated to stimulating and conducting collaborative multi-disciplinary research on multi-modal surface transportation issues, educating a diverse array of current practitioners and future leaders in the transportation field, and encouraging implementation of relevant research results. OTREC's theme is Advanced Technology, Integration of Land Use and Transportation, and Healthy Communities. OTREC is a National University Transportation Center created by Congress in 2005 and is a partnership between Portland State University, the University of Oregon, Oregon State University, and the Oregon Institute of Technology. With a grant from the U.S. Department of Transportation, OTREC sponsors research, education and technology transfer projects at our partner universities. OTREC programs relate to the OTREC theme and support national transportation initiatives and needs. Through collaboration and partnerships with transportation agencies, industry, and other universities in the Northwest, OTREC aims to address the transportation needs of Oregon, the Northwest, and the Nation. The OTREC theme is focused on contributing to USDOT strategic objectives including: safety, mobility, global connectivity, environmental stewardship, security and congestion.

1.1 OTREC Research

OTREC uses a rigorous peer review process to select the best research projects. Since December 2006, OTREC has received nearly 200 proposals and has funded 45 research projects, involving 45 faculty members and 12 laboratories and research groups. All projects include external public and private matching partners with a total of 22 different entities involved; half of the projects include the Oregon Department of Transportation as a partner. OTREC is multidisciplinary, with 12 different academic disciplines currently participating in our projects. The figure below illustrates how the many disciplines at our four campuses are interrelated around our theme:



The peer review process has included 380 unique reviewers for more than 800 reviews. We estimate that approximately 57 graduate students and 24 undergraduate students are working on OTREC-funded projects. In addition we have funded seven education projects and six technology transfer projects. Collaboration is strongly valued by OTREC, our partner universities and our many stakeholders, and has been woven through our activities as an important cornerstone:

- **Historic University Partnership:** The four partner universities—Portland State University, the University of Oregon, Oregon State University, and the Oregon Institute of Technology—signed a historic Memorandum of Understanding in March 2007. Strong communication among all parties is setting a precedent for future joint university efforts.
- **New Collaboration Among Faculty:** Faculty are encouraged throughout the proposal and project process to think of innovative collaborative approaches to research, education or technology transfer. In our first and second rounds of project awards, 13 projects involve faculty at more than one campus, and 28 have multiple investigators.
- **Strong Ties to ODOT and Transportation Community:** More than 20 external partners provide matching funds of cash or in-kind support for faculty-led projects. The Oregon Department of Transportation (ODOT) is a primary partner, jointly funding nearly half of our research projects selected to date.
- **Regional Collaboration:** OTREC is part of the Region X Transportation Consortium, made up of UTCs in Oregon, Washington, Idaho, and Alaska, as well as the four State DOTs, with input and participation by representatives of the USDOT. The Consortium meets twice a year, supports an annual student conference, and is exploring pooled fund research and joint educational initiatives.

- **National Connections:** OTREC strives to meet national transportation research and education needs, and is active with the American Association of State Highway and Transportation Officials (AASHTO), the Transportation Research Board (TRB), the Council of University Transportation Centers (CUTC) and other national activities.

1.2 OTREC Educational Activities

All OTREC activities have student success as a primary goal. Whether it's offering students hands-on research experience with hot topic transportation issues, opportunities to present their research at conferences, including the TRB Annual Meeting, scholarships and fellowships to help them reach their degree goals, or providing continuing education opportunities to practicing professionals, students are central to our mission.

Partner universities currently offer 16 undergraduate and graduate programs with transportation specializations, with more than 100 students enrolled. During this past year 36 students graduated with transportation related graduate degrees and are now working in the transportation field. OTREC also supports transportation student groups at the partner campuses. This support is allowing undergraduate and graduate students to travel to conferences, host guest speakers, coordinate events and field trips, and communicate transportation issues and opportunities to students across the campuses. OTREC also co-hosts an annual Transportation Student Conference with the Region X Transportation Consortium. Students are able to present their research and exchange ideas with their peers in an environment that does not exist in the classroom or at other conferences. The conference includes both student presentations and poster sessions to showcase the great student-led transportation research being done in the Northwest.

1.3 OTREC Technology Transfer

Sharing of knowledge and dissemination of program results are key components of all OTREC programs. All research projects have a technology transfer plan, so that research results are available to potential users in a form that can be directly implemented, utilized, or otherwise applied. OTREC is working towards an expanded and coordinated statewide program of transportation outreach involving accessible communication of research results and continuing education and training courses for transportation professionals in a variety of formats. A study by OTREC PIs and students is underway to identify the current transportation training opportunities in the region, and to determine how OTREC can best fill training needs for transportation professionals. OTREC is offering a series of short courses and partnering with other transportation organizations to offer more training and professional development opportunities in Oregon.

The OTREC website (*www.otrec.us*) serves as a primary communication tool, and includes up-to-date news, newsletters, annual reports, recorded seminars, project information, and professional development opportunities. Final research reports with search options will be available. Website capabilities will expand to fill technology transfer needs as OTREC programs evolve. OTREC regularly sponsors guest speakers as part of our Visiting Scholar Program. At PSU, the Center for Transportation Studies (CTS) offers weekly transportation seminars that are broadcast live on the web, and archived in streaming video and podcast. More than 200 seminars have been presented, with more than 145 available as online streaming video, and more than 30 available as Podcasts (.mp3) via iTunes. In addition to registered students, over 500 professionals and guests also attended the seminars. OTREC sponsored several visiting scholars, see: *http://www.cts.pdx.edu/seminars.htm.*

1.4 Impact of Intelligent Transportation Systems on Sustainability

A broad range of diverse technologies, known collectively as Intelligent Transportation Systems (ITS), holds the answer to many of our society's transportation problems. ITS are comprised of existing and new technologies, including information processing, sensors, communications, control, and electronics. Combining these technologies in innovative ways and integrating them into our multi-modal transportation system will save lives, time, and resources—including benefits such as reducing energy, fuel, emissions, accident exposure, noise and more. Delay reductions almost always mean increased productivity and quality of life since people's value of time is significant, and more so for business-related travel where drivers are being paid an hourly wage. Safety improvements also have direct benefits (fewer crashes mean fewer fatalities, injuries, health care costs and property damage) and indirect benefits since many crashes cause congestion.

Transportation is the backbone of our society—the movement of people and goods provides the foundation of our quality of life and economic prosperity. Fulfilling the need for a transportation system that is both economically sound and environmentally efficient requires a new way of looking at—and solving—our transportation problems. The strategy of adding more and more highway capacity neither solves our transportation problems, nor meets the broad national vision of an efficient, integrated transportation system. We focus on the integration and improvement of all modes—highway, transit, bicycle, pedestrian and freight. Traffic crashes and congestion take heavy tolls in lives, lost productivity, and wasted energy. ITS enables people and goods to move more safely and efficiently through a state-of-the-art, intermodal transportation system.

2. Research Related to Energy Efficiency and Sustainability

OTREC is just one component of a larger program in Oregon and in the Oregon University System to address sustainability. For example, the Oregon Legislature has created the Institute for Natural Resources (INR), the Oregon Climate Change Research Institute (OCCRI), and a signature research center focusing on the Built Environment and Sustainable Technologies (BEST), and is developing a statewide Sustainability Initiative. There is also a proposal for a statewide Oregon Water Institute (OWI) to address water problems.

Given OTREC's theme, a significant proportion of our research is aimed at improving the operation of the multi-modal transportation system, which is directly tied to energy efficiency and sustainability. Other research goals include providing improved equity and options for users of the transportation system, which is the basis for a sustainable economy and high quality of life. Fortunately the efficiency objective for transportation research typically includes the reduction in congestion which translates to standard measurements of travel time, delay and number of stops. Whenever congestion is reduced (via reduced travel time or delay), this is a time-based measure typically reported in vehicle-hours or person-hours of travel (VHT or PHT). When the total travel time is reduced, there is always an accompanying benefit in reduced fuel consumption, energy use, emissions, and other externalities such as noise, accident exposure and contribution to urban heat islands.

Other research that includes travel demand management or alternative mode strategies may result in reductions in vehicle-miles or person-miles traveled (VMT or PMT). For example for a given trip, a "green" traveler information system that provides information regarding alternative modes such as bus or rail, might encourage a user to forgo a trip by personal vehicle and choose transit instead. This reduction in VMT will also have a congestion reduction effect, with accompanying benefits such as reduced fuel consumption, energy use, emissions, and other externalities such as noise, accident exposure and contribution to urban heat islands.

Some research related to incident management, for example, has a large multiplier effect-when the duration of an incident is reduced by 50 percent, the resulting delay is reduced by 75 percent. It is important in transportation research to find these kinds of opportunity areas where a low investment can have extremely high benefits.

In the context of OTREC's mission as a University Transportation Center, we have identified more than 40 planned and ongoing projects that relate to energy efficiency and sustainability.

2.1 Ongoing and Planned OTREC Research

Consistent with our mission and under the guidance of our strategic plan, approximately two-thirds of OTREC's ongoing and planned research projects address energy efficiency and sustainability. As described below, we have grouped these projects into two categories: Intelligent Transportation Systems and Sustainability; and other Sustainability-Related projects. Keeping in mind that many of these projects are currently in their initial stages, we look forward to reporting specific project outcomes in the coming months and years.

2.1.1 OTREC Intelligent Transportation Systems and Sustainability Research Projects

Approximately one-third of OTREC's ongoing and planned research is related to Intelligent Transportation Systems (ITS) and Sustainability. Most of these project aim to improve the efficiency of the transportation system in support of national, State, regional and local transportation priorities. By focusing on improving the operation of the system in a more integrated way, without massive capital expenditures, it is possible to improve the efficiency of the transportation network so that

all levels of the network and all modes work together in a more seamless way. Projects are described in detail in the following sections. The advantages of ITS and sustainability-related projects include strategies for improving the efficiency of the multi-modal transportation system, leading to improved safety and reduced travel time, fuel consumption, energy use, emissions, and other externalities such as noise, accident exposure and contribution to urban heat islands.

Several projects focus on sustainable transportation pricing and tolling strategies, recognizing that new technologies and publicly acceptable financing systems are needed for a sustainable future—these could include specific "green" strategies. A number of OTREC projects deal with integrated corridor management strategies, via such strategies from the ITS toolbox such as incident management, ramp metering, measuring and improving arterial performance and improved traffic signal coordination on arterials via adaptive systems. These strategies focus on managing a multi-modal corridor more proactively, taking advantage of existing capacity. Recognizing the Nation's congestion reduction goals, several projects focus specifically on understanding and mitigating congestion by improving our understanding of stop and go traffic dynamics. Given the critical issue of travel time reliability, an innovative OTREC project will examine issues related to how drivers (and shippers) value travel time reliability. This work will be important for future implementations of advanced traveler information systems.

The issue of traveler information is also important as a sustainable strategy. By providing users with reliable information about travel times via different modes, routes or times of day, users can make better decisions which can result in an overall improvement in efficiency. OTREC has several projects underway in this area. As a fundamental foundation for research and evaluation, a robust, accessible, and inter-operable data infrastructure is critical. OTREC has several projects underway that focus on this issue, and strive to use the data infrastructure as a basis for generating performance metrics. It is possible to design programs and projects that by their very nature generate data that can later be used for evaluation, but early attention must be paid to this issue before projects are specified and implemented.

A sustainable transportation system is one that can be resilient in the face of emergencies—thus several OTREC projects focus on understanding the impact of climate change and potential flooding on the transportation infrastructure and on the effects of winter weather. Finally, recognizing the critical role that freight transportation plays in our society, several OTREC projects aim specifically at the freight sector in working to make the transportation system more efficient, to leverage data collected as part of a statewide pre-clearance system, lessen the energy needs for freight transport and to improve reliability.

Sustainable Transportation Pricing and Tolling Strategies

- *2007–03: Socio-economic Effect of Vehicle Mileage Fees, Phase 1 and 2008–81, Phase 2:* This project considers the socio-economic impacts of the new highway user fee structure made possible by advanced technology. The Oregon Road User Fee Task Force has proposed a vehicle mile tax to replace the gasoline tax. The purpose of this study is to develop a model which provides an analytical framework from which to quantify the impact of changing to the proposed vehicle-mile tax. The Oregon Department of Transportation (ODOT) will use the results from this study to help formulate the specific form of the vehicle-mile tax (flat tax, a graduated tax, a higher tax for less fuel efficient vehicles, a differential tax for urban/rural areas, etc.). ODOT needs quantitative information on the socio-economic impact of such a tax, to use in public relations. A huge factor in determining the ultimate adoption of such a tax structure will be the public acceptance of the change and, in turn, they need to have full information on what it will do. There are also implications for environmental stewardship as a vehicle-mile tax has also been suggested as an emissions tax. Finally, once the technology is in place for a vehicle-mile tax, it becomes possible to implement a vehicle-mile tax that may vary by time of day and location, providing an efficient congestion pricing tool.
- *2008–116: Understanding Driver Behavioral Changes Associated with Road User Fees:* The Oregon Department of Transportation (ODOT) conducted a test of an innovative technology to replace fuel taxes with mileage fees. In the test, some vehicles were charged a flat fee per mile and others were charged differential fees that were higher for travel in the Portland metropolitan area during weekday peak hours and lower for other travel. The objective of this project is to extend the analysis of changes in behavior by subjects in the ODOT Road User Fee Pilot Project, and to draw on other sources, to compare the behavioral changes observed in this experiment with those found in other

contexts. There is potential to gain further information on characteristics that caused or prevented changes in participants' driving patterns. A variety of statistical analyses will be conducted to evaluate both the extent of response to a vehicle mileage fee and the interaction with both demographic and attitudinal characteristics of the participants. A GIS analysis will be used to link household location with better measures of transit service. Results would include a better understanding of how pricing interacts with other factors in affecting driving patterns and in particular in affecting driving during peak periods. It would also provide a better understanding of the revenue potential from such charges.

Integrated Corridor Management

- *2007–79: Identify and Address Institutional Barriers Delaying Incident Clearance:* Effective incident management can substantially reduce congestion while expediting incident clearance. In Oregon, the Oregon Department of Transportation has a comprehensive incident management program in place. Due to cooperative efforts among ODOT, Oregon State Police, local police, and emergency providers most incidents are cleared rapidly and traffic operations resume normally. However, a major traffic-related incident can take considerable time to clear and the closure of a major highway during peak travel periods can cause major problems. The economic impact can be considerable when road closures and delays occur in a metropolitan area such as Portland. It is not known to what extent institutional constraints may account for inefficiencies that result in extended time elapsing from incident detection through final site clearance. The research proposed in this study will address several key objectives. Using a variety of data resources, the research team will examine recent traffic incidents in the Portland area to determine the extent to which the incident and associated traffic obstructions impacted systemic traffic operations. The research team will also develop an enhanced implementation plan for addressing institutional barriers that may affect the rapid clearance of incidents occurring on Oregon highways. Finally, this research effort will ultimately help identify specific legislative initiatives or administrative procedures that should be implemented to minimize delayed incident clearance and estimate the benefit of the recommended changes.
- *2008–190: Using Archived ITS Data to Measure the Operational Benefits of a System-wide Adaptive Ramp Metering System:* A system-wide adaptive ramp metering (SWARM) system is being implemented in the Portland metropolitan area. While SWARM is designed to be more effective than the current ramp metering strategy, the true benefits of the new system have not yet been quantified. Using an existing data stream, there is a unique opportunity to conduct a true before and after evaluation of the operational benefits of the new SWARM system. The project will also develop an interactive simulation laboratory for evaluating and improving the new SWARM ramp metering system in the Portland metropolitan area. The simulation-based evaluation will help confirm field experiment results, and complement the field experiment by testing alternative solutions to any operational issues identified during the field experiment. This project will also test different control parameters in the SWARM algorithm, and recommend strategies for improving the algorithm.
- *Monitoring Arterial Performance Using Data From Automatic Vehicle Location Devices and Inductive Loop Detectors:* The Portland region has good sensor coverage on freeways, but the arterial system is limited to snapshots of measurements from traffic studies using floating car studies and temporary traffic counts. There is a need to implement automated systems that can provide arterial travel time and performance measures for management of freight and passenger travel. This project will include a review of technological solutions for automating traffic measurement on arterials. Priority surface arterial locations for measurement will be identified, considering geographical balance and specific bottleneck locations. The task will include a case study of arterial operations on Barbur Blvd. in the City of Portland. Working with the City of Portland, we will review options for using existing system detectors and CCTV cameras to gauge arterial performance. The research will validate the delay measurement and recommend locations for such systems on Barbur Blvd. The City will then install two or three systems on Barbur, which will then be evaluated. The approach delay measurement system offers promise for providing an automated way to determine approach delay at a signalized intersection. This task will further validate that system on other intersection approaches. The results will also provide the City of

Portland with methods to provide meaningful performance measures for Barbur Blvd. and beyond.

- *Field-Based Evaluation of Corridor Performance After Deployment of an Adaptive Signal Control System in Gresham, Oregon:* The majority of traffic signal control systems in the United States use, as their basis for coordination, static timing plans (also called timing patterns) that have been generated on the basis of typical average traffic volumes. In 2005, the City of Gresham, Oregon selected and deployed the Sydney Coordinated Adaptive Traffic System (SCATS) on Burnside Road, a major five-lane arterial carrying 38,000 vehicles per day, between Eastman Parkway and Powell Valley Road. A field evaluation was conducted to compare optimized time-of-day coordination and the SCATS system on the basis of changes in travel time, delay, and stops along this road segment. Probe vehicle data were collected on three routes during peak and non-peak hours in two travel directions. Side street delay was also studied for three intersections in the corridor. Overall, it can be concluded that the implementation of the SCATS adaptive signal control system has improved the Burnside corridor in terms of travel time, stopped delay and number of stops. Travel times on the primary analysis route decreased two to 15 percent for weekdays and weekends with the exception of the morning weekday westbound direction which increased 10 percent (likely because the time-of-day plan had heavily favored this direction). Although the secondary evaluation routes did not see as consistent improvements, the majority of changes were still positive. Analysis of side street delay was less conclusive, although the majority of time periods and directions did see improvement.

Congestion Management

- *2007–37: Characteristics of Transitions in Freeway Traffic:* This project seeks to understand the characteristics of transitions as freeway traffic changes from one state to another. Transitions occur gradually over time and space, and their temporal and spatial features are relatively unknown. The dynamics of the transition zone will be explored by analyzing the relationship between the duration of transition (at a fixed location) and various traffic and location variables (e.g., distance from the bottleneck, change in flow before and after a regime change, etc.). Researchers are using data from inductive loop detectors for the analyses of transition zones near the tails of queues. These detector data are suitable for analyzing this type of transition since the propagation of a transition zone can be observed over a long distance. The length of transition can be estimated based on the duration observed at a detector location. For the other two types of transitions, data sets from the Next Generation Simulation will be utilized. These data sets provide individual vehicle trajectories whose resolution is suitable for analyzing these types of transitions. The length of a transition zone will be measured directly from the vehicle trajectories. This research will provide a valuable insight on how congested traffic behaves under various transitions that frequently occur on urban freeways. Hence, the results will expand the current knowledge on traffic congestion and serve as a building block for future traffic modeling and management practice.
- *2008–130: Value of Reliability, Phase 1 and 2009-248: Phase 2:* The issue of travel time reliability is becoming more critical for the movement of people and freight. In order to examine issues related to the value of travel time reliability, we plan to test drivers' preferences for alternate commuter routes in a real world setting. The research participants will drive on three different routes in two cities: (1) primarily freeway, (2) primarily arterial roads, and (3) other streets. Freeways have a possible trade-off between high speeds and congestion during rush hour. Arterials typically have a series of traffic signals that may be timed to favor through-traffic. Other routes might have some traffic signals and some stop signs, but they likely have less traffic. By comparing driver perceptions of the alternate commuter routes, it will be possible to determine the weights associated with the different components of travel time. Driver preferences may also be based on qualitative factors such as the attractiveness of the route. Thus one objective of the proposed project is to measure and then model the route preferences of drivers who have experienced real-world alternatives to their regular commute to and from work. Preference data will be obtained after the participants have completed their morning and evening commutes on three alternate routes (customized for each driver). The added realism of the novel data collection method proposed

for this project should enable the value of travel time reliability to be used in route preference models. In turn it will be possible to more accurately predict traffic patterns and produce solutions more likely to ameliorate traffic congestion. An additional objective of the proposed research is to make information about local road networks more available to drivers. This will allow for the better use of existing resources and road capacity for normal operations including when drivers are commuting to and from work.

- *2008–108: Empirical Observation of the Impact of Traffic Oscillations on Freeway Safety:* Traffic oscillations (also known as stop-and-go driving) are a typical feature of congested traffic flow. They are known to increase fuel consumption and emissions, and decrease driving comfort. It is also speculated that larger amplitudes of oscillations (i.e., larger changes in flow or speed) increase the probability of certain crash types (e.g., rear-end crashes). However, no current study exists that irrefutably confirms or disproves this speculation. The objective of this research is to find empirical evidence to substantiate this hypothesis and to quantify the relationship between the amplitude of oscillations and probability of crash event. This proposed research will be conducted using freeway traffic and incident data. It will be supplemented by a statewide database of reported motor vehicle crashes. Various features of oscillations (e.g., amplitude, period, etc.) will be measured from traffic data collected from inductive loop detectors. Existing databases for crashes and incidents will be used to analyze incidents in correlation with oscillations. This study will consist of general analysis to identify which crash types are particularly affected by traffic oscillations and detailed analysis via econometric modeling to quantify the probability of each crash type as a function of various characteristics of oscillations and relevant factors such as freeway geometry, congestion level, and others. These analyses will be conducted for several freeway locations in order to confirm reproducibility and to examine any site-specific features.

Advanced Transportation Information Systems

- *2007–57: Assessment and Refinement of Real-Time Travel Time Algorithms for Use in Practice, Phase 1 and 2008–145: Phase 2:* The Federal Highway Administration (FHWA) has set a high priority on the use of existing dynamic message signs (DMS) to provide travel time estimates to the public. The Oregon Department of Transportation (ODOT) currently has three DMS in the Portland metropolitan area configured to display travel time information. In the near future, ODOT would like to make travel time estimates available on additional DMS, over the Internet on *tripcheck.com* and via 511. Travel time estimates are valuable to the traveling public; however, the estimates must be accurate to be useful. The FHWA indicates that 90 percent accuracy is ideal and suggests a minimum accuracy of 80 percent. Thus, in order to display travel time estimates, it is essential to understand the accuracy of the estimates. The purpose of this study is to extend prior travel time research conducted at Portland State University with additional data collection and analysis to provide statistical confidence in travel time estimates and to determine the best travel time estimation approach for ODOT. Ground truth data in the form of probe vehicle runs will be collected and travel time estimates will be evaluated using that data. Several travel time estimation algorithms will be evaluated and modifications to existing algorithms will be proposed. In addition, this project will provide analysis to help understand the reliability and performance of the algorithms under various conditions (free-flow, congestion, incidents). A methodology will be developed for determining if travel time estimates fall within an acceptable accuracy limits. At the conclusion of the project, it is desired that a methodology can be recommended that will provide accurate measures of travel time for use with DMS, the Internet and 511 applications.
- *2007–64: Improving Travel Information Products via Robust Estimation Techniques:* Traffic-monitoring systems, such as those using loop detectors, are prone to coverage gaps, arising from sensor noise, processing errors and transmission problems. Such gaps adversely affect the accuracy of Advanced Traveler Information Systems. This project will explore models based on historical data that can provide estimates to fill such gaps. We build on an initial study using both a linear model and an artificial neural network (ANN) trained on historical data to estimate values for reporting gaps. These initial models were 80 percent and 89 percent accurate, respectively, in estimating the correct speed range, and misclassifications were always between adjacent

speed ranges (in particular, the free-flow range and congested range were never confused). Going forward, we will investigate other non-linear models, such as Gaussian Mixtures, that provide further statistical metrics, in contrast to the uninterpreted weights of ANNs. Initially we will build and test estimators in off-line mode. We will select a highway segment (comprising multiple detector stations) that is representative in terms of pattern of outages. We will build models for this segment, then examine their performance on estimates for synthetic gaps (so we can compare estimates to reported values). Later, using live loop-detector data we will work towards on-line estimation over the local freeway network, which requires computing estimates in a timely manner. Our end target is improvements in end-user travel information products, such as the Portland-Metro Speed Map on ODOT's Trip Check. Our main evaluation metric will be the trade-off curve between accuracy of prediction and percentage of gaps that can be filled.

Multi-modal Archived Data User Service

- *2009–269: Exploiting a Next Generation ITS Data Warehouse for Improved System Performance and Congestion Monitoring:* The objective of this project is to build on an existing data archive platform, toward development of next generation performance measurement and congestion reduction tools. This project will also review the current paradigm described by the National ITS Architecture's Archived Data User Service (ADUS) and examine the possibility of developing a new generation ADUS, going beyond the creation of a passive storehouse of data. Given current developments in the transportation operations and management area, this project will pursue several possible ADUS extensions including: live re-serving of data, additional services (e.g., selectable imputation methods), derived sources (e.g., pre-aggregated data), coverage of a wider variety of data sources (including contextual data such as weather and events), and active monitoring of performance metrics against the historical baseline. In order to frame this research, a survey of current and potential users will be administered, seeking input regarding requirements for next-generation transportation information portals on topics including types of products and services, performance requirements (e.g., latency, availability) and desired interfaces (FTP, web services, publish/subscribe). The proposed research will develop a system and software architecture that meets those requirements, and will address such issues as how such a portal should be structured internally, what storage and processing needs exist, how extensibility and availability can be ensured and how such portals could federate on a regional scale.
- *2008–115: Application of WIM Data for Improved Modeling, Design, and Rating:* The objectives of this research are to: collect, sort, filter, and archive WIM data to permit development of long-term continuous records of high-quality WIM data and; use the WIM data archive to monitor WIM sensor health, develop loads for asphalt design, load models for bridge rating and deck design, and monitor freight movement on the highway system, specifically the volume, weight, safety, and time demands. Researchers will collect WIM data from DOT agencies (ODOT and others nationally). The data will be analyzed and filtered to handle anomalous data and archived in a universally available format for use in subsequent research activities. This collection and archiving of data will allow researchers to continue development of one of the longest continuous and highest-quality WIM data archives available in the country. In developing the archive, the research team will develop data-processing techniques to help identify data and system performance metrics. Results from these studies will be compared with those used in the national specification and improvements will be recommended.
- *2008–176: Expanding Development of the Oregon Traffic Safety Data Archive:* There is a growing recognition in the safety community that decisions are more effective if they are knowledge-based. Traffic records such as driver files, crash data, enforcement, highway traffic and geometric information, court records, and emergency medical records are the typical data needed to make effective safety-related decisions. Often these data are in various formats, maintained by distinct agencies, and require specialized knowledge to use and link together to achieve maximum use of the data. While nearly all traffic safety data in Oregon is available on request from various agencies (Oregon Department of Transportation, Oregon Justice Department, U.S. Department of Transportation, Human Services Department) there is no clearinghouse where other interested researchers, students and professionals can

easily access the data in a processed, consistent and usable form. Linking data sources on an ad-hoc basis is time consuming and inefficient. This research proposes to systematically develop a knowledge-based clearinghouse of safety-related data in Oregon. This archive, the Oregon Traffic Safety Data Archive (OrTSDA), will serve as a comprehensive source of safety data. When fully implemented, the archive will provide significant benefits to decision-makers, researchers, practitioners, and interested citizens.

Emergency Transportation Operations

- *2009–257: Future Flooding Impacts on Transportation Infrastructure and Traffic Patterns Resulting from Climate Change:* Climate change is likely to bring more frequent, heavier winter precipitation as temperature rises. Transportation infrastructure and travel patterns are vulnerable to potential changes in runoff regimes and stream geomorphology. The objectives of the project are to investigate the changes in the timing and magnitude of winter runoff under climate change scenarios; determine the lag time of streams to adjust to changes in the discharge regime; and quantify the operational and economic impacts of these changes on transportation choke-points and damage related to flooding. The following methodology will be used to conduct the proposed work. (1) hydro-climate modeling; (2) stream geomorphology survey; (3) vulnerability analysis; (4) traffic analysis. The economic impact of the disruptions on workers, freight, and businesses will be estimated. The outcomes of this research will include maps showing potentially vulnerable roads to different magnitudes of flooding, socioeconomic damage of trip disturbance resulting from road closures, and a final report.
- *Dynamic Ice Warning System Evaluation:* ODOT has recently deployed an automatic ice detection and warning system on OR 140 near the Lake of the Woods pass. The ODOT Region 4 Traffic Manager and the District 11 office would benefit from an evaluation to determine the accuracy and effectiveness of the ice detection system. The potential to integrate the existing warning system into the larger regional ITS also needs to be examined. This task will include a quantitative assessment of the fidelity of the current ice detection and warning system. The integration activities will include a literature review, an evaluation of the current hardware and software, field studies to assess accuracy of ice detection, evaluation of the local warning system, evaluation of ITS system integration, particularly with the S. Oregon VMS, and reporting to ODOT. A validated ice warning system will provide ODOT with an assessment of the reliability of the current system in order to potentially deploy additional systems integrated in the S. Oregon VMS system and beyond.

Electronic Freight Management

- *2007–14: Using Existing ITS Commercial Vehicle Operation (ITS/CVO) Data to Develop Statewide (and Bi-state) Truck Travel Time Estimates and Other Freight Measures:* The transportation of freight is an important component of the Oregon economy. While other modes are clearly important for freight transportation, trucking is the dominant mode in terms of tons and value. Currently, there is no system that estimates travel time for many major freight corridors in Oregon. However, the existing infrastructure of Oregon's Green Light program provides an opportunity to generate travel time estimates for many travel corridors in Oregon with little additional investment. The Green Light program enrolls approximately 3,330 trucking companies with 30,200 transponder-equipped trucks (which does not include carriers participating in other electronic screening programs from other states). There are 22 equipped stations in Oregon where these transponders can be read and corridor travel times predicted. These estimates would also be useful to travelers and would be an additional enhancement to Oregon's traveler information system, TripCheck. In addition, these stations also include weigh-in-motion systems which provide axle weights, spacing, and gross vehicle weight estimates uniquely matched to a transponder-equipped truck. The objective of this research is to test the feasibility of using AVI data already being collected from transponder-equipped trucks to develop travel time estimates along major Oregon highway corridors and eventually link these estimates with those produced in Washington. Further, the research will seek to integrate other sources, particularly weigh-in-motion data to capture other key freight measures. As part of the research, it would be determined whether additional transponder readers can be deployed to read information at key

points not at weigh station, particularly in the Portland area. It is anticipated that privacy concerns could be addressed appropriately.

- *2008–131: Oregon Freight Data Mart:* Increasing freight volumes are adding pressure to the Oregon transportation system. Monitoring the performance of the transportation system and freight movements is essential to guarantee the economic development of the region, the efficient allocation of resources, and the quality of life of all Oregonians. Freight data is expensive to collect and maintain. Confidentiality issues, the size of the data sets, and the complexity of freight movements are barriers that preclude the easy access and analysis of freight data. Data accessibility and integration is essential to ensure successful freight planning and consistency across regional partner agencies and planning organizations. The main objectives of this project are: a) to maintain a long-term freight database that would be available for Oregon Universities, State transportation agencies, regional planning agencies, and economic development organizations, b) to integrate freight data into the existing and successfully operating PORTAL system, and c) to monitor freight performance measures. The data will be stored on a designated server space at Portland State University and integrated into the PORTAL system which will streamline data accessibility and consistency.
- *2008–133: Freight Distribution Problems in Congested Urban Areas: Fast and Effective Solution Procedures to Time-dependent Vehicle Routing Problems:* Congestion creates a substantial variation in travel times during peak morning and evening hours. This is problematic for all vehicle routing models which rely on a constant value to represent vehicle speeds. And while the ubiquitous availability of real time traffic information allows drivers to reactively alter routes and customer service sequences to better cope with congestion, static routing models are unable to take advantage of these advances in real-time information provision in order to proactively find adequate routing solutions. In addition, changes in travel time caused by congestion cannot be accurately represented in static models. Research in time-dependent vehicle routing problem is comparatively meager and current solution methods are inadequate for practical carrier operations which need to provide fast solutions for medium to large instances. Even faster solution methods are essential to take advantage of real time information. The aim of this proposal is to develop and evaluate new methods for vehicle routing in congested urban areas. The emphasis will be placed on improving the running time of the existing methods using tailored data structures, the efficient handling of local and global variables, hybrid approaches, and parallel computing.
- *2008–134: Practical Approximations to Quantify the Impact of Time Windows and Delivery Sizes on Freight VMT in Urban Areas:* Supply chains and urban areas cannot thrive without the efficient movement of goods and accessibility to services. From a freight planning perspective, it is crucial to understand and quantify how routes and distribution decisions translate into commercial VMT. In urban areas, most of the trips take place within a multi-stop tour or trip chain. In the logistics and operations research literature, modeling efforts have focused on the design of routes but not on the estimation of distances traveled or VMT. Freight planning models cannot quantify the impact of delivery size and time windows in urban areas. There is scant research relating number of stops per tour, delivery sizes, time windows, and VMT per tour. Delivery sizes and time windows have a significant impact on the efficiency and VMT generated by freight movements in urban areas. The fundamental research questions of this proposal are: a) how to obtain practical and intuitive approximations on the length of commercial vehicle tours and VMT traveled in urban areas? and b) is it possible to estimate the impact of time windows and delivery sizes on VMTs?
- *2009–230: Exploratory Methods for Truck Re-identification in a Statewide Network Based on Axle Weight and Axle Spacing Data to Enhance Freight Metrics:* This research seeks to develop an a new method to determine flow patterns of trucks by matching archived vehicle-attribute data such as axle spacing and axle weights at multiple geographic locations. Overall, this research focuses on developing advanced methods and algorithms to anonymously identify and match commercial trucks crossing two data collection stations on roadways; and on investigating how these re-identification methods can be employed to enhance freight metrics. By capitalizing on the vehicle-attribute data from a number of AVC and/or WIM stations in a network, the proposed methods can potentially support and benefit multiple applications, such as determining travel times, quantifying travel time reliability, esti-

mating truck flow patterns (i.e., origins-destinations), estimating empty truck movements, trip length estimation, tracking movements of trucks without transponders, and pavement management. The results of this study will benefit not only Oregon but potentially all other states since truck characteristics do not vary significantly from state to state, and many states also collect axle spacing and axle weight data.

- *2009–276: Analyzing and Quantifying the Impact of Congestion on Less-Than-Truckload Industry Costs and Performance in the Portland Metropolitan Region:* The manufacturing, service, distribution, retail, and wholesale economic sector is increasingly affected by growing congestion. Unreliable and increased travel times shrink the distribution radius of existing operations and reduce the operational efficiency of drivers and vehicles. Even though there is a clear consensus regarding the negative impacts of congestion, the quantification and measurement of these impacts in distribution logistics is a difficult task due to the lack of detailed routing data. Unlike most freight and trucking congestion studies based on aggregate measures, disaggregated dispatching and actual GPS fleet route data sets will be available for study in this research. The main objectives of this research project are: (a) to understand the impact of urban congestion on commercial vehicle fleets, (b) to quantify and discriminate between the impacts of recurrent and non-recurrent congestion on fleet operations, (c) to study how adverse weather conditions compound the negative impacts of congestion, and (d) to provide congestion performance measures at a network level.
- *2009–277: Analysis of Travel Time Reliability for Freight Corridors Connecting the Pacific Northwest:* Most supply chains cannot thrive without access to an efficient and reliable freight system. The objective of this research is to evaluate travel time reliability in the main freight corridors connecting the Pacific Northwest to California, the Midwest, and Southwest. Statistical analysis of Global Positioning System (GPS) commercial vehicle travel data will be used to study travel time reliability and identify congestion chokepoints affecting corridors to/from the Pacific Northwest. GPS data will be used to determine travel time distributions along different corridors by corridor segment (connecting main cities along the corridor), time of day, and day of week. Unlike previous studies, (a) GPS data will be complemented with detector and transponder based information to improve the accuracy of the travel time estimations in urban areas and to compare measurements and (b) the impact of travel time variability by time of day will be tested. A major objective of the project is to quantify travel time reliability on I–5 and I–84 freight corridors connecting major regional origin-destinations that start, end, or run through Oregon.

2.1.2 OTREC Sustainability-Related Projects

Another one-third of OTREC's ongoing and planned research projects related more generally to sustainability. Some of the projects aim to make transportation and land use systems more efficient, while others deal with making alternative modes such as bicycling and walking more attractive. We anticipate that this research will result in measures that can be implemented that will make our communities more efficient and sustainable by encouraging a shift toward travel that requires less energy. An additional set of projects deals with freight planning issues that also aim to reduce the carbon footprint of our freight transportation sector, specifically in the food supply arena.

Land Use and Transportation Linkage

- *2007–68: Co-Evolution of Transportation and Land Use:* The interaction between land use and transportation has long been the central issue in urban and regional planning. This project examines the land use-transportation interaction from an evolutionary perspective—once a certain set of goals are determined and pursued by politicians and planners, their land supply and transportation investment decisions are to a large extent driven by their previous decisions and the supply-demand dynamics in the urban system. Different from existing integrated land use and transportation models that assume exogenous network investment decisions, the co-evolution model considers both land use growth and transportation network growth as endogenous and market-driven. The central research question is how market and policies translate into transportation facilities and land use developments on the ground. The co-evolution model achieves a novel Urban Growth Equi-

librium, which is a useful concept for planning and policy analysis. An agent-based simulation approach is employed to integrate an existing land use model and the transportation network growth model. The resulting integrated co-evolution model is demonstrated in a series of policy sensitivity tests.

- *2008–137: Dynamic Activity-Based Travel Forecasting System:* The proposed research project has as its primary goal the development of a dynamic activity-based demand model system for Metro that will be capable of meeting these objectives through explicit consideration of time of day and accumulated activity times in the propensities of individuals to construct tours. Although activity-based travel demand models have been developed or are currently under development in several cities in the U.S. and elsewhere, sensitivity to time-dependent path information seems to be lacking in these efforts. Specifically, extant models tend to treat activity episode generation, duration, location, starting time, and travel mode choices as essentially independent, which they are able to do because they ultimately produce trip tables for static network assignment methods. Model components to be developed under this project include: activity pattern choice, daily starting time choice, tour generation, tour mode choice, next stop purpose, next stop location, next stop mode, next stop timing and system simulation event tracker.
- *2008–152: Overlooked Density: Re-Thinking Transportation Options in Suburbia, Phase 1 and 2009–216: Phase 2:* This project aims at understanding of how regulation and site design practices may be modified to transform existing and new suburban multi-family housing areas into places that offer a range of travel modes and potentially reduce the exclusive use of automobiles. This proposal investigates the integration of land use and transportation and also focuses on the role of site design as a critical aspect in the creation of livable, less congested and multi-modal suburban communities. Using a case study approach, this research will include transportation and demographic surveys of suburban multi-family residents, audits/analysis of existing site designs, and interviews with planners, developers, and designers of multi-family housing developments. In order to expose students to the challenges of creating integrated and sustainable suburban multi-family development, this project will also include an educational component in which a class of students will travel to study and document existing models of suburban multi-family development in Eugene, Oregon and Phoenix, Arizona. Both of these cities have seen growth of this housing type in the last decade and will serve as test cases of how different site design approaches have affected transportation behavior. Students will work with local officials, developers and architects to understand code and development related issues, and will then propose alternatives to existing models of development.
- *2008–163: No More Freeways: Urban Land Use-Transportation Dynamics without Freeway Capacity Expansion:* This research aims to answer the following critical land use-transportation planning questions: (1). Under what conditions will freeway capacity expansion become counterproductive to urban planning goals (where is the saturation point and are we there yet)? (2). How would urban land use and transportation dynamics evolve if an investment policy prohibiting all freeway capacity expansions was implemented (i.e., no-more-freeway). (3). What would be the implications of such a policy on mobility, accessibility, land use pattern, transportation finance, and social welfare? Improved knowledge on these issues should benefit planers and decision-makers who pursue mobility and sustainability objectives and have the power to shape future cities. The general public will also benefit from more informed transportation investment decisions. The proposed research builds upon an integrated modeling tool developed in previous research—ABSOLUTE (Agent-Based Simulator Of Land Use-Transportation Evolution)—which translates planning policies such as the "no-more-freeway" policy into alternative urban growth paths and possibly urban growth equilibria.
- *2008–160: Long-Term Evaluation of Individualized Marketing Programs for Travel Demand Management:* With increasing concerns over traffic congestion, fossil fuel use, air pollution, and livability, coupled with severe constraints on funding for new transportation infrastructure, cities and regions are increasingly looking to a wider range of options to address transportation problems. Transportation demand management (TDM) is one of those options used over the past 30+ years with varying success. More recently, the concepts of social and individualized marketing are being applied to TDM at the household level and for all types of trips. This research project has two specific aims: (1) to evaluate whether the benefits of these individualized mar-

keting programs continue to at least one year after the project ends; and (2) to examine whether the theory of planned behavior can help explain the behavior changes identified. To do so, we will conduct additional follow-up surveys of randomly-selected residents and program participants, examine secondary sources of data, and expand planned surveys.

- *2008–184:Understanding School Travel: How Residential Location Choice and the Built Environment Affect Trips to School:* This project will examine the relationship between parents' residential location decisions with the built environment and travel mode to school asking several questions: how is school travel implicitly or explicitly considered in families' decision-making process for residential location, a process that generally involves trade-offs a family faces in addressing its various needs? what and how do local environmental factors, such as land use patterns, street network characteristics, transportation opportunities, and housing stock characteristics around school sites play a role in housing location choice, and in turn home-school proximity? To what degree does family location preference is constrained by school siting and other environmental factors, and how does the constraint affect school travel behavior? We will survey random samples of families with children attending selected public schools in the City of Eugene's 4J school district. We will collect information on children's school travel behavior, household background, parents' attitude toward school travel means, and their consideration of school travel in residential location choice. Schools will be selected based on type, quality, size, and location. A comprehensive strategy aimed at reducing school auto-trips should consider providing more walkable environments and reducing the demand for auto-travel.

Walking, Bicycling and Healthy Communities

- *2007–18: Active Transportation, Neighborhood Planning and Participatory GIS, Phase 1 and 2008–98: Phase 2:* This project is aimed at developing, implementing, and evaluating new community-based walkability tools. This proposed project is designed to utilize new mobile GIS technology in the development of tools that communities themselves can use to assess, map, analyze, and deliberate within their efforts to improve local walking conditions. These goals will be achieved through the development, testing, evaluation, and transferring of GIS and PDA-based tools focusing on measuring and mapping the pedestrian environment. The tools will be developed in a way that maximizes public involvement by local municipalities, school districts, transit agencies, and citizen groups while minimizing the training needs of a general, non-GIS using public. With the data, communities can conduct self assessments of local scale walkability, identify specific geographic areas of unsafe conditions, prioritize areas of greatest need, engage with local transportation officials more productively, and be better prepared to leverage enhancement funds. The purpose of the tools is twofold: 1) to collect relevant information about the walking environment that can lead to greater safety and an increase in pedestrian utilization; and 2) to catalyze community involvement that can urge public involvement and sustain other efforts to encourage greater walking. There are four primary components of this proposal: 1) refine an existing walkability audit tool for Safe Routes to School; 2) develop additional walkability PDA and GIS based audit tools focusing on ADA standards, Complete Streets, and walking environments around transit stops; 3) test each of these tools in communities throughout the country interested in addressing walkability at the local scale; and 4) to conduct an evaluation of the utilization of these tools in the various communities. Once the tools are developed in the research lab, they will be field tested within a community setting.
- *2007–20: The Influence of Community Walkability and Safety on Active Transportation Among Low Income Children:* In the proposed study, we will examine the contributions of walkability measures and perceived neighborhood safety (traffic and crime-related) on active transportation among an ethnically diverse group of low income children. Second, we will investigate the relationship between children's active transportation and overall physical activity and obesity. The data set that will be used for this research is a cross sectional survey of 765 parents and guardians of children in Florida aged 5–18 who receive Medicaid, the health coverage program for the low income. Using this data set, we will develop multi-variate regression models to identify the independent influences of walkability and safety on active transportation, while controlling for children's individual characteristics. We will test whether walkability factors are equally important in communities that are perceived

to be safe and those that are unsafe. Then, we will examine the relationship between active transportation and overall physical activity and obesity for this low income population of children. The findings from this study will add to the emerging body of literature on the influence of community characteristics on active transportation and will uniquely focus on ethnically diverse, low income children. This study's findings will provide insight regarding policy approaches that may be effective for encouraging low income, minority children to use active transportation. Improving physical activity levels for low income children holds great promise for improving health status, and for reducing income and ethnicity-based disparities in health outcomes.

- *2007–33: Understanding and Measuring Bicycling Behavior: A Focus on Travel Time and Route Choice:* An ongoing project is: examining the relationship between urban form and people's decision to bicycle; examining other intervening factors influencing the decision to bicycle, such as weather, topography, attitudes and perceptions, and socio-demographics; and testing the use of readily available technology (personal digital assistants with GPS) to objectively measure physical activity of bicyclists. That project first included a phone survey of Portland area residents about bicycling behavior. The second part of the project, currently underway, involves 150–200 bicycle riders carrying a PDA/GPS unit with them when they ride. This new project supplements and builds upon that work in two ways: 1. Collect GPS data from an additional 100 bicycle riders. Recruitment for the additional participants will focus on people with demographic characteristics and located in areas that were under-represented in the original sample. This will allow for more robust results. 2. Analyze all collected GPS data to answer additional questions. The current project focuses on developing and testing the PDA/GPS technology and analyzing bike riding in relation to urban form variables. The proposed project will evaluate the following new questions, among others: what is the difference in travel time between bicycling and driving? how does this difference vary spatially? how do cyclists' routes differ from the shortest network distance? how do cyclists choose their routes? How do network characteristics (e.g., bike lanes or heavy traffic) influence those decisions?
- *2007–43: Factors for Improved Fish Passage Waterway Construction:* Roughened chutes (simulating natural stream passages) are a cost effective means to provide fish passage at locations where existing culverts and bridges are structurally sound yet do not meet current fish passage rules and regulations. Currently, the construction of roughened chutes consists of using equipment and water-wash methods to place the stream-bed materials; compaction consists of water consolidation and use of bucket and track (using the wheels and tracks of equipment). Excessive subsurface voids can be a significant problem that settles the larger rock and allows the gravel and fines to be washed away. The loss may result in subsurface flow which may impedes passage for fish. Among the factors contributing to this loss, both hydraulic design and construction methods may play significant roles. This project is designed to investigate the role that construction technique plays in the loss of simulated stream-bed materials. The overall objective of this research project is to determine a list of significant construction factors affecting loss of fines in roughened chutes and develop a tool that provides better direction for the construction of roughened chutes.
- *2009–227: Evaluation of Bike Boxes at Signalized Intersections:* Analyses of motor vehicle and police reported crash data reveal that nearly 68 percent of bicycle crashes in Portland occur at intersections which are consistent with national trends. Of these intersection crash types, a common crash pattern is the "right-hook" where right-turning motorists collide with through or stopped bicycles. To partially address these conflicts between bicycles and right-turning motor vehicles, the City of Portland will be installing up to 12 "bike boxes" at signalized urban intersections. We propose conduct a comprehensive, classical, observational before-after study of the effectiveness of the installed experimental traffic control devices and responses of all system users impacted by the installation of the bicycle boxes. Our approach will answer such research questions as: do the bike boxes reduce conflicts or the potential for conflict between motorized vehicles and bicycles? do the bike boxes create any new or potential conflicts between motorized vehicles and bicycles? how does motor vehicle driver and bicyclist behavior differ with and without the bike boxes? what design features affect behavior and conflicts? do the bike boxes affect pedestrian safety, behavior, or conflicts with motor vehicles or

bicyclists? what are the impressions of the drivers and bicyclists using the intersections about how the bike boxes affect safety and operations?

- *2009–249: Improving Regional Travel Demand Models for Bicycling:* There is very little research in the U.S. on bicycling. What does exist provides some general indications, but is limited in scope and often employs unreliable methods. Moreover, the primary tool used by public agencies to plan urban transportation systems—travel demand models—rarely includes bicycles as a separate mode. Without more sophisticated modeling tools, planners are not able to accurately evaluate infrastructure options that involve cycling. One reason models do not adequately address the bicycle as a mode of transportation is a lack of data. Models are built using travel and activity surveys, which usually don't include enough bicycle travel to develop better models. This project will address these problems. For the past two years, we have collected data from over 150 bicyclists on their bicycle trips using GPS. Past research has evaluated why and where people bicycle, including identifying different types of cyclists. Focusing specifically on route choice behavior, it has been possible to compare the characteristics of the cyclists' routes with those of the shortest paths. The research project proposed here takes that several steps further. The GPS data already collected will be used to develop a bicycle component to Metro's travel demand model. This will be done, in part, by estimating the relative utilities of various types of facilities and factors, e.g. bike boulevards, arterials with and without bike lanes, low traffic streets, hills, etc. In addition, the results will be used to improve a bicycle route planning guide (ByCycle) that is currently available.
- *2009–229: Implementation of Active Living Policies by Transportation Agencies and Departments:* The overall aim of this project is to examine how and why some public agencies adopt policies that are intended to create a built environment that that supports physical activity and active living. Understanding how and why is essential to promote reformation of planning and policy processes to support active living. The project will focus on transportation agencies, including city and county departments of transportation and public works, congestion management agencies, metropolitan planning organizations (MPOs), other regional transportation agencies, and State departments of transportation. To address the overall aim, we will answer the following questions: what actions (e.g., policies, plans, standards, programs, etc.) can transportation agencies take to support active living? which agencies have taken these actions? why have these agencies adopted policy innovations that support active living? what factors influence adoption? to what extent is health and active living a motivation for these actions? why don't more agencies adopt such actions? what are the obstacles to active living? Methods include a thorough literature review (print and web), an inventory of State DOT actions, interviews with innovative State DOTs, examining a random sample of MPOs and regional transportation plans, a survey of local and regional agencies that are undertaking best practices, and a random survey of MPOs and city/county agencies.
- *2009–224: Healthy Communities and Urban Design: A Multi-Disciplinary National Analysis of Travel Behavior, Residential Preference, and Urban Design:* This proposed research project is firmly and directly connected to that fundamental core through an examination of the connection between urban form and transportation behavior within and between cities across the country. This project seeks to understand the relationship between urban form and active transportation (walking and biking) by comparing behavior within new urbanist and traditional suburban neighborhoods in carefully selected neighborhood pairings in cities across the United States. In twenty different cities we have selected one new urbanist and one traditional suburban neighborhood by initial GIS analyses of their urban forms. By including these ?pairings? of neighborhoods within cities, and by including multiple cities across the country, we can both control for local policy and cultural conditions within a single city, and control for differences across cities. Thus, we will be able to analyze the relationship of urban form to active travel in a way that has not previously been done.

Sustainable Freight Transportation Systems

- *2008–154: Food Delivery Footprint: Addressing Transportation, Packaging, and Waste in the Food Supply Chain:* Bringing food products to the majority of U.S. consumers generally involves frequent and lengthy trips from the food

growers and producers through a distribution network to the institutional, grocery, and restaurant businesses. Increasingly, businesses are assessing the impact of their purchasing decisions on their carbon footprints. These decisions have complex implications for the environment based on the mode of transportation employed, the corresponding packaging used to transport the goods, and the resulting waste and disposal transportation. The objective of the proposed research is to examine the environmental implications of the purchasing decisions made by these intermediary food businesses. We will start by assessing the current condition; then conduct life cycle assessments of different types of materials and identify alternatives that meet packaging requirements (e.g., shelf stability, etc.) with reduced environmental impacts. Ultimately this project will serve as the foundation for a broader assessment of an organization's carbon footprint which would extend to other forms of energy usage, transportation, and materials management. This represents an enhancement of current 'food miles' assessment methodologies, which primary consider greenhouse gases emitted during food transport. The research results can be used to develop purchasing and logistics strategies and models for supplier collaboration to reduce carbon foot print as well as overall transportation and waste costs.

- *2008–195: Freight Performance Measures: Approach Analysis:* This research has two main objectives: develop a set of freight performance measures that can effectively guide State-level multi-modal transportation investment; identify existing freight data sources and recommend a freight data inventory system that supports the performance measures. This research will develop data-oriented approaches to freight performance analysis that focus on evaluating the cost-effectiveness of various alternatives in achieving identified policy priorities. This method is more likely to be supported by existing and/or expected future freight data sources than more comprehensive planning approaches, while focusing on a smaller number of policy objectives at a time. ODOT will use the results from this study to help make freight investment decisions, plan future freight data collection activities, and communicate the benefit of multi-modal investment to politicians and the general public.
- *2009–226: Maintaining Safe, Efficient and Sustainable Intermodal Transport through the Port of Portland:* The overall objective of this project is to help maintain safe, efficient, and sustainable intermodal navigation in the lower Columbia River by understanding, and suggesting remedies for, a problem that threatens both navigation and salmon habitat. More specifically, we will: use analyses of LOADMAX and historical water level data to document long-term changes in key datum levels and other tidal properties; use results from water level analyses, dynamical models, remote sensing, channel topography and other data to determine the causes of the decreased water levels in the LCR; develop strategies to combat water level reduction, facilitating timely connections to land transport. The proposed research will apply advanced data analysis tools and remote sensing to a transportation problem and its associated habitat restoration needs, in direct collaboration with the public and private sectors. This research takes a new look at the consequences of dredging and uses of dredged material, and considers the impacts of ongoing climate change.

2.2 Evaluating Environmental Impact of Technology

Within the realm of Intelligent Transportation Systems, a range of technology applications exist which can lead to improved safety which has direct benefits due to fewer fatalities, injuries and less property damage. Safety improvement technologies have secondary benefits since the congestion resulting from a crash is also eliminated which prevents unnecessary delay, energy consumption, emissions, exposure to secondary crashes and noise.

Other technologies result in reduced VHT and/or VHT, which can lead to reductions in energy consumption, emissions, accident exposure OTREC researchers have been involved in evaluating various technologies in the U.S. and abroad for many years, across all modes. Typically an evaluation will include some standard performance metrics such as:

- Travel time or delay savings (congestion)
- Variability of travel time (reliability)
- Emissions
- Number of trips
- Number of stops

- Mode choice
- Noise
- Fuel and energy consumption
- Carbon footprint (e.g., offset by tree planting)

Fortunately there are several national resources that assist with technology evaluation at the planning, design and implementation stages, including the U.S. DOT ITS Benefits Database (*www.itsbenefits.its.dot.gov*) and the Intelligent Transportation Systems Deployment Analysis System (IDAS—see *http://idas.camsys.com*). In order to rigorously evaluate any technology there are several important considerations:

- **Partnerships:** our evaluations of specific technologies have all involved strong partnerships, typically with transportation agencies and the private sector. We have found opportunities to work collaboratively with the transportation industry where we have been able to provide resources for unbiased evaluation when transportation agency staff lack time and resources to focus on research.
- **Problem identification:** it is possible to avoid the phenomenon of a problem looking for a solution by carefully identifying the problem that need to be solved before identifying a specific technology.
- **Data source:** there must be a sufficient data source, preferably as part of the technology deployment itself. In our experience, it is extremely helpful when there is an environment of open data sharing. Transportation agencies in Oregon freely share their data (subject to privacy requirements) with one another and with researchers and the private sector, which is a model that should be followed elsewhere.
- **Before and after:** typically technology deployments that result in the generation of data do not consider the need for both "before" and "after" data. If possible, evaluations should develop a robust set of baseline data before implementing the ultimate system.
- **Involve evaluator early:** if the need for evaluation is built into the project or program early, the costs will be minimized and the potential effectiveness of the evaluation will be maximized.
- **Test bed:** if alternative technologies are available, consider the development of a simple testbed that allows for raw data from several different sources to be collected by a neutral party for direct comparison. The freeway authority in Munich, Germany successfully used this format for evaluating alternative road weather monitoring systems.
- **Technology transfer:** communicating the results of technology evaluation through training, seminars, publications, new media and conference/workshop presentations has been a cornerstone of OTREC's work. In addition we focus on educating students who participate in the evaluations and will become the employees of the transportation agencies and private firms implementing future technologies. By involving agency staff in the evaluation there is also technology transfer directly to those employees (who may later move up through the agency to leadership roles).

2.3 Future Research and Development Needs

A wide array of research and development is needed in order to improve the energy efficiency and sustainability of the transportation system, and many are underway at OTREC and elsewhere. Recognition that the focus is shifting toward efficient and sustainable operation of the transportation system will require research and development of new sustainable performance based planning, design, operations and maintenance. New incentives for operations and maintenance will need to be developed. It is not possible to be exhaustive but several research needs related to categories of projects described above are listed here:

- **Sustainable Transportation Pricing and Tolling Strategies:** the area of transportation finance is receiving more and more attention, but a sustainable financing system with energy efficiency and sustainability goals does not yet exist. Strategies for implementing emissions fees, or further creative 'green' finance systems that are publicly acceptable should be developed.
- **Congestion Management:** Since about 30 percent of the vehicle miles traveled (VMT) occur on freeways (accounting for only three percent of the lane

miles), ITS based congestion management strategies should be aggressively pursued, including ramp metering, speed harmonization, and traveler information. This will require better infrastructure for data collection and fusion of data from multiple sources. Research and development of greater data quality is also needed. Incident management should be exploited to its maximum level of effectiveness. Basic principles such as better signing, striping and marking as well as enforcement, should also be pursued. Mechanisms for improving travel reliability should be the core of this work.

- **Integrated Corridor Management:** Arterials handle about 42 percent of the VMT with about 11 percent of the Nation's lane miles, and their operation should be optimized through better operations. This requires a national effort to exploit the existing infrastructure of controllers and surveillance systems to provide needed data for management purposes. Building on private sector innovation, investment in research and development for more open source capable traffic signal controller hardware and software should be considered. Communications systems and data quality management components supporting these systems will also be needed.
- **Advanced Transportation Information Systems:** There is great value in accurate, timely and customized traveler information. There is still research needed to understand how people use traveler information and how it influences their decision-making. For example, would providing travelers with detailed 'green' traveler information that reports emissions, noise, and energy impacts, influence mode choice and affect traveler behavior? Navigation systems could be extended to include not only the shortest distance and shortest time routes, but the 'greenest' route as well.
- **Multi-modal Archived Data User Service:** Transportation data will be more and more critical in the future so national attention should be paid to developing robust data collection, storage and management systems. Building on Oregon's open data sharing philosophy, further research is needed to understand how to fuse data from multiple sources, including a mix of public and private sources in a way that encourages innovation in both the private and public sectors.
- **Electronic Freight Management:** The unavailability of disaggregate freight data continues to be a problem decade after decade. Some strategy for creating a firewall between private sector needs in the freight sector and public sector needs should be developed, perhaps by a neutral third party. The need for data clearinghouses may be needed across the transportation system since the issues of fusing data from multiple sources with varying degrees of quality and sensitivity are becoming more important.

Several other issues that require further research and development include:

- Development of 'green' performance measures that can be generated and compared across different geographic areas (state, county, urban/rural, city) and across all modes.
- Development of standard traveler information graphics to replace text-based dynamic message signs.
- Dealing with automated enforcement legal and institutional issues.
- Serious exploration of liability issues (following the lead of the European Union and Japan) related to technology deployment.

3. Innovative Technologies in Transportation Systems

The deployment of innovative technologies in the transportation system involves a complicated array of public and private organizations, viewpoints, interests, motivations, legacies, funding programs, and cross-disciplinary collaboration and communication. Historically, the transportation profession has included engineers and planners (as well as many others), but not necessarily requiring expertise in computing, data processing, programming, communications, system engineering and system integration. The development of the field of Intelligent Transportation Systems (ITS) has required the formation of new multi-disciplinary teams that require more careful communication and collaboration. Educational institutions, firms and government agencies, and professional organizations have begun to respond to this shift, but the response is not complete. Challenges remain that impede the use of innovative technologies in transportation, and there are roles for transportation agencies (local, State and federal) as well as academia and industry.

3.1 Challenges Impeding Use of Innovative Technologies

As noted, there are many challenges impeding the use of innovative technologies in transportation systems.

- **Shift to operations:** the needed shift in the transportation field toward an operations environment is partially complete, but still impedes the advancement of innovative technologies. Organizationally, there may not be incentives and rewards for operations personnel to advance in their career. Some agencies may not have sufficient operations staff. Limited operations staff may not have time or expertise to oversee implementation of new technologies.
- **Finance and funding:** more flexible funding programs could expand the implementation of innovative technologies. Incentives that encourage transportation agencies to share resources across jurisdictional boundaries would remove barriers to implementation.
- **Human resources:** transportation professionals typically come from single-discipline educational backgrounds, and there may not be sufficient opportunities for professional development and continuing education. Many agencies and firms have travel restrictions that prevent employees from attending and participating in regional, national, and international conferences and symposia (even across State boundaries in some cases). There may not be programs for tuition reimbursement for pursuit of continuing education or advanced degrees, or rewards (e.g., promotion or salary increase) for attainment of graduate degrees.
- **Legacy systems:** there are numerous legacy systems throughout the transportation infrastructure that have not been maintained or upgraded. Funding for these kinds of upgrades should be expanded, along with performance incentives that allow for upgrades to new versions of hardware and software. Often the legacy systems do not allow flexible data transfers which impacts inter-operability.
- **Communications:** historically transportation systems have been linked to communications, but transportation professionals may not have the necessary expertise to plan, design or implement robust communications networks. More attention should be paid to the establishment of communications infrastructure that supports the implementation of innovative technologies for the transportation system.
- **Data:** there is a need for high quality ubiquitous transportation surveillance data across all modes and all levels of the network. Systems for measuring, storing, and disseminating transportation data are complex and currently inconsistent.
- **System integration:** diverse systems that have been implemented piecemeal require integration. Data standards are moving targets and it is difficult to establish concrete standards for data formats and structures.
- **Collaboration:** the implementation of innovative technologies requires thinking beyond traditional jurisdictional boundaries. Users want to operate on a seamless transportation network, so traditional boundaries that divide finance, data, and other systems must be broken down. Boundaries between public and private entities along with associated liability issues also present challenges.
- **Need for objective and continuing evaluation:** often once a project has been implemented and possibly evaluated, continuing maintenance and performance evaluation is not provided.

3.2 Federal, State and Local Actions Needed

There are many actions that can be taken by Federal, State, and local governments in order to break down barriers to the application of innovative technologies. Several examples of these roles include:

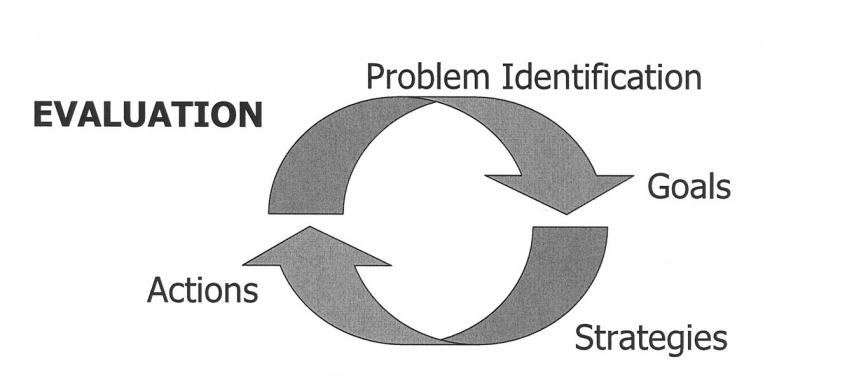
- **Encourage regional collaboration:** in the Portland metropolitan region, the TransPort ITS Advisory Committee has been meeting monthly on a voluntarily basis since 1994. TransPort includes representatives from Federal, State, regional, local governments, the private sector and academia. The committee provides official ITS advising to the regional transportation decision-making body and also provides a valuable forum for sharing project informa-

tion, data, and resources. TransPort could be a model for regional coordination nationwide.

- **Public/private partnerships:** government agencies could encourage public/private partnerships particularly in the area of standards for data sharing and communications.
- **Funding and incentives for operations:** new strategies for funding operations activities within transportation agencies should be developed, particularly for those with small staffs. Operations funds should not compete with funding for capacity improvements and dealing with aging infrastructure.
- **Reward data sharing:** agencies that openly share data with other agencies and make it available for research and to the private sector (e.g., value added resellers) should be rewarded.
- **Continuing education and mentorship:** agencies should partner with education and training organizations to advance the multi-disciplinary educational level of employees, using specific performance targets. Increase level of experience within agencies to effectively implement, operate, integrate and maintain technology. Agency personnel can serve as valuable mentors and colleagues for students and faculty.
- **Performance measurement:** develop new strategies and incentives for 'green' performance measurement and evaluation.
- **Rural infrastructure:** communications and utilities in rural locations can be unreliable and expensive to operate and maintain. Agencies should focus on improving rural infrastructure for technology.

3.3 Role for Industry and Academia Industry

Industry and academia play important roles in the implementation of innovative technology solutions. At a fundamental level, it is important for both industry and academia to be at the table at the planning, design, and implementation stages. Often industry can assist government. For example, new vehicles are already equipped with advanced positioning and communications systems that could serve as a backbone for those vehicles to act as 'probes' in the transportation system. However, serious privacy issues exist that prevent any aggregation of data generated from private vehicles to be used for management or information systems. Perhaps in the future, a collaboration of public, private and university organizations can work to develop a framework for integrating data from multiple sources in a mutually beneficial way. The figure below illustrates one way that academia can play a significant role in the development of new technology. Most transportation agencies have systems in place to identify problems, set specific goals for their region or state, select and assess multiple alternative strategies, and ultimately take particular actions. The feedback loop is complete when the evaluation step is completed, which provides feedback into the next stage of problem identification. Many times, the evaluation step is left out and this is where academia can play an important role. Through collaboration, universities can work with transportation agencies and industry to provide unbiased, rigorous evaluations that complete the feedback loop.



In the ITS field, often academia can play an important role in the collection, storage and maintenance of data archives. It has been shown that having a group of researchers who are interested in using data can ensure its quality. Academia also plays a crucial role in providing unbiased, rigorous evaluations of ITS projects and programs, which serves as a training ground for future and current professionals.

4. Technology Transfer

4.1 OTREC Technology Transfer

OTREC's technology transfer efforts are contributing toward an expanded and coordinated statewide program of transportation outreach involving accessible communication of research results, continuing education and training courses for transportation professionals at all levels and at all stages of their careers, in a variety of formats. These programs are being developed in coordination with a statewide needs assessment, transportation agency, industry, and community needs, and may also appeal to a larger national and international audience. In addition, all OTREC projects have an explicit component of transferring ideas, skills, and results as part of the research process. OTREC is also working with individual campus commercialization officers to efficiently move intellectual property into the marketplace as relevant.

There is a need to improve our transportation systems to make them more sustainable through research and education. There is also a workforce crisis in the transportation sector in that half of our nation's transportation system employees will be eligible for retirement in the next ten years. Many rural city managers and transportation planning staff are expected to retire within the next decade, yet many rural towns in Oregon are experiencing either rapid growth or decline where transportation issues become central issues. OTREC is supporting efforts to link student service learning projects with improving rural community planning, and will bring this approach to developing transportation training modules for new city managers, planners, planning commissioners, and legislators throughout rural Oregon. OTREC is encouraging and funding investigator-based technology transfer initiatives and encourage development of ways to share knowledge nationally and internationally. An example of such an initiative is the free web-based

Friday seminar program already underway at PSU. Each research/education project proposal requires a technology transfer plan that is evaluated as part of our peer review process. OTREC will encourage dissemination of research results via journal publications and presentations at recognized conferences.

There is a comprehensive OTREC website with links to all reports and publications. Project descriptions are posted on the OTREC website and submitted to TRB's RiP database one month after project selection. The OTREC newsletter is a key communication tool, and has been published twice a year and posted on the OTREC website. We also use electronic communication by e-mail as a key outreach tool for faculty, students, professionals and stakeholders. OTREC provides the Uniform Resource Locator (URL) of all full text reports to TRIS, transmits it to NTL and sends five printed copies to the Northwestern University Transportation Library, Volpe National Transportation Systems Center the Institute of Transportation Studies Library at the University of California at Berkeley, the TRB Library and NTIS within two months of project completion.

In addition to national conferences such as the Transportation Research Board Annual Meeting and others, OTREC faculty and students actively participate and present at local conferences including:

- Annual Region X (TransNow) student conference
- Oregon Planning Institute (OPI) Conference
- Northwest Transportation Conference currently sponsored by ODOT in even-numbered years
- Oregon Transportation Safety Conference
- Institute of Transportation Engineers District 6 Annual Meeting (13 Western states)

Research PIs will be encouraged to produce posters and "project capsules," one page summaries of project results with graphics. These are posted on the website and are also used in hardcopy to provide a convenient format to distribute to transportation professionals. The OTREC newsletter also features abstracts from recently published results. A series of seminars/lectures/symposia/panels will be continued and/or expanded at all campuses.

OTREC is supporting and expanding existing short courses and training programs (e.g., Kiewit Center Safety Courses, PSU's Urban Rail series, NCAT training, etc.).

OTREC hopes to develop programs for the Pacific Rim (e.g., China and Vietnam). In addition, we try to work with other organizations to be a clearinghouse for a broad array of training programs (ODOT's Road Scholars, the University of Washington's Transpeed programs, WTS leadership programs, OSU's Kiewit Center courses, FHWA sponsored courses through the National Highway Institute (NHI), the National Transit Institute (NTI) and ITS Oregon sponsored courses.)

OTREC has been in operation for about 18 months, and so far we believe that our technology transfer efforts have been successful. By funding 85 projects, there are now about 60 different faculty involved in OTREC projects with roughly 95 students involved as research assistants. Each project has an external matching partner who is interested in the research undertaken. External partners also assist with peer review of the final report, which also requires review by a federal agency staff member. These efforts, along with direct access to the products of each project, will help get the results into the hands of those who can implement the technology. Our projects have about 30 external partners. We have 17 undergraduate and graduate degree programs that are preparing future transportation professionals and providing opportunities for working professionals to seek additional education and training. OTREC faculty and students are quite active publishing and presenting their research results and providing opportunities for students to gain experience presenting the results of their work. Finally, during our first year of operation our 31 professional development courses and symposia have reached about 585 transportation professionals.

4.2 OTREC Industry Partners

Industry partners play a significant role in technology transfer in several ways. First, each project has an external matching partner to help ensure success, and some of these come from industry. Second, OTREC's External Advisory Board includes four members from private industry, who help identify research topics and ensure technology transfer.

4.3 OTREC Demonstration Projects

OTREC has not been involved in any official federally-funded demonstration projects for new technologies.

5. Conclusion

Our themes—healthy communities, integration of land use and transportation and advanced technologies—are guiding us, along with our transportation agency and industry partners across the state, to develop research and education programs aimed at solving transportation problems and strengthening the transportation workforce. Our research is being developed through a collaborative process and all products will be peer-reviewed. Thank you for this opportunity to provide testimony at this important hearing. With your continuing support, we are looking forward to making important contributions toward a more intelligent and sustainable future.

BIOGRAPHY FOR ROBERT L. BERTINI

Dr. Robert L. Bertini is an Associate Professor of Civil & Environmental Engineering and Urban Studies & Planning at Portland State University in Portland, Oregon. A registered professional engineer in Oregon and California, he is also the Director of the Oregon Transportation Research and Education Consortium (OTREC), a statewide collaborative national university transportation center that is a partnership between Portland State University, the University of Oregon, Oregon State University and the Oregon Institute of Technology. OTREC is advancing new research, education and technology transfer initiatives throughout the State of Oregon with a multi-disciplinary theme of advanced technology, integration of land use and transportation and healthy communities. With 20 years of experience in transportation, Bertini is a recipient of the National Science Foundation CAREER award entitled *Mining Archived Intelligent Transportation Systems Data: A Validation Framework for Improved Performance Assessment and Modeling.*

Since joining the Portland State faculty in 2000, Bertini has developed an Intelligent Transportation Systems Lab, unique in the Northwest, where he and his students and colleagues are developing ways of archiving and mining transportation data to improve the operation of our transportation system, reduce congestion and fuel consumption and improve quality of life. Bertini's goals at Portland State University have been to create rich classroom and laboratory environments to prepare leaders in transportation field; to conduct relevant research toward more efficient, equitable, effective and sustainable transportation system; and to develop new partnerships at Portland State, within the Oregon University System, with transpor-

tation agencies, consultants and industry. During this time Bertini has developed new courses, curricula and seminars; published over 200 papers and articles (81 peer reviewed), most with student co-authors; his published work has been cited 139 times; he has presented 163 invited lectures and presentations; he has been principal investigator or co-principal investigator on 53 research projects; and has supervised 87 undergraduate and graduate students. He is the recipient of several best paper awards from the Institute of Transportation Engineers, a diversity achievement award from the Women's Transportation Seminar and the Distinguished Faculty Achievement Award from the Portland State University Alumni Association.

Bertini works to bring a community-based learning component into the classroom and serves as the advisor for the Portland State University student chapter of the Engineers Without Borders. He is the Secretary of the Transportation Research Board's Committee on Traffic Flow Theory and Characteristics. He received a Ph.D. in Civil Engineering from the University of California at Berkeley, an M.S. in Civil Engineering from San Jose State University, and a B.S. in Civil Engineering from California Polytechnic State University San Luis Obispo. His government and industry experience includes positions with the San Mateo County California Department of Public Works, DeLeuw, Cather & Company, Parsons Brinckerhoff Quade & Douglas, Inc., and DaimlerChrysler Research and Technology North America, Inc. As a transportation engineer he has worked on public works, highway, light rail and airport projects, including planning, design and construction. Bertini and OTREC are members of ITS America, ITS Oregon, the Institute of Transportation and the American Road and Transportation Builders Association.

Chairman WU. Thank you, Dr. Bertini.

Mr. Voigt, please proceed.

STATEMENT OF MR. GERALD F. VOIGT, P.E., PRESIDENT AND CEO, AMERICAN CONCRETE PAVEMENT ASSOCIATION

Mr. VOIGT. Thank you. Good morning, Chairman Wu and distinguished Members of the Subcommittee. It is both my pleasure and privilege to represent the 460 members of the American Concrete Pavement Association before you today. I will address two areas: how paving materials can contribute to energy efficiency and sustainability and what challenges impede the adoption and implementation of sustainable practices.

Concrete is inherently a long-lasting and renewable building material. One of the unique distinguishing factors and features of concrete pavements are their well-documented durability and longevity over many decades of evaluation. Most pavements have a design life of 20 years but concrete pavements generally last much longer. In fact, there are cases of heavily trafficked concrete pavements that have performed for longer than 40 or even 50 years. A good local example is Interstate 66 just outside the Beltway here in the Capital region, which was completed in 1963 and is still in service today carrying a daily traffic level 10 times what it was designed for. There are many other examples like that across the country.

According to research in Canada, it is this exceptional longevity that is primarily responsible for enhanced sustainability benefits, particularly fewer repair cycles, which is the primary reason concrete pavements have a significantly lower energy footprint than comparable asphalt pavements. Although cement, the glue that binds all the rocks and sand together in a concrete mixture, requires a significant amount of energy during manufacturing, it makes up only about eight percent of the volume of a typical concrete paving mixture. Over the past two decades, the trend has been for less Portland cement to be used per cubic yard of concrete, largely because of improved mixture technology and the industry's significant use of industrial byproducts, which I believe were men-

tioned earlier, such as fly ash from coal-fired energy plants and slag from iron blast furnaces. Concrete is also 100 percent recyclable and reusable.

There are a number of sustainability features and benefits that concrete pavement provides in addition to those based just on materials. For example, concrete roadways require about one-fifth the energy to produce as comparable asphalt pavement. If concrete were substituted for the 500 million tons of asphalt used in roadways each year, it would save around 1.2 billion gallons of diesel fuel used in construction, or roughly the equivalent of removing 2.7 million cars off the road annually. I would like to point out that we are not suggesting that every road in America needs to be concrete. We are just trying to make the illustration of the benefits and the sustainability features that concrete provides.

According to the National Research Council of Canada, trucks traveling on concrete pavements use up to 6.9 percent less fuel than on asphalt, so if all asphalt surfaces on the national highway system were concrete, it would save as much as 2.1 billion gallons of diesel fuel per year, or $8.2 billion at $4 a gallon.

Concrete pavements are also naturally light colored, reflect light and do not retain as much heat as darker colored pavements. This could save cities and municipalities up to one-third on energy costs associated with streetlights. Concrete pavements also have a direct effect on mitigating urban heat islands and have been used successfully with other light-colored surface technology to reduce urban temperatures. According to Lawrence Berkley Laboratories, the potential energy savings in the United States from this approach is estimated at $5 billion per year through reduced cooling costs in those cities.

In terms of the current and needed future research and technology activities, at the top of the list for us is a new sustainability technology initiative within our industry's long-range research road map which will encompass a wide range of activities to close research and technology transfer gaps. We have outlined these in our written testimony.

Lastly, I want to mention several challenges our industry sees to further implementation of sustainable materials and practices for transportation infrastructure. First, there is a lack of a clear and universally accepted way to measure the sustainability of roadways. Second, current specifications should be replaced with specifications that require more sustainable practices. In many cases, existing specifications unintentionally limit the use of more sustainable materials like blended Portland cements. Demonstration projects and workforce training at all levels will be necessary to develop the knowledge and skills to implement sustainable and innovative technology. And there is also an acute need for a design and decision tool or tools to assess and continually improve the sustainability of all pavements. At present, most pavement decisions are based on, first, cost and, to a limited degree, life cycle cost without regarding to sustainability factors and benefits. A stronger federal position with an objective and more comprehensive pavement selection policy would help ensure that agencies effectively apply appropriate considerations for energy use and sustainability. The decision process must change to impact the use of innovative and cur-

rent materials that are more sustainable and less costly in the long run.

Mr. Chairman, the stakeholders in our nation's surface transportation network currently stand at an important fork in the road. We can let our surface transportation network continue to erode through the continuation of current practices or we can reinvest in new practices and quality materials that contribute to sustainable development. Our industry looks forward to continuing this dialogue with you. Thank you for the opportunity.

[The prepared statement of Mr. Voigt follows:]

PREPARED STATEMENT OF GERALD F. VOIGT

Good morning, Chairman Wu, Ranking Member Gingrey, and distinguished Members of the Subcommittee.

My name is Gerald F. Voigt, President and CEO of the American Concrete Pavement Association. The American Concrete Pavement Association represents more than 460 member companies, including paving contractors, cement companies, ready-mixed concrete producers, and suppliers of capital equipment, machines, materials, value-added products, and services that are used in the construction of concrete pavement.

It is both my pleasure and privilege to appear before you today to talk about the concrete pavement industry's research and development activities aimed at reducing life cycle energy consumption and to address sustainability for surface transportation infrastructure. My testimony today will address questions aligned with three key areas:

1. How concrete pavements contribute to energy efficiency and sustainability;
2. What research is improving or will improve the sustainability of concrete pavements; and
3. What challenges impede the use of innovative and more sustainable materials in the Nation's surface transportation infrastructure.

How Concrete Pavements Contribute to Energy Efficiency and Sustainability.

Concrete is the most commonly used building material in the world. It is often taken for granted, but you find it in your homes, buildings, under your feet while walking down a sidewalk, supporting airplanes at airports and, yes, as a major component of many miles of roads and highways in the United States and elsewhere in the world. Concrete is inherently a long-lasting and renewable building material, primarily made from locally available raw materials, including limestone or other natural stones, gravel, sand, and relatively small amounts of water.

To be clear, the other common paving material, asphalt, is also made from locally available aggregate and sand, which is combined with bitumen, a product of distilling petroleum.

One of the unique distinguishing features of concrete pavements is their well-documented longevity compared to asphalt pavements. Most pavements are placed with a targeted design life of 20 years, but in reality concrete pavements generally last much longer, while asphalt pavements last less than 20 years. In fact, there are well-documented cases of heavily trafficked concrete pavements that have performed for longer than 50 years. The State of Minnesota has recently begun specifying a 60-year concrete pavement design and California (CALTRANS) is working toward the goal of 100-year Sustainable Pavements.

Modern technology also continues to extend the service life of old concrete pavements through innovative repair and rehabilitation strategies. Increasingly, highway agencies are turning to a process known as diamond-grinding, which can be used as part of a long-term strategy to restore exemplary surface characteristics to structurally sound concrete pavements. Diamond grinding uses large machines that travel across the surface of the pavement, removing bumps and restoring the surface texture to like-new condition. A study by CALTRANS[1] suggests that the service

[1] "The Effectiveness of Diamond Grinding Concrete Pavements in California," CALTRANS, May 2005.

life of a well-designed concrete pavement can be extended by about 17 years with diamond grinding.

Of the two types of highway pavements—asphalt and concrete—concrete pavements inherently have the lowest overall energy footprint. The reasons for this are many, but the primary factors are the exceptional longevity of concrete pavements, the relatively low amounts of fuel required to place concrete pavements, and, of course, the fact that our product is not a byproduct of petroleum refining and production and thus has a much lower embodied primary (including feedstock) energy.[2] It is the exceptional longevity of concrete pavement that is primarily responsible for its enhanced sustainability, as the lack of frequent repair and replacement results in reduced congestion; fewer construction cycles (and the associated energy consumption, pollution generation, and use of natural resources); and enhanced safety through surface characteristics.

It is important to distinguish cement from concrete. Concrete is the mixture we form into pavements, bridges and other structures. Cement (technically Portland cement) is a powder that when combined with water and aggregates becomes the glue that binds the gravel and sand together and gives concrete its strength and rigidity. Cement requires the most energy to produce of all of the concrete constituents. However, it makes up only about eight percent of the volume if a typical concrete pavement mixture. The energy and sustainability benefits of hardened concrete used in transportation infrastructure overcome any drawbacks from the energy intensive manufacture of this one component.

The concrete pavement industry has recognized and embraced the concept of sustainability. We are supporters of the Green Highways Partnership,[3] and have taken on self-imposed actions and research focused on improving concrete and concrete pavement sustainability.

In recognition of their corporate obligations, the U.S. cement industry has adopted voluntary reduction targets for key environmental performance measures. Member companies of the American Concrete Pavement Association and Portland Cement Association have adopted four goals:

- *Carbon Dioxide*—Reduce carbon dioxide emissions by 10 percent (from a 1990 baseline) per ton of cementitious product produced or sold by 2020.
- *Cement Kiln Dust*—Reduce the disposal of cement kiln dust by 60 percent (from a 1990 baseline) per ton of clinker produced by 2020.
- *Environmental Management Systems*—At least 75 percent of U.S. cement plants will implement an auditable and verifiable environmental management system by 2010 and 90 percent by 2020.
- *Energy Efficiency*—Improve energy efficiency by 20 percent (from a 1990 baseline) as measured by total Btu per unit of cementitious product by 2020.

Over the past two decades, the trend has been for less Portland cement to be used per cubic yard of concrete. This trend stems from improved mixture technology, and the industry's use of industrial byproducts, such as fly ash (from coal-fired energy plants) and slag (from iron blast furnaces), to replace cement. Cement manufacturers have developed new products where these supplementary materials are combined during manufacturing as a blended cement product.

Some pavements have been constructed with as much as 25 percent fly ash and 50 percent slag replacing Portland cement, and research is just getting underway to further increase the amount of fly ash that can be used. The net effect of this is a positive diversion of a large amount of "waste" away from landfills, while at the same time improving concrete properties and cost effectiveness, ultimately reducing concrete's overall energy footprint. The proper use of these byproduct materials in concrete also improves a pavement's longevity and overall performance, illustrating how the concrete pavement industry is and can be an even more integral part of creating a sustainable transportation infrastructure.

Concrete is also 100 percent recyclable and reusable. Routinely, old concrete is crushed, steel components are removed and recycled, and then, the crushed concrete is used for roadbed materials, for stormwater management, for aggregate in new concrete mixtures, and also for some non-paving applications.

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[2] "A Life Cycle Perspective on Concrete and Asphalt Roadways: Embodied Primary Energy and Global Warming Potential," Athena Institute, September 2006.

[3] See http://www.greenhighways.org. The Green Highways Partnership (GHP) is a voluntary, public/private initiative. It strives to change the manner in which roadways are developed through concepts such as integrated planning, regulatory flexibility, and market-based rewards. GHP seeks to incorporate environmental streamlining and stewardship into all aspects of the highway life cycle.

With regard to energy consumption, there are a host of energy-related factors that are not considered in the typical pavement type selection process in use presently by State transportation departments. Primary among them is the energy required to build pavements and the energy consumed by vehicles to drive on pavements once they are opened to traffic.

According to the Federal Highway Administration's Technical Advisory on Price Adjustment Contract Provisions, construction of hot-mix asphalt roadways consumes more than five times as much diesel fuel as the construction of comparable concrete roadways. Given the Federal Highway Administration's (FHWA's) estimate of 500 million tons of hot-mix asphalt placed annually, this would equate to a 1.2 billion gallon annual savings of diesel fuel if those pavements were built with a more sustainable concrete pavement. Considering the associated reduction of carbon dioxide by constructing only concrete pavements. this equivalent to taking 2.7 million cars off the road annually.

The National Research Council of Canada[4] recently completed a study on fuel efficiency of commercial trucks on both asphalt and concrete pavements. The study demonstrated a statistically significant fuel savings for semi-tractor trailers (18 wheelers) on concrete versus asphalt pavements. Trucks traveling on concrete pavements use between 0.8 percent to 6.9 percent less fuel. The National Highway System is the primary system for the delivery of goods by truck in the U.S. Some 80 percent of U.S. communities can be accessed only by truck for deliveries. The system presently consists of approximately 160,000 lineal miles of pavement, 59 percent of which has an asphalt surface. If these asphalt surfaces were converted to concrete surfaces, it would save 2.1 billion gallons of diesel fuel per year at the pump (an $8.2 billion dollar annual savings at $4.00/gallon), reduce our dependence on oil, lower the emissions from vehicles, and decrease the cost of transporting goods.

Concrete pavements are also naturally light-colored, reflect light and do not retain as much heat as darker-colored asphalt pavements. This enhances night-time visibility, which in turn, improves both pedestrian and vehicle safety. These properties also can have a profound effect on energy savings, as it requires fewer lighting fixtures or lower wattage fixtures to illuminate concrete roadways in comparison to the darker asphalt surfaces. When properly accounted for during design, cities and municipalities can save up to one-third on energy costs associated with street lights. The potential savings are huge, considering that the cost of keeping street lights illuminated is often the third costliest item a typical city might incur, right behind schools and employee salaries.[5]

Concrete pavements have a direct effect on mitigating urban heat island effects. Urban areas can be up to nine degrees Fahrenheit warmer than surrounding areas, related to among other things heat-absorbing dark-colored horizontal surfaces like roofs, roadways and parking areas, which translates to more pollution and more energy required for cooling buildings. Concrete has been used successfully, along with other light colored building materials and strategic planting, to reduce the urban heat island effect. According to work done in 2005 at Lawrence Berkeley Laboratories,[6] the potential energy savings in the United States from this type of planned mitigation is estimated at $5 billion per year through reduced cooling costs. At this time urban heat island is not a factor used in the selection of pavements by FHWA or State transportation departments.

Naturally, when we talk about sustainability, it is logical to focus solely on the longevity and environmental aspects of concrete pavements. But there's more. Concrete pavements have indirect societal and economic benefits, too. Downtown areas have been revitalized by the use of decorative concrete pavements, which are colored and stamped with decorative textures to create a higher aesthetic quality. This not only improves civic pride and creates a sense of community; it also tends to improve business along Main Street, U.S.A.

What ongoing or future R&D projects will improve the sustainability of concrete pavement? What are the most important current technical challenges, and what types of R&D projects are needed to overcome these challenges?

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[4] G.W. Taylor, P. Eng., & J.D. Patten, P. Eng. "Effects of Pavement Structures on Vehicle Fuel Consumption—Phase III," 2006.

[5] Data from City of Milwaukee, Wisconsin.

[6] Akbari, H. "Energy Savings Potentials and Air Quality Benefits of Urban Heat Island Mitigation," First International Conference on Passive and Low Energy Cooling for the Built Environment, Athens Greece, May 17–25, 2005.

In September, 2005, the National Center for Concrete Pavement Technology (CP Tech Center),[7] seated at Iowa State University in Ames, Iowa, published the Concrete Pavement (CP) Road Map,[8] which is a comprehensive and strategic long-term plan for concrete pavement research, prepared with broad industry participation under the aegis of the Federal Highway Administration. The CP Tech Center is an independent, third-party organization that represents the research and technology transfer needs of the concrete pavement community. It is also unique among technology centers in that it has the established goal of collaboration with universities and other organizations across the country to leverage the best minds and expertise. Today, the CP Tech Center and the Concrete Pavement Roadmap are managed by executive and advisory boards consisting of private, public as well as academic leaders in the field of concrete pavement engineering.

When published, the CP Road Map consisted of 12 research tracks. Although it was decided then that sustainability must be an inextricable component of each of the 12 tracks, the ever sharper focus on sustainability worldwide led the CP Road Map's Executive Committee to create a separate sustainability and environmental track in September 2007.

The track is currently underway, with the first meeting of the Leadership Group[9] scheduled for July 23, 2008. The diverse group will lead the development of a Track Framing Document to guide research and outreach, as well as to select projects for immediate and future funding, all with the goal of advancing the sustainability of concrete pavements, and building on concrete's already outstanding position as a sustainable paving material. This track will closely align with the 12 other CP Road Map Tracks to ensure a coordinated and comprehensive effort to address sustainability.

Inherent to increasing the sustainability of concrete pavements is the need to increase energy efficiency, both in the production and operational phases of the pavement's life. Current and future research that directly or indirectly increases energy efficiency during the production phase includes:

- Development and adoption of new recycling methods for concrete pavements to further advance the means through which existing materials may be reused.
- Development and adoption of advanced construction testing and monitoring to assure the quality of the end-products as more sophisticated and complex material combinations are implemented.
- Development and adoption of advanced, highly efficient equipment, as well as methods for evaluating and improving constructability to ensure that contractors operating under the low-bid procurement process have the technology and capability to achieve specified results.
- Optimized aggregate sizing to reduce cement content to reduce the energy embodied in concrete.
- Increasing fly ash and slag contents in pavement concrete to advance the extent of reuse of these byproducts for cement substitution.
- Two-lift slipform paving construction to allow further use of locally available aggregate that may be acceptable in the lower region of the pavement, but not near the surface.
- Development of practices to reduce and eliminate construction waste and increased use of recycled water as further improvements in sustainable construction practice.
- Development and adoption of advanced, highly efficient equipment to minimize fuel consumption and emissions generated during construction.

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[7] *See http://www.cptechcenter.org*

[8] *See http://www.cproadmap.org/index.cfm*

[9] The Leadership Group, consists of individuals representing government (Federal Highway Administration; U.S. Environmental Protection Agency; the Vermont Agency of Natural Resources; Virginia Department of Transportation; Caltrans; North Dakota Department of Transportation; Kentucky Department of Transportation; Minnesota Department of Transportation; and New York Department of Transportation. Also, the group is represented by industry (in the form of representatives from companies including Holcim (US); Lafarge North America; Duit Construction; The Right Environment, Snyder and Associates; and Applied Pavement Technology), as well as associations (American Coal Ash Association; American Concrete Pavement Association; Wisconsin Concrete Pavement Association; Slag Cement Association; Cement Association of Canada; National Ready-Mix Concrete Association; Portland Cement Association, and the American Association of State Highway and Transportation Officials); and academia (Iowa State University—CP Tech Center and the University of New Hampshire—Recycled Materials Resource Center).

In addition to improvements during the construction phase, improvements in energy efficiency during the operational phase are being targeted. These include improvements that may be realized through the maintenance, rehabilitation, and recycling operations and those that directly benefit the highway user and surrounding communities. Current and anticipated research that addresses improvements in energy efficiency during the operational phase includes:

- Increased pavement longevity, minimizing future maintenance and reducing user costs and delays resulting in significant energy savings.
- Fast-track (expedited) repairs and rehabilitation of concrete pavements to reduce construction time and congestion and associated wasted energy from vehicles delayed through work zones.
- Precast pavements/slabs for maximum durability, and rapid repair and replacement to minimize disruption to motorists and businesses.
- New and improved in-place recycling techniques that save energy by eliminating any need to transport materials to and from a crushing and processing facility.
- New concrete overlay techniques that extend pavement life with the least amount of materials and energy expended, while also providing the energy-related advantages of concrete pavement surfaces.
- Lower rolling resistance that increases the fuel efficiency of vehicles operating on the pavement surface.
- Highly reflective surfaces that require less illumination, saving lighting energy and lives while lowering energy required for cooling urban areas.
- Optimized textures that reduce tire-road noise, maintain frictional characteristics, and provide pavement demarcation to improve aesthetics and community acceptance.
- Photo-catalytic surfaces to treat air pollution, lowering energy required for alternative treatment strategies.
- Pervious concrete surfaces that eliminate energy consumed to treat point source run-off.

ACPA also is working closely with researchers at Arizona State University's National Center of Excellence on SMART Innovations for Urban Climate and Energy to better understand how pavement designs and materials contribute to surface temperature changes. Begun in 2005, this research was designed to identify mix design factors that could allow production of cooler pavement surfaces and a modeling tool by which to evaluate the surface temperature changes. This work will provide further awareness of the urban heat island issue, and influence municipal ordinances and building codes to adopt environmentally appropriate materials and solutions.

In pursuing this research, ASU has developed a simplified laboratory test method to evaluate the thermal conductivity of paving materials using conventional construction techniques. ASU also collaborated with ACPA to develop infrared images and place in-pavement sensors for a concrete overlay of an existing asphalt concrete parking lot in Rio Verde, Arizona. This collaboration provided dramatic information and imagery on concrete's benefit in reducing urban heat island effects in a living community.

What challenges impede the use of innovative materials for transportation infrastructure? What actions can the Federal and State and local governments take to overcome these impediments? What is the role of industry and academia, especially in technology transfer?

Current institutional and technical challenges exist that impede a more widespread use of sustainable and energy efficient pavements. It is our contention that significant improvements could be achieved simply by including consideration of these important factors in the selection process used for pavements. At present, most decisions are based on first cost, and to a limited degree life cycle cost. However, factors such as user costs, the energy required to build and operate pavements, as well as the energy consumed by vehicles driving on pavement surfaces or used for lighting roadways, is not appropriately considered. New, more comprehensive selection processes could take these real agency and societal impacts into consideration. A stronger federal position on the use of federal aid funds coupled with an objective and more comprehensive federal pavement selection policy would help insure that states and other agencies effectively apply appropriate considerations for energy use and sustainability.

The culture of considering "lowest first cost" in place by most State Departments of Transportation (DOT's) must change to impact the use of innovative and current materials that are more sustainable. Traditionally, State departments of transportation have considered the construction and maintenance of a roadway as two separate operations, with separate funding levels assigned to each. Some states have adopted life cycle cost strategies for some of their pavements, in which both the initial construction costs and long-term maintenance and operation costs are included as a way of comparing alternate pavement designs for a section, but this has not pervaded all of their decisions. An asset management and sustainability strategy can only truly be reached when an agency applies this mindset both simultaneously across their roadway network and continuously throughout time. In doing so, the pavement network is viewed as an asset and a mix of different rehabilitation strategies are employed to sustain its value.

We do not intend to be critical of our partners in the State highway agencies, but the fact remains that a new mindset is needed to achieve more sustainable practices. We also would be remiss if we did not recognize the challenges faced locally with constrained funding that limits an agency's initiative to adopt new, more sustainable practices.

Application of strategic asset allocation to a pavement network would allow the states to maintain the network in the highest overall condition possible at the lowest constant level of dollar flow into the pavement network. Such a system is inherently dynamic and necessarily would adhere to the principles of sustainability. The FHWA has recognized this need in their publication *A Quick Check of Your Highway Network Health*[10] which states: "By viewing the network in this manner [with each pavement as an asset in a collected network], there is a certain comfort derived from the ability to match pavement actions with their physical/functional needs. However, by only focusing on projects, opportunities for strategically managing entire road networks and asset needs are overlooked."

A number of specific implementation challenges currently impede the immediate adoption of more sustainable pavements. These include:

- Lack of a clear and universally accepted way to "measure" the sustainability of a roadway. However, research conducted in Canada[11] provides many answers, but has not yet received broad acceptance within the transportation industry. The Canadians have looked at the embodied primary energy of a roadway segment over a 50-year life cycle (including material extraction, processing, mixing, placement, operation, maintenance and salvage). However, more work is required in this area.
- Existing specifications. In most cases, existing specifications unintentionally limit the use of more sustainable practices. Paving specifications are often based on dated information and agencies do not often respond quickly to changes in materials or industry advancements. Current specifications should be replaced as appropriate with specifications that require more sustainable practices. One such change that would have immediate benefit is opening up the use of blended cements. Blended cements (Portland cement blended with slag or other supplementary materials during manufacturing) are used extensively throughout Canada and Europe, but are not widely used by State DOT's in the U.S. As noted earlier, these materials have a lower energy footprint than standard cements. Another positive change would be to allow much great amounts of SCM's in concrete paving mixtures. When given the opportunity, industry often will find innovative ways to make use of these byproducts, while improving the pavement quality and saving dollars.
- Training the workforce. The design, construction, maintenance, rehabilitation, and recycling of sustainable pavements requires great knowledge and skills. As such, the current and future workforce must be educated with respect to sustainability and the important role each individual plays in increasing sustainable infrastructure. This includes all members of the workforce, from the construction laborers and superintendents through the planners and designers. Immediate and long-term benefits can be derived through focused training programs that bring current and future innovations to light.
- Lack of design and decision tools. There is an acute need for tools designers can use to assess and improve the sustainability of pavements. Although the technology exists to create such tools, none are currently widely available and

[10] FHWA–IF–07–006, "A Quick Check of Your Highway Network Health."

[11] "A Life Cycle Perspective on Concrete and Asphalt Roadways: Embodied Primary Energy and Global Warming Potential," Athena Institute, September 2006.

thus there is no systematic way to determine the sustainability of a given design or to compare design alternatives. Tools need to be developed and implemented that are based on international standards for assessing the life cycle costs and benefits of design alternatives.

- Demonstration projects and commensurate technology transfer workshops can be used to demonstrate current and emerging technologies that improve the sustainability of concrete pavements.
- Gaps in research, as outlined earlier.

Many of the achievements of the CP Tech Center were accomplished through a cooperative agreement with the Federal Highway Administration and used federal research funds to leverage funding from others, including our industry. We greatly appreciate the efforts of Congress to support of research and development for improved pavements. We are confident that with our public sector partners, we can close gaps in the technology and practice that will break down barriers to use of innovative and more sustainable materials and practices.

Closing Remarks

Mr. Chairman, to summarize these remarks, I submit that the stakeholders in our nation's surface transportation network currently stand at an important fork in the road.

We can let our surface transportation network condition erode through the perpetuation of current practices that ultimately will have dire consequences to the safety and personal mobility of our citizens, as well as the ability of our nation to compete in the global economy. Or, we can reinvest in new practices that contribute to sustainable development of our surface transportation systems.

In many ways, sustainable pavement technology is already available in a familiar building material called concrete. We need to fill some research gaps and develop the mechanisms to put more sustainable practices into common use. If we accept this challenge, we will once again create a system that stands peerless above all others and neither detracts from our environment nor impedes future generations from achieving the standards of living that we have enjoyed as a direct result of our surface transportation network.

The concrete pavement industry stands ready and willing to invest the time and other resources to advance our products and processes in pursuit of even more sustainable practices. We look forward to the support of the public sector to realize the American vision of the best highways and roadways in the world. Thank you for your time, for providing this opportunity to our industry, and for your kind consideration.

BIOGRAPHY FOR GERALD F. VOIGT

Professional Summary

American Concrete Pavement Association, 1988 to Present

Capstone: Serving the ACPA for almost two decades, I have been involved in every facet of the Association's business, predominantly in technical and management positions. During my entire tenure, I have consistently balanced the dynamic needs of the industry by developing and implementing new ideas; leading by example; and staying true to our founding principles of service, hard work, and extra effort for the betterment of the industry and the pavements we produce. I have concentrated my work on technology and technology transfer for all three primary segments of our mission: airports, highways and streets.

- **President & Chief Executive Officer, 2005 to present**
- **Chief Operating Officer/Senior Vice President of Technical Services, 2004**
- **Chief Operating Officer/Vice President of Technical Operations, 2000–2003**

Role and responsibilities:

- Formulate and oversee annual budget and manage general operations and finances.
- Manage diverse professional staff.

- Work as proactive appointed member of ACPA Board of Directors and Executive Committee to develop and implement policies, programs, and budgetary guidelines.
- Guide overall work programs and implement process flows to improve productivity.
- Lead all areas of Association's focus, including technical & research programs, promotion programs, communications, and government relations.
- Provide some key hands-on technical support, troubleshooting and research management.
- Serve as Trustee for employee (ACPA and chapter/state) 401–k plan.

Key Achievements:

- Successfully lead ACPA through the creation of National Concrete Pavement Technology Center in 2005.
- Reorganized staff structure for improved service to members and industry.
- Formulated a streamlined budgeting process.
- Developed first-ever ACPA employee/management review process.
- Solidified relationships and built trust with chapters and key industry partners (FHWA, EPA and State DOTs).

- **Vice President—Technical Operations/Chief Knowledge Officer, 1999–2000**

Role and responsibilities:

- Manage staff work programs
- Direct ACPA's technical information and information technology programs.

Key Achievements:

- Worked with colleagues to develop and initiate the Innovative Pavement Research Foundation.
- Created ACPA's first (and currently used) highway market measurement process and associated quarterly report, "Pavement Market Quarterly."
- Initiated ACPA's first "Knowledge Management" program, integrating the latest computer- and network-based technology to streamline and expedite the flow of information.

- **Director of Technical Services, 1988–1999**

Role and Responsibilities:

- Assisted ACPA members and agencies with questions and technical issues related to pavement construction and design concerns, saving member contractors millions of dollars in unnecessary removal and replacement costs.
- Researched, produced and published technical publications and guide specifications in all segments (airports, highways and streets).
- Prepared and presented more than 400 technical presentations, white papers, and training sessions on concrete pavement design, construction, and rehabilitation.

Key Achievements:

- Developed relationships with State DOT, FAA, FHWA and industry contacts.
- Produced more than 35 technical publications and guide specifications, most of which are still actively used in the industry and among agencies.
- Provided technical assistance or guidance in response to more than 8,000 inquiries or requests during this period.

Midwest Consulting Engineers, Inc., 1987–1988

Capstone: Before accepting a position with the ACPA, I served in an engineering position with this Chicago-based design and construction consulting-engineering firm. During my tenure, I worked on several major design and construction projects, while also providing administrative and technical support to colleagues, and introducing the company to computer spreadsheets for cost estimating and geometric design.

• **Staff Design Engineer, 1987–1988**

Role and responsibilities:

- Served in key role on a team responsible for the design of pavement rehabilitation strategies for Illinois Department of Transportation.
- Provided administrative and office management support to principals of the firm.

Key Achievements:

- Developed concrete pavement rehabilitation strategies used by the firm.
- Designed geometrics for two major arterial roadway and expressway interchange improvement projects still in service in suburban Chicago.

Significant Skill Sets and Experience

- Personnel and fiscal management experience.
- Expansive range of technical knowledge in all phases of pavement design, construction, rehabilitation and materials.
- Broad range of hands-on research and management of research projects.
- Extensive experience in Association management issues.
- Widely published technical author and experienced speaker and presenter.
- Clear and concise communicator.

Education

- Master of Science, Civil Engineering, conferred by the University of Illinois, 1986
- Bachelor of Science, Civil Engineering, conferred (with honors) by the University of Illinois, 1985

Professional Registration

- Registered Professional Engineer (Civil) in the State of Illinois.

Chairman WU. Thank you, Mr. Voigt.

We have another vote called on the Floor, and we also have a request from the Minority side that we pause the testimony at this point so that a larger number of Members can listen to the witnesses and participate in the Q&A, and that is a request which the Chair intends to honor. So with your forbearance, we are going to pause the testimony for a moment and continue when the Members have had an opportunity to return. Thank you for your forbearance.

[Recess.]

Chairman WU. At this point I would like to resume witness testimony. Dr. Poe, please proceed.

STATEMENT OF DR. CHRISTOPHER M. POE, P.E., ASSISTANT AGENCY DIRECTOR; SENIOR RESEARCH ENGINEER, RESEARCH AND IMPLEMENTATION DIVISION–DALLAS, HOUSTON, TEXAS TRANSPORTATION INSTITUTE, TEXAS A&M UNIVERSITY SYSTEM

Dr. POE. Chairman Wu, Members of the Subcommittee, thank you very much for the opportunity to testify today.

As you know, the Nation's transportation system has a substantial impact not only on our economy but on the environment as well. In addition to impacting air and water quality, it affects our energy efficiency and sustainability. The Texas Transportation Institute's environmental research encompasses air, water and soil

studies as well as roadway landscaping and environmental management and control.

In my written testimony, I provided examples of how TTI is testing new pavements that reduce water runoff, noise and air pollution. TTI is also studying how technologies and products reduce soil erosion and impacts on ecosystems. However, in the interest of time, I would like to focus this morning on the issue of traffic congestion and how it is affecting the environment. Some might say some congestion is a sign of growth and economic development but it is also a sign of waste. In 2005 alone, we as a nation wasted 2.9 billion gallons of fuel in the urban areas of our country and that does not count the rural areas where traffic tie-ups and a number of other causes stress our road network.

TTI has worked to help mitigate this problem through more accurate data gathering, improved reporting and developing Intelligent Transportation System technologies to link the various components of the transportation system together. We are also working to solve this problem through projects such as the Dallas area Integrated Corridor Management Project, which will provide State, transit and local agencies comparative travel data which they can then provide to the public to help travelers avoid congestion and select the best routes and modes. By using cities such as Dallas, San Antonio and Houston as real-time laboratories, research findings and technology transfer occurs instantaneously as we work with our counterparts from local transportation agencies and private industry on a daily basis.

What is the benefit-cost ratio of decreasing congestion? Well, in a series of studies from 2003 to 2006, for the Texas Governor's Business Council, the Texas Department of Transportation and the Texas Metropolitan Planning Organization, researchers at TTI estimated that investment of $66 billion in efforts to eliminate congestion and improve mobility would generate $540 billion in savings from lower travel delay, reduced fuel consumption and increased business efficiency, an eight to one return on investment. By reducing stop-and-go driving, researchers estimate that Texans could save as much as $37 billion in fuel consumption alone, and that was done when gasoline was at $3 a gallon.

What are the impediments to solving this problem? Well, the first is money. Sixty-six billion dollars is a lot of money. Secondly, at a time with increasing gas and grocery prices, we must effectively communicate the need, how it will be addressed and the resulting benefits. To communicate more effectively, we must first improve even further our ability to gather data, interpret the impacts of transportation on the environment today, and more importantly, how transportation improvements will affect the environment tomorrow. This will give us firm footing in terms of benchmarking progress.

As for the solutions, there is not a one-size-fits-all approach that works. Decreasing congestion, emissions and fuel consumption will require all the stakeholders, public and private, federal, State and local, to come together, share information and work together to ensure that we as a nation can continue to grow our economy but do it in a way that protects our environment.

TTI was established 58 years ago as the research arm of the State of Texas. Even from the early days, the groundwork of the business plan of the Institute had been established, that is to say that we primarily are sponsor driven. Today research funding comes from Federal, State and local governments or private industry. While this approach works well to address short-term and mid-term solutions, we are also fortunate that we have received federal funding through projects such as the Translink Laboratory and Research Center and the University Transportation Center for Mobility. These projects provide multi-year funding which enables researchers at the Institute to look at nationwide problems in the long-term. Addressing the impact of our nation's transportation system on the environment will require a comprehensive, multi-year program. Even at TTI with our long history and broad ranging environmental research program, we have had to seek solutions one project at a time. Without a national, comprehensive, long-range approach, our program will only be successful at incremental advances rather than providing major solutions. That is why your effort to advance green transportation is so important. The University Transportation Center, as part of that initiative, provides multi-year funding which is important to solving long-term problems. It also provides a well-established process for getting research into practice and training the transportation industry. In addition, this research program model has been successful in providing the research and academic community more input into setting the research agenda at the federal and State levels while ensuring continued cooperation and input of all the other stakeholders in our nation's transportation system.

With that, I will conclude my remarks. I appreciate the opportunity.

[The prepared statement of Dr. Poe follows:]

PREPARED STATEMENT OF CHRISTOPHER M. POE

Mr. Chairman, distinguished Members of the Subcommittee, I would like to thank you for the opportunity to testify today. It is indeed an honor. I would also like to commend you all for your efforts to address the environmental impact of our nation's transportation infrastructure through H.R. 5161, the *Green Transportation Infrastructure Research and Technology Transfer Act.* I believe this legislation will help address many of the issues this Subcommittee is examining today, such as the need for improved coordination among Federal, State, and local governments; the private sector and university-based research organizations, as well as the need to shorten the time to find and implement solutions.

The Texas Transportation Institute's (TTI's) environmental research encompasses air, water and soil studies, as well as roadway landscaping issues, environmental design and other aspects of the field. TTI is nationally recognized for its state-of-the-art testing facilities, experts in transportation-related environmental concerns and an interdisciplinary approach to environmental research.

TTI's Environmental Management program conducts landmark transportation research in areas such as storm water quality and erosion-control materials, housing a full-scale evaluation facility. Research from the Air Quality Studies Program expands analytical approaches to transportation air quality analysis and provides results that help to more effectively evaluate air quality policies and emission reduction measures. The University Transportation Center for Mobility focuses on infrastructure congestion, which is a major cause of wasted fuel each day.

Offices housed in several of the state's air quality non-attainment areas provide TTI with awareness of local concerns and targeted solutions. Personnel throughout the agency conduct research on wide-ranging environmentally related topics such as public transit, urban planning and traffic patterns.

We consider Green Transportation Infrastructure as the design, construction, operation, and maintenance of transportation infrastructure to mitigate air pollution, ground water contamination, and surface water contamination with an end result of reducing congestion, flooding, erosion, and impacts to ecosystems.

First, let me summarize my key points.

- Green Transportation Infrastructure includes a diverse group of stakeholders that must act together to fully address the impact of transportation on the environment. I would like to commend the Committee for its efforts to elevate the topic through a University Transportation Center.
- Congestion problems will continue to challenge our metropolitan regions in the future. Travel delays and unpredictable travel times for people and freight will be a problem leading to increased emissions and fuel consumption. With the increase in gas prices, the impact will only become more costly to the average citizen.
- Research is needed to quantify the benefits of green transportation strategies. The transportation industry needs solid evidence on the impact of technologies, strategies, and materials.
- There are design, operational strategies, technologies, materials, and construction techniques that will reduce transportation's impact on the environment. Technology transfer of research and best practices is needed to increase implementation of green transportation.

I would like to expand on these ideas in five key elements: the congestion problem, improvements in design and operations, improvements in pavements, improvements in construction materials, and future research needs and the federal role.

The Congestion Problem

Most, if not all of you, have driven through the District during rush hour, so I need not point out that congestion is a major problem, not only in our nation's capital but in cities across the Nation. Technically we might use words that describe elements of problems or solutions like accessibility, mobility, reliability, connectivity, and seamless productivity. These are all useful distinctions and point to viable and important solutions, but the meaning of these various words may be lost on people and freight shippers who understand their congestion problem, but do not parse it in the way that experts do. People are concerned when it takes them longer to get where they want to go than they think it should. I think it is important to recognize this difference between what people call the problem and how we attack it.

Our research suggests that no matter what you call it, we've got several problems. A quick summary:

- We waste quite a lot of time—3.7 billion hours in 85 cities in 2005
- We use more fuel than we should—2.3 billion gallons in those 85 cities
- This has value—$63 billion in 85 cities in 2005
- We cannot reliably predict travel time very accurately due to several factors such as crashes, vehicle breakdowns, weather, special events and road work.
- Jobs, shops and homes are spread out for a variety of understandable reasons, many of which make transportation service more difficult to provide.
- There are fewer travel options than people say they want, but many of the existing options are underutilized.
- We have to plan around congestion during most daylight hours and on weekends.

A 2003 study for the Texas Governor's Business Council used information developed by the State's metropolitan planning organizations and the Texas DOT to estimate the benefits of improving mobility. To keep the relatively high level of congestion experienced in major Texas cities from getting worse will require an increase in spending from $108 billion to $123 billion between now and 2030. The more desirable outcome of eliminating serious congestion will increase spending to $174 billion. That $66 billion increase generates $540 billion in savings from lower travel delay, reduced fuel consumption and business efficiency, an eight to one return ratio. Reductions in fuel purchases that would result from less stop-and-go driving were estimated at $37 billion alone, more than half of the cost of the program.

Addressing the congestion problems can provide substantial benefits and provide improvements in many sectors of society and the economy. The costs involved in eliminating serious congestion problems are large and the projects, programs and

policies that are implemented will require the cooperation of the public, agencies at all levels of government and, in many states, the private sector as well.

The Texas Governor's Business Council study estimated that solving the serious congestion problems in the State's eight largest metropolitan regions would generate $540 billion in economic benefits—including $37 billion in reduced fuel consumption and $104 billion in travel time savings (Figure 1). The analysis estimated almost $80 billion in business efficiencies and operating savings would result from lower congestion levels. More than $320 billion in construction benefits, which include more than 110,000 jobs that would be created, were also identified.

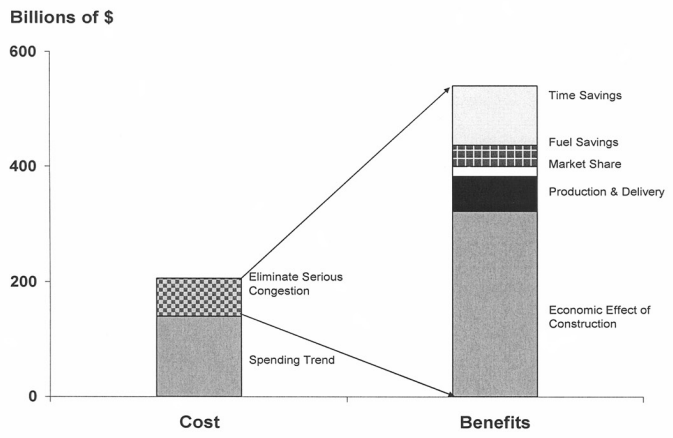


Figure 1. 25-Year Costs and Benefits of Implementing Texas Metropolitan Mobility Plan
Source: TTI Mobility Study, 2007

Design and Operation of Transportation Infrastructure

Some may say congestion is a byproduct of success and economic development. However, accommodating the growth does not have to produce the same past results. Public agencies need to find new ways of designing and operating the transportation system to accommodate the growth. An example of this in the Dallas area is the Integrated Corridor Management project jointly funded by the U.S. DOT and Dallas Area Rapid Transit and in cooperation with the North Central Texas Council of Governments, North Texas Tollway Authority, Texas Department of Transportation and the cities of Dallas, Richardson, Plano Highland Park, and University Park. The goal of this project is to operate the U.S. 75 corridor in a collaborative manner among all agencies to save the traveler from congestion. For the first time, all agencies will have comparative travel data for freeways, toll roads, arterials streets, and transit. By knowing the fastest way to travel and sharing this with the public, travelers will be able to avoid congestion by traveling on different routes, traveling at different times, or traveling by transit.

Improvements in New Pavement Surfaces

New pavement surfaces can improve safety and improve the environment. Porous friction courses (PFC) are special asphalt mixtures characterized by high air-voids content (i.e., air gaps between the asphalt material) as compared to the most commonly used dense-graded hot mix asphalt. Placed as a surface layer, the PFC mixture reduces the risk of hydroplaning and wet skidding, decreases splash and spray, and improves the visibility of pavement markings in wet weather. These safety benefits (as evident in Figure 2) are realized as water travels through the connected air voids within the pavement layer instead of over the surface.

PFC also serves as a filtering mechanism for storm water runoff. The quality of storm water runoff monitored before and after installation of PFC on a highway in Austin showed a much lower concentration of total suspended solids and pollutants associated with particulate material after installation of the PFC. PFC pavements

also provide a significant reduction in traffic noise that is readily and reliably measurable at the roadside and is the primary reason for their increasing use in Europe.

The safety and environmental benefits associated with PFC result from the high-air voids in the pavement layer which allow for water and air to infiltrate and move through this layer. These same characteristics also have the potential to reduce the life of the pavement surface by causing oxidative aging of the asphalt binder (causing brittleness and stone loss in the surface) or by the action of water with traffic destroying the bond between the asphalt binder and the stone (leading to potholes) or destroying the bond of the PFC layer to the underlying surface (causing delamination or separation of the pavement material). TTI has an extensive, ongoing research effort aimed at optimizing the mix design and construction practices for PFC, as well as characterizing the properties of the asphalt binder and stone which are needed to guarantee the safety and environmental functionality without sacrificing durability.

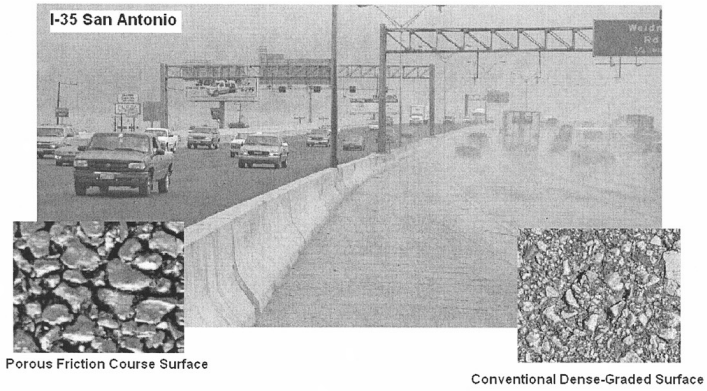


Figure 2. Porous Friction Course Surface (left) Compared to Conventional Surface (right) After a Rain Storm.

Improvement in Pavement Construction

Warm mix asphalt pavement technology can reduce air pollution and save energy. Traditional hot-mix asphalt is typically produced in either batch or drum mix plants at temperatures ranging from 280°F to 325°F. It has been necessary to use these elevated temperatures to dry the aggregates, coat them with the asphalt binder, achieve the desired workability, and provide sufficient time to compact the HMA mat. A new technology, warm mix asphalt can reduce the production temperature to as low as 200°F. This reduction in both production (mixing) and paving (compaction) temperatures yields beneficial environmental effects:

- decreased fuel or energy consumption at the plant;
- reduced emissions and odors from plants; and
- improved working conditions at the paving site.

While preliminary field trials (Figure 3) have indicated that these mixtures perform as well as conventional mixes, the technology is in its infancy and some of the laboratory tests that engineers use to predict performance indicate a cause for concern. The warm mix asphalt tends to exhibit lower strength and a propensity for moisture susceptibility in laboratory tests. TTI is conducting a comprehensive field and laboratory study to ensure that the improved benefits of warm mix asphalt do not cause a sacrifice in pavement performance.

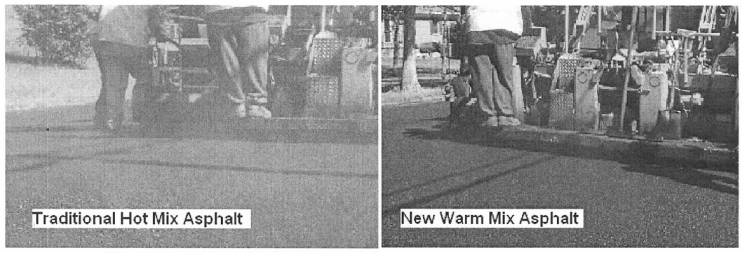


Figure 3. WMA Field Trials in Lufkin, Texas.

Environmental Management in Construction

When examining the impact of our surface transportation infrastructure on water quality, one should keep these numbers in mind:

- *1 soil*—is the number one pollutant of receiving waters
- *2 acres*—the size of a stormwater runoff oil slick created by a quart of motor oil
- *3 million dollars*—the largest stormwater fine ever assessed by EPA was levied on Wal-Mart for runoff violations at construction sites across the country
- *4 metals*—lead, mercury, iron, manganese can be found in runoff
- *5 pollution prevention benefits of vegetation*—includes protecting soil from the impact of raindrops, slowing down storm water runoff, anchoring soil in place, intercepting soil before it runs off, increasing filtration rate of soil

Roadway Grasses: A Marriage of Function and Beauty

Grass. It isn't just for mowing anymore.

In fact, the sometimes lush and pretty patches along roadways are an important frontline defense in the battle to improve water quality. But which varieties work best? For example, which seed mix of grasses will stand up to brutal Texas weather and regimented mowing heights? And just how much grass is needed to effectively filter roadway stormwater runoff?

The Texas Department of Transportation (TxDOT) sponsored a study conducted by the Texas Transportation Institute (TTI) studying these very questions.

The native alternative

While the concept of using native seed sounds great, two things need to be considered in its use, however. Number one, when a contractor goes in and strips off the soil, gets it down to subgrade, pours concrete and does everything else you have to do to build a road—you no longer have a native environment. Number two, in their natural environment, native seeds are left alone and allowed to grow. But highway rights-of-way are mowed three or four times per year. This changes the development of the native vegetation.

In a research project which concluded in August of 2005, researchers studied native seed species along with the standard, TxDOT-approved seed mix. Using soil samples taken from Austin, Abilene, Lufkin and Corpus Christi, TTI researchers tested the different seed mixes at greenhouse facilities and outdoor laboratories.

In addition, test plots were planted in Georgetown, north of Austin, using both commercially available native seed mixes and the standard TxDOT seed mix. Researchers also monitored a second set of test plots at TTI's Erosion Control Laboratory on the Riverside campus.

The laboratory at TTI is a unique testing facility that helps us cut down on research costs and yet still conduct accurate testing. One section of the test plots was mowed according to TxDOT specifications and the typical mowing schedule. This ensured that the performance of the seed mixes is evaluated under the normal conditions grasses would encounter along roadways.

Vegetation along roadways plays an essential role in stabilizing soil banks, stemming erosion and protecting habitats and waterways from too much sediment. Beyond beauty, this is ultimately grass' most important function.

Grass filters

Most environmental researchers agree that sediment is the number one pollutant of receiving waters. While some techniques, like construction sequencing, can help minimize sediment runoff during construction, establishing vegetation is the single most important step toward protecting waterways from harmful runoff.

Water streaming off the hard-packed surface of roads can grab sediment and pick up heavy metals and organic compounds (like motor oil), and would eventually deposit such sediment in pipes, drainage systems and water bodies were it not for one potent defense mechanism along roads: grassy filters.

The premise of this research was to study how vegetative buffer strips affect runoff from highways. Preliminary findings show that the more grass water runs through, the cleaner it gets. Leaving vegetation buffer strips near roads is a good management practice.

To study how effective grassy strips are at filtering runoff, researchers buried 30-foot lengths of eight-inch PVC pipe at two, four, and eight meters from roadway pavement edges along Hwy 6 in College Station, Texas, and Hwy 360 in Austin. Rainwater is collected during test periods and is then sent to the Lower Colorado River Authority in Austin for chemical analysis.

Research into how vegetated roadside swales (shallow depressions that carry water mainly during rainstorms) can function to filter storm water runoff, reduce the need for end-of-channel water quality structures, and improve the overall quality of runoff from the highway system is important. Understanding the properties of and having good documentation of roadside water quality performance can potentially reduce the cost and size of end-of-channel water quality structures on the highway system. The results of this project showed that up to a certain distance, grass can be quite effective at trapping and filtering sediment.

Introducing Native Plant Life to Roadsides

Traveling down the highway can be tedious—miles and miles of road, tens of thousands of lane markers and traffic signs. Sometimes the scenery is the only thing that keeps you awake. But the Texas Department of Transportation (TxDOT) sponsored a study conducted by the Texas Transportation Institute (TTI) to use native plants to recreate the visual character of the regional native landscape. Prior to this time, the typical approach to interchange landscape design was to create a park-like setting dominated by canopy trees. Maintenance required mowing the area at the same frequency as other sections of corridor.

This project explored the use of local plants in landscaping the roadside rather than using a one-size-fits-all approach. This would not only give the roadside a 'local look,' but would also facilitate the growth and maintenance of the landscaped area by using plant life native to the area.

An interchange in Austin was used as the test case. A context-sensitive design was used to enhance both the local community and the natural environment. Located in an urban area amid office buildings and shopping centers, the interchange presented some design challenges. TxDOT wanted to reduce maintenance while developing a publicly acceptable landscape aesthetic. The first three goals of the design plan were established as eliminating the need for hand maintenance wherever possible, especially near travel lanes, preventing erosion on slopes and improving the appearance and maintainability of the detention ponds.

Researchers worked with various stakeholders—City of Austin Parks Department representatives, representatives of the Lady Bird Johnson Wildflower Research Center, the Texas Parks and Wildlife Department, and representatives of local, grassroots environmental programs—to finalize the site design.

Water quality was identified as the key environmental issue since so much water flowed through the site. The plan called for enhancing the siltation function of the ponds by installing a rock filter dam and reducing mowing. The aesthetic goal was to recreate the visual character and, as much as possible, the ecological character of the Texas Hill Country live oak savanna.

Aesthetically, the site today resembles some commonly seen rural landscapes of native plant communities. The new maintenance schedule reduces the frequency of mowing, which, in turn, reduces management costs to TxDOT and taxpayers.

This project demonstrated that we can improve maintenance, make the roadside look better, reduce erosion, and improve the environment for native plants and wildlife, even in urban areas.

Future Research Needs and Federal Role

The Green Transportation Infrastructure initiative is bold idea that will impact how surface transportation is designed, built, and operated. Thus, it is imperative

that the industry fully understand the benefits of "going Green." There is significant research needed to fully explore the impact and benefit that will result from Green Transportation implementation. The research must take a holistic approach to ensure direct benefits and secondary benefits are fully analyzed.

Furthermore, once the relationships between Green Transportation strategies and the resultant impact are known, this information must get into the hands of transportation design and construction industry. Research is only as good as the ones implementing it. The university transportation center network has well established processes and delivery methods to disseminate and train the transportation industry.

The research and academic community has not always had direct input into setting the research agenda at the federal and State level. To ensure that Green Transportation Infrastructure builds on successful past research and truly addresses gaps in research going forward it is imperative that the academic community has input. The University Transportation Centers have successfully created the environment where academia and industry can collaboratively set research agendas.

BIOGRAPHY FOR CHRISTOPHER M. POE

Professional Interests

- Freeway management systems
- Intelligent transportation systems
- Advanced traffic management systems
- Geometric design
- High occupancy vehicle lanes

Education

- Ph.D., Civil Engineering, The Pennsylvania State University, University Park, Pennsylvania, 1999.
- M.Eng., Civil Engineering, Texas A&M University, 1987.
- B.S., Civil Engineering, Texas A&M University, 1986.

Experience

- Assistant Agency Director, Research and Implementation Division—Dallas, Houston, Texas Transportation Institute, December 2006–Present.
- Senior Research Engineer, Research and Implementation Division—Dallas, Houston, Texas Transportation Institute, June 2005–Present.
- Senior Research Engineer, Research and Implementation Division—Dallas, Houston, Texas Transportation Institute, June 2005–November 2006.
- Center Director, TransLink® Research Center, Texas Transportation Institute, December 1996–August 1999.
- Associate Research Engineer, System Monitoring Program, Texas Transportation Institute, January 1996–August 1999.
- Research Assistant, Pennsylvania Transportation Institute, 1993–January 1996.
- Assistant Research Engineer, System Operation Management, Texas Transportation Institute, September 1991–August 1993.
- Engineering Research Associate, System Operation Management, Texas Transportation Institute, December 1987–August 1991.
- Research Assistant, System Monitoring Program, Texas Transportation Institute, September 1986–December 1987.
- Junior Structural Engineer, Hudson Products Corporation, 1985–December 1985.
- Junior Structural Engineer, Raymond Kaiser Engineers, 1984–May 1984.

Consulting

- Parsons Brinkerhoff Farradyne, Dallas, Texas, October 2002–May 2005.
- Parsons Brinkerhoff Farradyne, Dallas, Texas, August 1999–October 2002.

Professional Registration

Registered Professional Engineer in Texas, Registration No. 70345.

Selected Publications

E.J. Seymour, J.D. Carvell, D.W. Borchardt, R.E. Brydia, C.M. Poe, M.D. Bomar. *Development of Guidelines for Data Access for Texas Traffic Management Centers.* Research Report. 0–5213–1. Texas Transportation Institute, College Station, TX. May 2007.

Selected Presentations

Technologies for Managed Lanes. Presented at ITS America Annual Meeting, Palm Springs, California, June 2007.

Advanced Public Transportation Through Technology. Presented at Texas Transportation Summit, Irving, Texas, August 2006.

DISCUSSION

Chairman WU. Thank you very, Dr. Poe, and at this point we will begin with the first round of questions, and as Chair, I recognize myself for five minutes.

For the next major surface transportation reauthorization, which is coming up very soon, I would like to ask of each of the witnesses what you all think are the key research priorities for the Nation for surface transportation in this next bill, especially in the context of reducing life cycle energy use and promoting sustainability. Whoever is right can proceed, but if Mr. Brubaker, you would like to start, perhaps we can just sweep from my left to my right.

Mr. BRUBAKER. Okay, Mr. Chairman, sounds great. I would suggest that, I think we have laid the ground for, as we have laid out our priorities for research in the Department, particularly in the areas of materials. We have divided up the research portfolio into communities of interest, one of which is materials, and focusing on that and ensuring that there is, you know, enough visibility and enough investment going into that particular arena, both in terms of basic research development, some applied research development, particularly focusing on the applied side and then the technology transfer activities, and I think that would be most helpful, as well as the continuation of the Intelligent Transportation System portfolio but to make sure that it is focused in such a way as you described in your opening statement.

Chairman WU. Thank you.

Mr. Iwasaki.

Mr. IWASAKI. I think that the way the research program is set up currently, it is a good one. The problem is, it doesn't have enough money, and I mentioned in my testimony that the Strategic Highway Research program was set up for $450 million and it was reduced to $150 million. There are some key components that are left out that we could take a look at not only on congestion relief but on the material side as well, and being able to do our jobs faster, better and for less money. So I think that make it performance-based however you do it but I think we ought to add more money to the research program nationwide. Percentage-wide in the transportation business, it is a small amount of money versus what other facets of industry looks at. The other thing is, those demonstration projects are pretty critical and we would be willing to submit any performance-based criteria proposal to Congress to get

some of that money. I think California competes very well and we love to compete and we are very aggressive at it, and so maybe more deployment or demonstration projects and then couple that with the resources necessary to get the word out on the benefits of those demonstration projects.

Dr. BERTINI. Sure, for the reauthorization, there are a couple points that I made earlier. The first one is the data infrastructure, so if we want to have a transportation system that is sustainable and green, we need to be able to measure that, and so having the infrastructure for robust data collection and evaluation is really important. Evaluation—I have—we talk about one percent for art in government-funded buildings and projects. I sometimes talk about X percent for evaluation. Sometimes I say four percent if I am talking about a project in the city of Portland in the safety area that we have going. Randy mentioned this need for ongoing—you know, thinking of setting aside a percentage of what we do for evaluation and monitoring, and then I guess the idea of green performance measures so we talk often about reducing congestion, reducing delay, but I think the general public is not really aware of what the, let us say, sustainability impacts of that are, the fuel consumption, emissions, noise and so on.

Mr. VOIGT. Thank you. I think our industry's picture of what would be needed in research is probably best split into two major focus areas, the first being with regard to the material side and things we can do to further enhance the sustainability in use of materials within concrete particularly, recycling methods. There is a great ability to recycle concrete and use it back into the mixtures that are used directly in highways. There are a lot of agencies that are reluctant to do that in certain areas. We feel that there is a lot more opportunity there as well as further use, and I believe it was mentioned earlier in one of the remarks with regard to further use of fly ash and further use of slag as part of concrete mixtures. There are blended cements that are manufactured by the U.S. cement industry that are not routinely used in highway pavements that could be routinely used in highway pavements and they would have a sustainability benefit. So there are a number of associated materials issues that could be addressed. We also see the other side of looking at the sustainability of the use of the paving structures, and by that what we are getting at is, some of those things I directed in my comments earlier with regard to the fuel efficiency of vehicles on the pavements, the lighting and energy savings that could be derived by the reflectivity of the pavements, and those associated benefits in energy savings that we are not currently accounting for in the selection and the use of pavement systems. And so we see need for research and further development of our understanding along those areas coupled with a decision framework that needs to be put into place to include those sustainability benefits as part of the selection criteria, and that simply is not happening right now. It is purely a cost basis method of selection that is being used. So we see a need along those lines.

Chairman WU. Thank you.

Dr. Poe.

Dr. POE. Two things. Let me echo Dr. Bertini's comments about evaluation. If we are going to challenge the industry to do things

differently, new transportation solutions, we better know the impact of those and what the relationship between those transportation solutions are and the impact on our environment, and that closely ties a measure and be able to evaluate is highly important. The second thing is, green transportation is a very broad topic. It involves researchers and industry working all different parts, and by bringing—currently right now they are kind of working in their areas, and by bringing attention to green transportation and allowing to come under one umbrella and getting those collaborations between the research environment and industry working together on one solution, how do we reduce the impact on our environment, will go a long way in reauthorization to come up with good solutions.

Chairman WU. Terrific. Thank you very much to all the witnesses.

Dr. Gingrey, you are recognized for five minutes.

Mr. GINGREY. Mr. Chairman, thank you. I was at a meeting early this morning, the Oversight and Investigation Subcommittee of the House Armed Services, of which I am a Member, and we were talking about making sure that people understand the difference in a strategic plan and how that leads to policy and operational activity, and so I want to ask a real direct, simple question of all the witnesses and start with Mr. Brubaker, and that is, what do you think is the single most important thing that the Federal Government could do to increase adoption of new transportation technologies from a strategic perspective as we go forward to set policy for the 21st century in regard to surface transportation?

Mr. BRUBAKER. I am glad you asked that question. Fundamentally, knowledge sharing, and it is an area of focus that we have put into our strategic plan but the good news about, you know, having it in our strategic plan is, we have actually made it actionable. We are actually coming up with a construct to share knowledge, particularly and beginning with the University Transportation Centers. It is very—it was very telling when I took over this organization that we had a lot of great activity going on in various University Transportation Centers and out in the research community generally but that knowledge, that research wasn't being shared amongst researchers who were doing work in similar areas. That is one aspect of it. The other aspect of it is, we would have these great meetings where, you know, the research community might get together once a year, and particularly at TRB, Transportation Research Board's annual meeting, and they would communicate with other researchers as opposed to making a concerted effort to share knowledge, capture that knowledge and be able to transfer that knowledge to the private sector or to not-for-profits who could actually look at commercializing some of these things and deploying them and develop standards that you could actually use for deploying these technologies and getting them out in the field. So that is key to us.

Mr. GINGREY. Thank you.

Mr. Iwasaki.

Mr. IWASAKI. I think the best way to phrase this would be, in our strategic plan, we have guiding principles, and one of our guiding principles is innovation, and there are a lot of mothers and fathers

of innovation when it works right. There are no takers when it doesn't work, and so how does the Federal Government help states deploy innovation? Accept some of the risk. Take a risk, don't make us go through these arduous review processes and get that technology deployed sooner because at the end of the day it is just costing us more money, so it is going to take some time, but I think on a strategic level, accept some more risk.

Mr. GINGREY. Dr. Bertini, in Oregon?

Dr. BERTINI. I would say if I had to say one word, I would say incentives, so there are incentives built into the way transportation systems are developed now. People are rewarded by feeling proud about a big project, a big bridge. I got into transportation because of the Golden Gate Bridge. When I was a kid, I loved this bridge. But people—you know, I get excited—Mr. Iwasaki mentioned this earlier this morning, I get excited when a new sensor is placed out on the roadway network, but are there incentives for transportation agencies to make sure that the underlying hidden infrastructure is as good as it can be, as advanced as it can be, so incentives across the board for the individual, let us say, people who are doing the work, for them to become more educated and more inspired by implementing advanced technology and for the agencies who are building and maintaining the systems as well.

Mr. GINGREY. Mr. Voigt.

Mr. VOIGT. Thank you. I would go back to address the question to some of the remarks in my testimony. I think that most pavement decisions right now are really based on a first cost or a lowest cost method. That really is not necessarily easily linked to doing more sustainable construction unless you include within that decision process those benefits and economic impacts of the longevity and the other things that are associated with sustainable practices.

Mr. GINGREY. And that—if you will permit me to interrupt, that is basically what I was getting at in regard to strategic planning, and I think you are getting to that point.

Mr. VOIGT. Yeah, you know, we have looked at a number of research studies that indicate that there is some benefits that simply we haven't accounted for in the methods that we are using in the processes we are using, so what we feel that the federal level could really be helpful in this regard is to develop a strategic framework for including those factors of sustainability and those benefits and features, perhaps creating that and deploying that within the more local agencies. That would be motivation, I think, and guidance perhaps to allow that practice to pervade across the country, but I think it needs to—personally, I think it needs to start at the federal level to provide that framework and that guidance to go on down.

Mr. GINGREY. Thank you.

Mr. Chairman, if you will permit me to allow Dr. Poe to respond as well? Thank you very much for your generosity.

Dr. Poe.

Dr. POE. Similar to what was said, I think incentives and some reward for challenging the community to further pursue green transportation. As I was saying just earlier to Chairman Wu, we have researchers working on soil erosion, we have researchers working on pavements, we have researchers working on traffic con-

gestion and traffic signals, but by calling attention to this and giving incentives for the states and universities to work on this problem brings those collaborations together and I think that will advance the whole area significantly.

Mr. GINGREY. Thank you, Mr. Chairman. I yield back.

Chairman WU. Thank you, Dr. Gingrey.

The gentlelady from California, Ms. Richardson, is recognized for five minutes.

Ms. RICHARDSON. Yes, thank you, Chairman Wu.

First of all, a statement for all of the panelists that we have here. Much has been said about providing additional funding for research but I would like to respectfully request that you provide to the Committee is specifically how much do you think would be needed and for what specific projects. As we go through looking at SAFETEA–LU reauthorization and various appropriation changes that we can do in the upcoming year, if you give us specific examples of what you would like us to consider, I am sure the Chairman and others would welcome that thought.

Mr. Iwasaki, coming from California, I apologize that I wasn't here to properly welcome you to the great area here of Washington, D.C., but California is known to be at the forefront and more people need to know the tremendous work that is done at Caltrans, so thank you for being here. My question for you is, has California carried out any cost-benefit analysis, which is leading really into the last comments that were made, for specific technologies and materials that you described in your testimony? If so, what were your findings and how do life cycle costs and benefits affect your decisions about which technologies and materials to use?

Mr. IWASAKI. We are currently analyzing the cost-benefit basis for a lot of the technologies that I mentioned, the system-wide adaptive ramp metering, those kinds of things. We did an 18-month project and deployed signal synchronization down in the Los Angeles area as well as a SWARM project along the 210 which has dramatically improved the throughput through that corridor, and what we are doing now is, we are analyzing the benefit-cost information then to pass onto other regions for that technology. We have done some benefit-cost analysis on some of the demand management strategies like freeway service patrol. In some cases where you have a highly congested corridor, it is 22 to one and it is better than any new freeway STIP project that you could ever achieve but it is not really sexy. It a freeway service patrol. But as far as getting people on the move, it is a very, very effective tool. I think some of the things in the future, what we are trying to do is, we are trying to on our corridor mobility improvement account, the $19.925 billion bond, the $4.5 billion worth of projects, on those we are doing before-and-after studies to see how effective the change was that we made.

As far as materials are concerned, we don't do a lot of benefit-cost analysis on our material-type selection. We do it based on, we design to a certain life so if we want a 20-plus-year pavement, generally we go to Portland cement concrete. If we do a rehabilitation project, we will do an asphalt concrete. And so in those cases, we are driven by past practices.

Ms. RICHARDSON. And some of the other Members spoke about the fact that when you are responding to bids, it is typically on an initial cost perspective. So you find that your states are being more supportive of looking at the more lifetime, lifespan cost and making sure that they are really evaluating the cost of the project effectively?

Mr. IWASAKI. Well, absolutely. If you look at the rapid rehab project that we did at Devora on I–15 heading to Las Vegas, it was done in about 17 days. It cost a lot more money initially but it put the utility back in the hands of the public. I say you are going to take your castor oil over an eight-month period or are you going to do it over a 17-day period. Most people would rather do it on a short-term basis. Currently, we are rehabilitating the boat section in Sacramento. We did each direction in 10 days, and we used a new, fast-setting concrete mix designed there so it would limit the amount of shrinkage and those kind of things, and that project is going to last another 50 years, but we had to take traffic off of it and so it cost us more money up front but the benefits far outweigh the initial costs.

Ms. RICHARDSON. Okay. And Mr. Voigt, a couple questions for you. You note in your testimony that many State transportation departments do not consider life cycle costs when making decisions regarding transportation infrastructure. How does the concrete industry determine life cycle costs, especially when multiple variable factors, such as the cost of fuel, come into play? What research is needed to better understand the life cycle costs of transportation infrastructure?

Mr. VOIGT. Let me clarify that where the states are not using in many cases—I have to be a little careful with making judgments across many states because the practices vary so widely but in general, where we see less decisions being based on a life cycle basis is on the maintenance and the preservation end of the system, and so that is an area where we feel there could be more done, but going back to linking the usage end, this is the key piece to us, the usage end of the roadways, there are many sustainability benefits and/or disadvantages, depending on what you are looking at for your project, that are simply not accounted for in the process and we feel that again if we begin to account for those, then that will in and of itself incent the use of more sustainable practices. It would be simply looking at it maybe from a local government perspective of saying we are paying so much energy for lighting costs, but if we use this pavement selection, we would reduce that cost on this side of our budget while we may have to pay a little bit more up front on this side of our budget, but in the long run, it will take down the entire budget of the agency. It is a matter of looking just simply not at the paving materials end, the projects themselves, but looking across the perspective.

Ms. RICHARDSON. Thank you, Mr. Chairman. I yield back.

Chairman WU. Thank you.

The gentleman from Michigan, Dr. Ehlers.

Mr. EHLERS. Thank you, Mr. Chairman.

Mr. Brubaker, what is the total annual budget of the federal Department of Transportation?

Mr. BRUBAKER. That is a good question. It is in the high 60s. I will get you an exact number for the record but it is in the high 60s.

Mr. EHLERS. Okay. Now, that includes what? Is that everything? That includes the FAA as well as the highways, et cetera?

Mr. BRUBAKER. No, I don't think—I think—my staff informs me that that is the total budget.

Mr. EHLERS. How much did you say, 80?

Mr. BRUBAKER. No, close to—it is in the high 60s.

Mr. EHLERS. Okay. And what is the budget of RITA, your little niche there?

Mr. BRUBAKER. Well, that is a great question. The appropriated budget for operations is in the neighborhood of $12 million but that doesn't include fee-for-service organizations such as the Transportation Safety Institute which adds probably another $20 million in revenue plus an additional—and I will get you the exact numbers for the record—plus the Volpe National Transportation Center, which is a fee-for-service organization that adds another $160 million or so to the operation.

Mr. EHLERS. Where does that money for that come from?

Mr. BRUBAKER. That comes from customers on a fee-for-service type——

Mr. EHLERS. And who are the customers primarily?

Mr. BRUBAKER. The customers are primarily the transportation modes within DOT. It is a fee-for-service-type arrangement.

Mr. EHLERS. Okay. The reason I am asking these questions, do you know any private sector company with an annual budget of $70 billion which would have a research budget somewhere in the low millions?

Mr. BRUBAKER. No, sir, I do not.

Mr. EHLERS. And I suppose you understand there is a reason why they spend more than that.

Mr. BRUBAKER. Yes, sir, I do.

Mr. EHLERS. Because they want to stay in business, right?

Mr. BRUBAKER. Yes, sir.

Mr. EHLERS. And you can't stay in business, you can't do a job without the research money. The reason I am asking this is, we have to publicize the fact that the government is being very stupid in this, and I have to implicate the Congress in that as well. The private sector has learned that if you want to stay alive, you have to do the research. This committee has the responsibility for the research direction and funding and yet we are advisory in a sense to the Transportation Committee. When we went through the last go-round and Mr. Wu, our roles were reversed then but as you recall, we worked together very hard to improve the amount of funding going for research in the transportation department, particularly in RITA, and it got knocked down by the House Transportation Committee, got knocked down every more by the Senate Transportation Committee, and what we had submitted was not nearly as much as you should have. You can demonstrate that research money saves money in construction, no question about it, and yet we are not doing it. We are throwing away a lot of taxpayers' money in the name of getting projects done without researching the best way to do it, and I think we simply have to publicize this so that the

next go-round, we can give you the kind of funding you need, and I am not saying you are not doing a good job. I think you are doing a great job with the small amount of research funding that you have, but it is just unconscionable to me. It is not just because I am a physicist and a researcher, but any businessperson looking at this would say good grief, if we can do enough research to add just an extra year to the life of the concrete we are laying this year, how much do we save? Well, obviously you would save enough to pay for the research many times over. Similarly, the different types of concrete, as Mr. Voigt mentioned, and all the research that is being done there, and similarly for asphalt. We are being penny-wise and pound-foolish. Now, this is pretty much the end of my sermon, and I know, I am preaching to the choir when I talk to you or to this group, but we really have to make that impact on the Transportation Committee on the next go-round. Mr. Brubaker.

Mr. BRUBAKER. I would like to make a couple of clarifying points just so we understand what we are talking about here. The numbers I was giving you or I gave you are the operational numbers of RITA, and staff reminded me that there is an additional $27 million going for the Bureau of Transportation statistics, which is the data side of the house. But just to be clear, I want everybody to understand that the total research budget of the Department is almost $1.2 billion, so there is sufficient—we can talk about sufficient—what I want to make sure of is that we understand that the total research budget dollars that are allocated for research-related activities in the Department of Transportation amount to about $1.2 billion a year. Now, getting to your question, I don't know any similar ratio in a technology-intensive private sector firm that would even equate to that, so your point is still well taken.

Mr. EHLERS. And I am not criticizing your department or your operation in any way. I want to make that clear. That is not the reason for the questions. The reason is simply to say we have to do better than that, and if we are really talking about running government efficiently, then we have to design projects efficiently and you have to build them efficiently, and I am convinced that we could add a considerable amount to RITA's budget and have it pay for itself by doing the research properly and building bridges and highways properly and so forth. So this is just a plea to you to help us in our battles with the Congress next time around to make sure you get the funding that you need and that will really pay for itself. I think the states will all agree with that too, and I know states, individual states spend money on research too. When I was in the Michigan legislature, I helped get some funding for research at one of the universities.

But putting it all together, we are just not doing it as well and as efficiently as we could, and so let us all join this battle together next go-round and make sure we start off from the blocks running and make a very strong case. Thank you, Mr. Chairman.

Chairman WU. Thank you, Dr. Ehlers.

Mr. Brubaker, when Dr. Ehlers is trying to push research money your way, my recommendation is to just accept is graciously, especially when you take into account the building dollars that come in from city sources, county sources, State sources, and what I would

guess would be proportionately smaller research budgets at those levels. I am going to try to squeeze in two quick questions.

Mr. EHLERS. Mr. Chairman, may I just add one comment?

Chairman WU. Of course.

Mr. EHLERS. I am sure that you are aware that if we do increase the research budget, that a good share of it gets shoveled off to Dr. Bertini's institute and other institutes in Oregon.

Chairman WU. That thought had not occurred to me but I am glad you point that out. Metrics—we have had some sort of cursory discussion of metrics but how do you measure lifetime environmental impact or energy costs or other costs, what methods exist, what are the metrics that are being used? To the extent that any of you all can expand on the discussion that we have already had, I would greatly appreciate that. And if we do this quickly, then I will try to rush on to a second question.

Mr. VOIGT. I can respond to that to some degree. The National Research Council of Canada has done work in looking at the life cycle of paving systems. That includes all of the energy and the embodied energy in the materials that are used as well as the energy used to place the pavements, to recycle the pavements or to—I should say to rehabilitate the pavements over many cycles. They did a 50-year analysis. That was information that we had. It is cited in my written testimony. And I think a similar thing would be very helpful here. Now, the one thing the Canadian study did not include was the operational fuel issues but that could I think also be included, linked up with some research on the fuel efficiency issues. So there is some work that has been done. It needs to be expanded but I think it would be greatly helpful to making this connection and this framework that we need to really put those sustainability issues into practice.

Chairman WU. Thank you.

Dr. Bertini.

Dr. BERTINI. In my testimony, I talk about standard metrics that are used and I think we know how to estimate the emissions, let us say, costs of different alternatives and different projects or products. We know how to estimate the noise impacts, fuel consumption impacts. One of the problems is that these impacts accrue to different people in different ways so in the case of a project that Caltrans wants to build, their capital budget has to pay for additional capital costs of the 17-day project versus the eight-month project. The benefits, if I save time or if I live near there and I breathe fewer particulates, there isn't some slot machine where coins are coming out and going into my pocket. Those are costs that are spread out and not accounted for anywhere, even though they are a benefit to society, so I think a lot of the, let us say, green and sustainable benefits of projects are not ones that show up in a capital budget, they are ones that show up over a much longer term in people's health, in the health of our economy and so on. So I think incentives and rewards for finding ways to include those slightly more intangible benefits are really important. There was seminal work done at the University of California–Davis. I should say I am a product of the UTC at UC–Berkeley so the UTC program is, you know, creating generations of transportation researchers and, in my case, UTC directors. But at UC–Davis, Mark

Delukey has done a lot of work, it would probably fill this table, with trying to quantify the full cost of transportation on society in some of these unquantified ways so a lot of that has already been established. It is just a question of how to account for it.

Chairman WU. A lot of these methods exist. Some need to be disseminated, and then to the extent that others are missing, I am particularly interested in that, particularly with respect to new materials or methods. Does anyone else want to—Dr. Poe?

Dr. POE. Just on congestion specifically, one of the things—we spent a lot of time trying to relate to the public and media, how do you convey this congestion. Travel time is very well understood. How much time does it take you to get from where you are starting your trip to your destination and how much time you actually spend in congestion. The public measures this on a daily basis. But the other thing that is gaining increased importance is reliability, and reliability is, how much extra time do you have to plan for to make it to your trip on time, and people really understand that, and so trying to come down to this hearing itself, how much extra time did you have to budget in your day and your trip to make it. It plays very well and the public understands that and they are paying the price right now with congestion.

Chairman WU. Anyone else? Mr. Iwasaki.

Mr. IWASAKI. I will just add this. Through the bond initiative, we are looking at how green our projects are, and it is project-specific. The problem is, we don't have data for every project and so we are having to go put detection systems in to gather the information to correlate the reduction in carbon, for example, and so, that is the other piece is that we need data. We need a reliable, good source of data then to make the calculations and that is not everywhere in the United States and so we need to kind of keep that in mind when we do these things. It is not a model. You have to get down specifics of a project and the benefits and that is what is harder to do, and we worked very closely with one of the UTCs, UC–Davis, on the sustainability issue.

Chairman WU. Thank you very much. Since I seem to be the lone person standing, I choose to recognize myself for an additional five minutes. What has happened in the course of this hearing is one graphic illustration of what you plan for and then sort of the dispersion of time that can occur. My flight might leave from Dulles at 6:15 and if everything goes right, I could leave the Hill at 5:00, but that would be very unwise. I try to leave at 3:00, and if everything goes right, I am at the gate at 3:45, but if things go wrong, and that happens about 40 percent of the time, yeah, that time gets taken down and I have to plan for that no matter what, and I think the general public gets that very, very well, and I just want to work with you so that we can all get a little bit more certainty on our planning. We can enhance our research budgets where we need them to be on the transportation side.

I wanted to ask a pretty general question about workforce training. Until I got more familiar with some of your work, I was quite frankly a user of the end product or service but not well aware of you all's work, and I am sure that there is not only a huge workforce in building the transportation networks but there is significant issues in workforce training on the research side and on the

implementation side, and if you could try to address some of those workforce issues, whether it is at the research end or at the far end of actually getting things built and everything in between about removing barriers to better transportation system.

Mr. BRUBAKER. Just on the research side, if I may, and this is a dangerous thing to say sitting at a table with a whole bunch of civil engineers, but, you know——

Chairman WU. And they are civil.

Mr. BRUBAKER. And they are civil, with an emphasis on the civil. The point you were asking or the question that you were asking before about data, I think it illustrates what I am about to say. We really have to have a better understanding of the holistic performance of the supply chain, of passenger movement, of system performance generally speaking and then understand and mitigate whatever impacts that construction projects may have on system performance, disruptions, manmade or natural, have on that system performance. In order to best do that, it is really imperative, and particularly when this comes to planning as well, that we had taken an interdisciplinary approach to the research, that we bring not just civil engineers to the table but we bring economists, business people, you know, social scientists, behaviorists so that we have this holistic understanding of system performance and disruptions to the system and what that may mean for the economy and how people respond and react as well as getting into the material side of sustainability issues but also the business side of it. For example, when Mr. Iwasaki was describing, you know, the 17-day project and the reason why they do that, it is because they recognize that there is an economic cost to that disruption that has to go into that equation when they determine what is the best course of action for the public. So that is what I would say in terms of workforce, to ensure that we are training researchers and opening our aperture, if you will, to embrace folks from multiple disciplines and not just the civil engineering community anymore, not that they are not important and critical to this but it needs to go beyond that.

Chairman WU. Mr. Iwasaki.

Mr. IWASAKI. About 50 percent of the managers in California State government are eligible for retirement over the next five to seven years. That includes Caltrans, and that really concerns us. Of course, that is not me. I am too young for that yet. But ultimately I will retire and so somebody has to replace us and so that was a focus. So, with this influx of new money from our bond initiative, we created what we call ICE. It is Industry Capacity Expansion. So we need more aggregate because we are going to build more. We need more people to go to the trades. How do we go out to the grammar schools, the grade schools and get people energized about going into trades, to be finishers, concrete finishers, to drive trucks. And then how do we work with the UTCs to generate the next generation, like Dr. Rob here, he is a product of the UTC system so he is—because you fund UTCs, he is a product. Now he is a leader. He is one of the directors of a UTC. It is a great process. But how do we get these people energized into going into civil engineering rather than becoming the next owner of Google or something else because that is really what our video games and those

kinds of things. And so we are trying to energize the young people, and also we have the Garrett Morgan symposium where we adopt high schools. Caltrans has—we try to adopt 12 different high schools in California and talk about science and mathematics and get them interested in not only engineering but the trades as well. And so we recognize the problem. How do we rebuild America? How do we rebuild America smart and use existing labor? We can't. We need more people. And so we are trying to do that through various tools.

Chairman WU. Dr. Poe, did you have something? Dr. Bertini.

Dr. BERTINI. Going in order. It is safe to say that we have a workforce crisis in the transportation field and many of us are working hard to respond to that, and the technology transportation and education mission of the UTC program in addition to research is critical to that, and it is exciting to me in our UTC that I believe have about 12 different disciplines working on projects, working together. I am a civil engineer but my colleagues from statistics and computer science, urban planning, geography, psychology and landscape architecture and more are working together, sitting around the table working to solve problems, and that extends to students, so you visited our Intelligent Transportation Systems lab and we have students there from not only civil engineering but urban planning, statistics and computer science, and they are working together on projects and learning to communicate in each other's language, which I think is part of this issue. Communication from the various disciplines is a little bit different. So I think the workforce crisis can be solved. There are some easy things in my written testimony that I talk about, so part of it has to do with funding. The other part has to do with some policies that could be easily changed with regard to out-of-state travel, so if a staff member of a transportation agency in Oregon wants to come to Washington, D.C., for the Transportation Research Board annual meeting, perhaps they work on their own time on a paper that gets accepted for presentation but the agency policies won't allow them to leave the state, won't even allow them to spend the night in Washington State. So I think thinking about the fact that we want to retain the top talent that we have and giving them opportunities to share knowledge about their projects and learn about other projects in other states, I think is a very small price to pay and those policies could be easily changed.

Mr. VOIGT. I represent a lot of companies that have laborers and it is a challenge to get practices, you know, and get those folks to the point where they are able to apply the technology. What we started in 2006 really was the National Concrete Pavement Technology Center. It is centered at Iowa State University, and we took a different approach with that, somewhat based on a frustration level on how long it takes for new technology to come into practice, and we hear different people say, you know, different things, and our estimation is, it is somewhere between 10 and 15 years in the transportation area for new technologies to really pervade practice, and that is just not good enough, and so we put a technology center together and the idea behind that was collaborative research, and we feel when we involve the industry with the states and the Federal Highway Administration Together, creating the technology and

doing the research, that the acceptance to put into practice should be shortened and we are starting to see some fruits from that. So I think as we look forward to, you know, new technologies and sustainability and energy efficiencies and many of things we have talked about this morning, we have got to also factor in that working together is the way to get that into practice faster and we have really looked at it that way in the way we are approaching all of our research and technology areas. The last thing I would say is, in our industry, we are just now starting to use technology, putting technology on our sides, webinars and those types of things as just additional ways to get the information into the hands of the people that need to do it. For many of the challenges that we see out there from our traditional education, people can't travel across State lines. You can't do regional seminars. We have to find other ways to get the information into their hands.

Chairman WU. Mr. Voigt, you talked about the program at Iowa State that your organization was setting up. I have seen Dr. Bertini's transportation research center. Is there a role at a—is there a role for our community colleges apart from research in this human training need?

Mr. VOIGT. I would think yes. I would think that there could be very interesting benefits to that and some programs that could be created at that level. At a time in a young person's life when they are still maybe looking at what it is they want to do, that could inspire them, and we are, I don't think, doing a lot in that area that I am aware of across the industry, the transportation industry. I think that sounds like an interesting idea.

Chairman WU. Dr. Poe, anything to add, or do we have further comment?

Mr. IWASAKI. I just want to really quickly add, at the community college, we actually work with a community college to help train equipment operations in the Stockton area so we have a joint program with the community colleges there. We also have a program with the community colleges to help sign up DBE participants. They explain how to fill out the forms and those kinds of things and so that helps us get more DBEs under federally funded contracts.

Dr. POE. Just real quickly, I will just say that when you invest in research, the workforce training is a byproduct of that. You not only invest in the researcher doing the work but the students that are helping the researcher do the work and it helps broaden the workforce. We have added a technology transfer component on researcher proposing projects. They have to get funded. They have to show a path that they are going to take technology transfer training, so we don't even fund projects through out UTC now that don't have that built into the whole project from the start.

Chairman WU. With respect to intelligent highway systems, is there an inter-operability or compatibility issue? And I am asking this question because in other context, for example, in first responders, we have significant inter-operability compatibility issues. Is there a parallel issue in intelligent highway systems?

Mr. BRUBAKER. I think it is fair to say that there is a concern but it has been somewhat obviated by the fact that we have got an intelligent transportation system architecture that we have more or

less prescribed. We have laid it out there for people to build to so we have got an architecture that establishes certain communication standards, certain communication protocols to ensure inter-operability for that very specific reason. And we are in the process right now of refocusing, re-energizing that architecture, particularly at the communications layer to ensure inter-operability in the future. So it is a significant concern, particularly when you have got new communications capabilities that are coming on line that we haven't really dealt with before like wireless communications and wi-fi and wi-max and some use of cellular and radio spectrum that we are interested in exploiting to enable future intelligent transportation systems applications. So it is an issue but I think we are working hard to make sure that it doesn't overwhelm us and that we can ensure inter-operability.

Chairman WU. Okay. I have many other questions that I will either submit in writing or just keep to myself until some future date when we meet in a far, far better world where the premium of time is a lot less, but I do want to ask one further question of the panel and particularly Dr. Bertini. Sometimes I am a quick adopter of technology. Most frequently I am a late adopter because I want to make sure it works. The one thing that would drive me to have one of those little display screens on my dash that shows a map of the street grid, I have seen it in your laboratory, the current traffic status from red to yellow—I am sorry—from green to yellow to red, I believe. There is this horribly slow way of getting traffic news through the radio, and I frequently wondered why does this late-model car not have a little pop-up so that I can access not only the map, the static map but I can access the current flow information on the highway grid. Does that exist and I am just not using it? Go ahead, whoever wants to take that.

Mr. IWASAKI. In California we have predicted travel times so we have the algorithm set up to give you on changeable message signs from, let us say, Navado to SFO so that you as a traveler, if you take that often, you are going to——

Chairman WU. No, I have seen those and I really appreciate that. I am just wondering if——

Mr. IWASAKI. In the next generation of—we just recently were the recipient of a Safe Trip 21 grant, actually the only one so far at Caltrans. We got it at Caltrans. It is a $12 million proposal, a public-private partnership where we are going to use the next generation of cell phones, which are GPS enabled which will give you data from all over the arterials. So, the plan is to send thousands of these phones out in the Bay area, San Francisco Bay area, and then get information on travel times on the local arterials as well as the freeways so you will be able to plug into your dash a nav unit that says shortest trip, shortest time trip and that is what you are really looking for, right? I mean, you are looking for the ability to maneuver——

Chairman WU. Will I have to get new hardware in order to do that?

Mr. IWASAKI. Well, it depends. I mean, it depends on what kind of nav unit you have, but possibly, yeah, absolutely, but that is the next generation of nav unit, that we are taking the imbedded com-

munications and we are putting it into the consumers' hands and then using those as probes.

Mr. BRUBAKER. Just—I am not sure if everybody on the panel is aware of it but that capability actually does exist today. There is really a handful of companies that produce GPS devices that actually provide real time—some provide real time, some provide probe data, some provide historic data. There is one in particular that actually acts as a probe in a network that you can use leveraging wi-fi communications. It is a company from California called Dash. I actually went out and bought a unit myself because I wanted to test it, and there are several hundred other folks in the area who have them and it acts as sort of a self-contained network so I can see where other people have gone before me real time and pick up on that data and it is integrated with this historic data that is probe data from vehicles, delivery vehicles, commercial vehicles and such, and it tells a much better picture. Now, is it perfect? No, but does it tell me that, you know, I have got congestion on Route 66 when I am trying to get on the same flight probably you are to the West Coast to Dulles airport and that I should take an alternative route. Yes, it will do that. Not perfect but it is pretty darn good. Likewise, I was just, you know, recently using a, I believe it was a Garmin unit that I got from a rental car company that I was late getting to Logan airport and it told me to take an alternative route, and I don't know what they use for that but it was very helpful. So that technology exists. It is not quite perfect. What Randy is describing here is a—and I will change that to Mr. Iwasaki for the record.

Mr. IWASAKI. You can call me Randy.

Mr. BRUBAKER. Okay. What Randy is describing is going to provide a much higher level of fidelity in the data and much more current data as opposed to a probe from somebody that went down the road, you know, five minutes before I did or 10 minutes before I did. When you have got 10,000 phones and eventually 100,000 phones and millions of phones out there that are GPS enabled and everybody is sort of acting as a probe, privacy protected, hopefully, I mean that is the game plan, making sure that we are protecting privacy here but at the same time getting better situational awareness. That in effect is the goal so that people can plan their routes better and avoid traffic and keep traffic moving, which is totally green.

Mr. IWASAKI. I would invite the Committee to come to California and kick the tires of ITS. If you want to come down to the Berkeley area, we can take you out to the Richmond field station and show you the next generation of these types of technologies, ITS technologies.

Chairman WU. Why don't we go to the mother lode of traffic and try it in the Hollywood Freeway on a Friday afternoon?

Mr. IWASAKI. We can take you down there as well, absolutely.

Chairman WU. Dr. Bertini.

Dr. BERTINI. These are great examples, and I think the answer to your question is, some places and some times you can get real-time information that is useful for you. The problem is, this is a big jigsaw puzzle, and I have been involved in this for maybe the last 13 years and have seen different generations of these compa-

nies with different technologies, different ideas. I visited other countries and kind of kicked the tires of different systems in Japan and Europe. We have done some research with BMW looking at the real-time traffic information system on some of the autobahns there. So if you go to a place that is kind of like a test bed or has data in place that has been validated, my concern is that what we have is not consistent across the country, so if you have a vehicle and you want to use it in Portland but you cross the Columbia River to Vancouver, Washington, it may not work because the sensor infrastructure may not be there, the communication system may be different. So we have got pieces, we have got demos, we have got examples and we have got lots of great ideas but what we don't have are fully deployed projects. I think we would all like would be something that is real time, that is available to everyone, that is low cost, that is proven, that you can customize so you are not getting information that you don't need or information that is old. Maybe it is even alerting you so you might get, you know, a message that you need to leave for Dulles airport now or you might get a call, a wake-up call in the morning and it would say take the Metro today because the freeway is going to be all jammed up. So the idea that each user can interact with the system so they are not getting information that is outside their purview I think is where we are all interested in going. We still have a ways to go.

Chairman WU. Perfect. Thank you very much. I just want to—as I was listening to you and the challenges that we face, it is a challenge. It is an opportunity. To all of you on the panel, it is kind of like Dr. Goddard fooling around with sounding rockets in the 1920s. To the folks on this side of the dais, it might be like being a Congressman and having the Internet and being Al Gore in 1975. A small political joke, a very small one.

Before we bring the hearing to a close, I want to thank all of our witnesses. We look forward to working together with you all, with Republicans and Democrats, everyone who is interested in helping move people the way that they want to be moved and particularly before the next reauthorization of the Surface Transportation Bill. The record will remain open for additional statements from Members and for questions and answers to any follow-up questions that the Committee or individual Members may ask of the witnesses. I want to thank the witnesses for their tremendous flexibility, tolerance and patience and also the attendees in the room today, and with that, the witnesses are excused and the hearing is now adjourned.

[Whereupon, at 12:20 p.m., the Subcommittee was adjourned.]

Appendix 1:

Answers to Post-Hearing Questions

ANSWERS TO POST-HEARING QUESTIONS

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

Questions submitted by Chairman David Wu

Q1. What are the primary impediments to inter-operability for intelligent transportation systems (ITS)? If there are technical challenges, what research is needed to overcome those challenges? What actions should the Federal Government take to promote inter-operability for ITS across regions?

A1. In general, the primary impediment to inter-operability is the lack of sufficiently mature and robust Intelligent Transportation Systems (ITS) standards. ITS standards are critical to all applications of ITS, such as ITS infrastructure, traveler information, and vehicle-based safety technologies. Each area has unique issues that must be addressed, in addition to development of standards. For example, lack of staff experience in successfully procuring and operating standards-compliant systems is a particular impediment to deploying ITS infrastructure at the State and local level. For emerging wireless communications for vehicle-based safety, impediments include resolving diverse interests and standards requirements of the broad range of stakeholders, from traditional ITS equipment manufacturers and customers to the vehicle and communications equipment industries.

These technical challenges require research to develop sufficiently robust standards and associated procedures and tools to test conformity; a time-consuming process due to the complex nature of ITS technologies. The U.S. DOT ITS program provides technical and financial support to facilitate standards development, create test procedures, and evaluate test results to facilitate the broad adoption of inter-operable ITS technologies by State and local governments, transit agencies and others. For emerging wireless communications technologies, challenges include developing standards concurrently with a rapidly-advancing state of the technological art and cooperating with both vehicle and traditional ITS equipment manufacturers and customers to agree on standards that meet their respective needs. The vehicle industry is a global one; the most cost-effective standards would meet international as well as U.S. market requirements. Developing standards is complicated by the diversity of worldwide ITS standards and practices.

The Federal Government maintains a strong role in promoting inter-operability. Facilitating inter-operability of ITS technologies remains a primary focus of the DOT's ITS program for traditional ITS hardware and software, as well as for the emerging vehicle to infrastructure and to vehicle communications technologies. DOT's primary roles include expediting development of standards, enabling testing, providing education and technical assistance on the use of standards, and facilitating easy access to information about standards. In accordance with legislative direction, DOT developed the National ITS Architecture and mandated that project architectures be developed that comply with the National ITS Architecture. DOT provides technical and financial support to develop ITS standards to define architecture interfaces.

Q2. How do energy efficiency and sustainability fit within RITA's priorities? Do you anticipate any changes in the amount of support for projects related to energy efficiency and sustainability? What percentage of university transportation centers (UTCs) have as increased energy efficiency or sustainability as one of their research goals? Should energy efficiency and sustainability goals be integrated into the R&D at all the UTCs?

A2. Energy efficiency and sustainability research supports DOT's "environmental stewardship" strategic goal, and the DOT research strategy that addresses "environmental sustainability." Within RITA, the Hydrogen Fuels R&D Program and some of the work of the University Transportation Centers (UTCs) address these priorities. Thirteen of the UTCs (22 percent) have energy efficiency as primary research themes, and 11 centers (18 percent) have environmental sustainability as primary research themes. We anticipate minimal changes to this support in the near-term, pending the results of the next surface authorization act.

Energy efficiency and sustainability goals should be integrated into the R&D at all the UTCs, but only to the extent practicable. Due to the differing research and technology strengths and thematic goals of the individual UTCs, the extent of integration of energy and environmental aspects will vary considerably. All UTCs already have energy efficiency and environmental sustainability issues integrated into their curricula.

Questions submitted by Representative Phil Gingrey

DOT Views and Priorities

Q1. What are the priority research areas for the Research and Innovative Technology Administration? How do you plan to transfer successful research projects to State DOTs and industry where they can be implemented? Additionally, do the statutes governing departmental and university research programs at RITA currently allow you to effectively manage the Federal Government's research investments? If not, do you have suggestions for potential improvements? Finally, does the funding for current projects within the Department and University Transportation Centers accurately reflect the Administration's research priorities?

A1. RITA's priority research areas mirror the Secretary's RD&T focus areas:

- Enhance System Performance;
- Reduce Congestion;
- Improve Safety;
- Address Climate Change and Environmental Linkages to Quality of Life;
- Maintain Infrastructure Integrity;
- Meet Freight Logistics and Global Challenges; and
- Assess Policy and System Financing Alternatives.

To a lesser degree, DOT's priority research areas reflect the Administration's Research and Development (R&D) Priorities:

- Homeland Security and National Defense;
- Energy and Climate Change Technology;
- Advanced Networking and Information Technology;
- National Nanotechnology Initiative;
- Understanding Complex Biological Systems;
- Environment;
- Next Generation Air Transportation System;
- Federal Scientific Collections; and
- Science of Science Policy.

There cannot be a direct correlation with the Administration's R&D Priorities, because the Priorities do not include all of DOT's mandated missions in safety, reduced congestion, global connectivity, environmental stewardship and security, preparedness and response. However, through the DOT research coordination process, RITA and the other Operating Administrations are engaged to some degree in all of the Priorities. Flexibility to shift funding to the Administration's R&D Priorities is limited by legislative designations for specific research and technology programs and projects.

Planning for research and technology implementation is a priority for all Operating Administrations, with research partnerships including likely State and local or industry implementers, and research plans and contracts requiring an implementation segment. Within RITA, each University Transportation Center (UTC) is required to present its technology transfer plan as part of its UTC Strategic Plan, which is reviewed by representatives of FHWA, FTA, OST, RITA and other parts of DOT. In those plans, each UTC addresses how it plans to transfer successful research projects to State DOTs and to industry.

In each UTC's annual report to RITA, the UTC is required to specify how it has transferred its research results to State DOTs and industry. Each UTC also receives a periodic formal site visit from a RITA team that specifically inquires about the UTC's technology transfer activities and accomplishments and includes face-to-face interviews with representatives of the relevant State DOTs and industry regarding technology transfer.

RITA has sufficient authority to coordinate, facilitate, and review DOT's research and development programs and activities, and to advance innovative technologies, as provided by the *Norman Y. Mineta Research and Special Programs Improvement Act* ("Mineta Act," P.L. 108–426, November 30, 2004).

RITA Planning and Coordination

Q2. What led you to institute the new Research Planning and Investment Coordination process at RITA? How will this process, and especially the new Commu-

nities of Interest model, affect current University Transportation Centers? In your testimony you state that all projects will be required to have a mechanism for technology transfer and deployment. Will currently funded projects be reviewed for compliance?

A2. RITA is implementing the Research Planning and Investment Coordination process, with the full support of DOT, as a means of pursuing the primary goals of the research coordination program, including:

- Completing a full inventory of all DOT R&D projects;
- Assessing those projects for unnecessary duplication;
- Ensuring that all projects support an Administration or Secretarial R&D Priority;
- Reviewing all projects to ensure that they meet the goals of the R&D Investment Criteria—relevance, quality and performance.
- Reviewing funded and planned projects for compliance with the requirement for technology transfer and deployment plans.

The RPIC process builds upon the Research, Development and Technology (RD&T) Planning Council, Team and Process, established by RITA in 2005. The RPIC process will not affect current UTCs, except to tie in the expertise found at the UTCs into the Communities of Interest, building the corporate expertise of the transportation community. The initially-planned Communities of Interest are:

1. Transportation Planning and Policy Research;
2. Systems Performance Research;
3. Human Factors Research and Applications;
4. Transport, Logistics and Infrastructure Research;
5. Advanced Materials Research;
6. Hazardous Materials Research;
7. Vehicle Systems Research;
8. Communications, Navigation and Surveillance (CNS)/Traffic Management; and
9. Safety Analysis and Risk Management.

Tech Transfer

Q3. In the end, implementation of new technologies will require local developers and planning boards to accept and cooperate in their use. Do local decision-makers have access to comprehensive and comprehensible data on potential new technologies? Are pilot projects enough to demonstrate effectiveness across the wide variety of weather and built environments?

A3. Within RITA, the Intelligent Transportation Systems Joint Program Office's (ITS JPO) Electronic Document Library (EDL) provides historical and comprehensible information on new, innovative technologies for transportation. The EDL, a web-accessible collection of RITA's National Transportation Library (NTL), provides access to over 2,100 research reports, lessons learned, product evaluations, and articles published or sponsored by ITS JPO. On average, over 150 items are added to EDL annually.

Beyond ITS technologies, the NTL cooperates with libraries and information providers in State and local agencies through regional networks. The purpose of these networks is to facilitate knowledge transfer, including technology information and applications reports, between members and across other transportation stakeholder groups. This outlet also provides local decision-makers with access to comprehensive and comprehensible data on new technologies.

Pilot projects, and more importantly their results and lessons learned, provide local decision-makers with critical information for the research implementation and project investment planning process. Depending on the scope of the pilot project, results may or may not demonstrate effectiveness across the spectrum of environments in the U.S., but they do provide a level of evaluation upon which other research can be built or technology investment decisions made. Stakeholder feedback on NTL collections indicates that pilot projects, implementation of new technologies, and evaluation of these experiences are of high value to State and local decision-makers, and that more data and information of this type is desired. Successful practices will also be promulgated through various trade journals, conferences and technology customers.

The most effective support to local agency technology transfer is FHWA's Local Technical Assistance Program (LTAP). LTAP is a network of transportation technology transfer centers established specifically to enhance local agency road management and safety. There are 51 LTAP Centers, one in each state and Puerto Rico, and seven regional Tribal Technical Assistance Centers (TTAP) that help tribal governments improve transportation management. The LTAP–TTAP Centers provide training and materials to over 12,500 local communities. In 2007, the LTAP and TTAP Centers provided training and technology transfer services to more than 115,000 people at 4,000 training sessions; provided information newsletters to more than 131,000 local contacts, and distributed 250,000 materials to local agencies. RITA's University Transportation Centers (UTCs) often host LTAP Centers, making the transition from technology to local training easier.

Workforce Training

Q4. The U.S. DOT estimates that there are 349 thousand people employed in bridge, street, and highway construction. What impacts do the research activities discussed at the hearing have on these workers? Will implementation of sustainable transportation technologies require wide-scale training and education? If so, who is responsible for providing this training?

A4. We are pleased the committee recognizes the essential role of a well trained workforce as a key component of a viable transportation system. Our experience has shown that addressing this need requires partnership across the industry which includes the collaborative efforts of the private, education and public sectors. DOT, and especially FHWA, have sponsored numerous activities to support workforce partnerships, including partnering with the Transportation Research Board and Council of University Transportation Centers (CUTC) on studies and workshops, and working with the Education Subcommittee of the President's President's Council of Advisors on Science and Technology to develop a federal agenda of actions. Through implementation of SAFETEA–LU, we have expanded the number of universities focusing on transportation, and initiated new grant programs for attracting students to transportation careers and development of new transportation curriculums.

To obtain the benefits of new research and technologies, whether from federal or State research, educational institutions or other parts of the transportation industry, joint efforts from across the transportation community are required for implementation. For example, in 2007 FHWA's National Highway Institute conducted over 700 training and professional development activities reaching over 19,000 people, and the LTAP–TTAP centers provide training to transportation employees at professional, journeyman and apprentice levels. We partner with professional associations and organizations (e.g., American Association of State Highway and Transportation Officials, American Public Transportation Association, Institute of Transportation Engineers, American Public Works Association, National Association of County Engineers) to move innovation from research to application through professional development and training activities. The expanding FHWA and FTA partnerships with RITA's UTCs goes far in addressing transportation's future workforce needs through education and professional development.

Coordination

Q5. How can RITA and the other agencies of the Department of Transportation increase the coordination within the research community and awareness of research results in the broader community

A5. RITA, in collaboration with the other Operating Administrations, has made significant progress in improving coordination within the transportation research community, and across the broader transportation planning, design, construction, operations and maintenance enterprise. All OAs are active members of the DOT RD&T Planning Council and Planning Team, which has been successful in increasing program- and project-level coordination within the DOT research community. All OAs continue to develop the needed external partnership with State and local DOTs, universities, other research entities, and stakeholder organizations, to increase awareness of research in progress, and research results. Specifically, the existing relationship between RITA's National Transportation Library and the Transportation Research Board has increased broad community awareness of research results and new technologies. The development of regional Transportation Knowledge Networks (TKNs), bringing federal, State, university, association and other partners

together specifically in collaboration for information sharing, promises significant benefits in dissemination and deployment of research results.

Operations & Maintenance Costs

Q6. A recurring criticism of some sustainable transportation practices is the need for regular maintenance or significantly increased initial deployment costs. Are transportation research agencies and centers capable of adequately assessing life cycle costs when developing new technologies and processes?

A6. We believe that the University Transportation Centers (UTCs), and other research centers supporting DOT, State DOTs and industry have the capability to conduct life cycle costing in support of technology transfer and commercialization. Most of RITA's UTCs use life cycle costing as a standard practice, and offer their expertise to State DOTs and other implementing agencies.

Questions submitted by Representative Adrian Smith

Q1. By how much does the total cost of construction of a mile-lane increase for every $1/gallon increase in fuel?

A1. The U.S. Department of Transportation does not collect information that allows calculation of the increase in lane-mile construction costs as a result of fuel price increases. RITA's Bureau of Transportation Statistics (BTS) could not find a reliable estimate of this impact; anecdotal calculations vary widely.

FHWA provides guidance to State Departments of Transportation (DOT's) for use in preparing fuel price escalation clauses in highway construction contracts. This guidance indicates a scope of construction cost impacts from on-site fuel costs, but not the significant impact of fuel costs on materials such as asphalt and steel. The FHWA Technical Advisory may be found at: *http://www.fhwa.dot.gov/programadmin/contracts/ta50803.cfm.* Broader discussions of recent highway construction cost increases and issues are available at: *http://www.fhwa.dot.gov/programadmin/contracts/price.cfm*

In addition, there is abundant anecdotal evidence of energy prices driving up the costs of highway construction,. Some illustrative examples include:

- Florida Department of Transportation finds that leading indicators, including diesel prices, continues to put upward pressure on construction prices, but competitive pressures have some moderating impacts on those increases. *Highway Construction Leading Indicator Report,* June 2008. *http://www.dot.state.fl.us/planning/policy/costs/indicators-may08.pdf*
- Washington State Department of Transportation provides a summary of market analyses of several key markets from various publications, including asphalt, concrete, fuel, lumber and plywood, steel, and highway material and construction. *WSDOT Market Analysis,* June 2008. *http://www.wsdot.wa.gov/biz/construction/CostIndex/CostIndexPdf/20082QMarket%20Analysis.pdf*
- California Department of Transportation reports price trends for several construction items, including roadway excavation, aggregate base, asphalt concrete pavement, Portland cement concrete pavement, Portland cement concrete structures, bar reinforcing steel, and structural steel. *Summary, Price Index for Selected Construction Items, Second Quarter ending June 30, 2008. http://www.dot.ca.gov/hq/esc/oe/contract_progress/cost-index-summary.pdf*
- The American Road and Transportation Builders Association reports on the increases in highway construction materials prices. *Highway Construction Producer Prices,* July 2008. *http://www.artba.org/economics_research/recent_statistics/prod_price_index/PPI%20July%2008%20Report.pdf*
- The Associated General Contractors of America reports on the increased costs of steel and fuel and their impacts on construction costs. *Construction News,* April 2008. *http://agc.org/cs/news_media/press_room/press_release?pressrelease.id=167*
- The U.S. DOT Office of the Inspector General reports on the extent of recent price increases in project construction costs, the main drivers of those increases, whether the increases are transitory or structural, and the extent of regional differences. *Growth in Highway Construction Costs and Maintenance Costs, Report CR–2007–079,* Sept. 2007. *http://www.oig.dot.gov/StreamFile?file=/data/pdfdocs/Growth_in_Highway_Construction_and_Maintenance_Costs_Final.pdf*

ANSWERS TO POST-HEARING QUESTIONS

Responses by Randell H. Iwasaki, Chief Deputy Director, California Department of Transportation

Questions submitted by Chairman David Wu

Q1. What are the primary impediments to inter-operability for Intelligent Transportation Systems (ITS)? If there are technical challenges, what research is needed to overcome those challenges? What actions should the Federal Government take to promote inter-operability for ITS across regions?

A1. Inter-operability is seamless and efficient interconnectivity. Caltrans has actively participated in many of the national ITS standards development efforts, and it is considered a pioneer in the field of ITS inter-operability. Starting from the Mobility 2000 Initiative and the early Intelligent Vehicle-Highway Systems (IVHS) Architecture efforts, Caltrans established the Testbed Center for Inter-operability (TCFI: 1992–2002), which addressed many ITS inter-operability issues, including:

- Technical inter-operability, such as communication inter-operability and traffic control inter-operability.
- Information inter-operability.
- Operational inter-operability, especially in the areas of regional ITS.

In response to 9/11 and other natural disaster events, better situational awareness and new emergency management approaches put "First Responders" inter-operability at the top of most agencies' goals for safety and security. To this end, Caltrans has participated in the Department of Homeland Security (DHS) efforts to address First Responders' inter-operability needs for the 21 Century.

Primary Impediments:

a. Availability of funds to develop, implement, and ensure compliance with standards and inter-operability best practices.
b. Weak public agency involvement in the standards testing programs, especially compared with the early days of IVHS/ITS. Public sector ITS practitioners are the best agents of change within government.

Technical challenges:

a. Many ITS projects address inter-operability as an after thought, and in ad-hoc way. A "Design for Inter-operability" philosophy needs validated standards, test metrics, and identified best practices, many of which don't exist today.
b. Developing inter-operability best practices requires familiarity with the evolving standards and the system(s) in an ongoing basis.
c. There are excessive delays between research completion and dissemination of research findings/publications.
d. There is a lack of standards quality assurance (validation and testability).
e. Gaps exist between research and real-world operations (internal technology transfer).

Needed research:

a. Standards testing and validation.
b. Inter-operability testing of new and after-market technologies.
c. Integration and standards compliance.

Actions needed from the Federal Government:

a. Increase the level of funds for State and local agencies to implement and validate measures of inter-operability.
b. Help make research findings available to the ITS community and require that lessons learned, test procedures, and metrics be widely distributed and reviewed beyond the funded entities.
c. Facilitate the use of Web technology to accelerate the dissemination and validation of current research activities.

Q2. How do you find a balance between competing requirements for infrastructure such as safety, cost, and sustainability? Is there adequate data to provide a realistic picture of the benefits and disadvantages of various technologies and materials?

A2. As the owner and operator of the State Highway System, Caltrans is frequently challenged to find an acceptable balance between safety, cost, and sustainability when deploying new infrastructure. To overcome this challenge, we adhere to State laws, established policies, and specific work plans that guide our actions. Per the California State Legislature, Section 167 of the California Streets and Highways Code establishes the sequence of priorities for Caltrans as:

1. Stewardship of the existing State Highway System.
2. Improving safety.
3. Expanding capacity.
4. Reducing environmental impact.

This legislation also identifies specific plans that we develop to guide us in implementing these priorities. For stewardship, we have the Rehabilitation Plan and the Maintenance Plan under the State Highway Operation and Protection Program. For safety, we follow the Strategic Highway Safety Plan. For capacity, we use the Regional Improvement Plan and the Inter-regional Improvement Plan under the State Transportation Improvement Program. Finally, for protecting the environment, we follow the guidelines under the Environmental Enhancement and Mitigation Program.

Caltrans has also adopted departmental goals that are closely related to the priorities listed above. We consider these goals when making trade-offs between safety, cost, and sustainability. Here are the five goals for Caltrans:

- **Safety—**Provide the safest transportation system in the Nation for users and workers.
- **Mobility—**Maximize transportation system performance and accessibility.
- **Delivery—**Efficiently deliver quality transportation projects and services.
- **Stewardship—**Preserve and enhance California's resources and assets.
- **Service—**Promote quality service through an excellent workforce.

Regarding the availability of data that identifies the benefits and liabilities of new technologies, we typically make the pursuit of this information a crucial part of the research that leads to the deployment of new technologies. Whenever possible, we use pilot deployments to help capture this data, so that decision-makers can consider real-world experience when determining whether or not to fund full-scale deployment.

Q3. What methods does California use to encourage private developers to follow the state's example with implementation of sustainable and energy efficient practices, materials and technologies? Are there incentives for the use of these technologies and materials?

A3. Two pieces of recent legislation, one enacted and one pending, provide the basis for answering these questions. Both are described in detail below.

Assembly Bill 32 (AB 32), Nunez. Air pollution: Greenhouse Gases: California Global Warming Solutions Act of 2006.

In response to the requirements set forth in AB 32, on or before January 1, 2009, the state's Air Resources Board (ARB) shall prepare and approve a Scoping Plan for achieving the maximum technologically feasible and cost-effective reductions in greenhouse gas (GHG) emissions from sources or categories of sources of greenhouse gases by 2020. On June 26, 2008, ARB staff presented the initial draft of the AB 32 Scoping Plan for Board review. The AB 32 Scoping Plan contains the main strategies California will use to reduce the GHGs that cause climate change. It includes incentives for use in GHG reductions, including the use of "feebates" (which would combine a rebate program for low-emitting vehicles with a fee program for high-emitting vehicles), congestion pricing, Pay-As-You-Drive (PAYD) insurance programs (in which motorists could lower their insurance costs by driving less), and Indirect Source Rules (which are designed to address air pollutant emissions associated with residential and commercial developments through better urban design and development patterns).

Pending Legislation: Senate Bill 1754 (SB 1754), Kehoe. Energy: California Alternative Energy and Advanced Transportation Financing Authority. 2007–2008 Session.

This bill would establish an authority to finance renewable energy sources. The authority would establish a renewable energy program to provide financial assistance to public power entities, independent generators, utilities, or businesses manufacturing components or systems, or both. Assistance would be used to generate new and renewable energy sources, develop clean and efficient distributed generation, and demonstrate the economic feasibility of new technologies, such as solar, photovoltaic, wind, and ultra-low emission equipment.

In addition, this bill would authorize the authority to purchase alternative source energy or projects for sale to a specified participating party and to make a loan to a participating party to purchase alternative source energy or projects.

Questions submitted by Representative Phil Gingrey

Tech Transfer

Q1. In the end, implementation of new technologies will require local developers and planning boards to accept and cooperate in their use. Do local decision-makers have access to comprehensive and comprehensible data on potential new technologies? Are pilot projects enough to demonstrate effectiveness across the wide variety of weather and built environments?

A1. Pilot projects are valuable mechanisms to evaluate technologies within specific parameters. However, the achieved results are specific to the conditions set forth in the variables of the project, and may not be appropriate across varying circumstances.

Activities proposed under the AB 32 Scoping Plan both (a) create a need for better information to be made available as part of the local decision-making process, and (b) offer a new source of data that can be used to analyze effectiveness of new technologies in a variety of situations.

Under AB 32, local governments and regional government agencies are seen as essential partners in achieving California's greenhouse gas goals. Local governments are encouraged to build on existing strategies and adopt best practices, such as those developed by the Institute for Local Government's "California Climate Action Network," to achieve greenhouse gas reductions. They are also encouraged to develop climate action plans, to set 2020 targets to reduce greenhouse gas emissions, and to incorporate greenhouse gas reduction measures and regional blueprint plans into their general plans.

As part of process, the California Air Resources Board, along with relevant State agencies, will work with the California Climate Action Registry, ICLEI–Local Governments for Sustainability, Local Government Commission, and the Institute for Local Government's "California Climate Action Network," to develop measurement and tracking protocols, planning tools, and best practices to assist local governments in planning for, quantifying and reporting greenhouse gas emissions reductions. Using these tools, ARB encourages local governments to set municipal and community-wide 2020 greenhouse gas reduction goals and adopt measures and best practices to meet those goals. ARB will work with local governments to reconcile local level accounting with State and regional emissions tracking as the AB 32 Scoping Plan is implemented.

Workforce Training

Q2. The U.S. DOT estimates that there are 349 thousand people employed in bridge, street, and highway construction. What impacts do the research activities discussed at the hearing have on these workers? Will implementation of sustainable transportation technologies require wide-scale training and education? If so, who is responsible for providing this training?

A2. The objective of research is to find ways for these people to plan, design, construct, operate, and maintain the highways faster, safer, and with greater efficiency and sustainability. For example:

a. Technological advancements in automated three-dimensional surveys (total station) reduce the exposure of survey workers to traffic and enable three-dimensional design and GPS-guided construction equipment. The result is quicker, more accurate construction with fewer workers needed.

b. Intelligent Transportation Systems will assist motorist in construction work zones and provide a safer environment.

Implementation of sustainable transportation technologies requires two forms of training and education. The first is wide-scale education of the workforce for modern technologies such as computers, communications, and sustainable transportation systems. Schools (K–12), universities, colleges, and trade schools have the primary responsibility with support from industry and government. The second is specific training for the individual technology. Users of the technology have the primary responsibility for this training, with the assistance from manufacturers, researchers, industry organizations, and government.

Coordination

Q3. How can RITA and the other agencies of the Department of Transportation increase the coordination within the research community and awareness of research results in the broader community?

A3. Caltrans is involved in a number of efforts to improve coordination of transportation research, including the AASHTO Research Advisory Committee's Coordination and Collaboration Task Group. An Authorization Position Paper developed by this Task Group, and adopted by AASHTO, is attached. We concur with the findings and recommendations presented in this paper. Among these are the following highlights:

- Transportation research coordination and collaboration is needed to:
  - Transfer knowledge or technology
  - Prevent research duplication
  - Identify research gaps
  - Save time and money.
- Most current transportation research coordination and collaboration activities are unfunded, and administered by volunteers.
- Congress should fund coordination, collaboration, and deployment of research efforts to support the transportation sector, including federal, State, and local transportation organizations.
- Funding should include support for development, maintenance and marketing of a research collaboration web site.

Operations & Maintenance Costs

Q4. A recurring criticism of some sustainable transportation practices is the need for regular maintenance or significantly increased initial deployment costs. Are transportation research agencies and centers capable of adequately assessing life cycle costs when developing new technologies and processes? Are states and localities meeting their current operations & maintenance requirements and do they have the capacity to perform more? What are the consequences of failing to perform this work?

A4. The cost of operating and maintaining new technologies after they are deployed is becoming a greater challenge as time goes on. Caltrans has recently begun considering life cycle costs when making the decision on whether or not to deploy new technologies in capital projects. In the past, the divisions within Caltrans that were planning, designing, and constructing the facilities that include new technologies did not always consider the needs of the divisions that would operate and maintain these facilities over time. Therefore, they were not always built with ease of operation and maintenance in mind, which proved to be a challenge for the divisions that inherited them. We've been working to improve the coordination between these two groups to ensure that new facilities can be sustained over their lifetime. The answers to your specific questions are shown below.

Capable of assessing life cycle costs?

We are keenly aware of the need to estimate the life cycle costs of a new technology as part of the research that develops it, including an evaluation of the tradeoffs associated with one that might have a higher initial deployment cost, but a lower life cycle cost overall. This estimate serves as one of the primary decision-making criteria when determining whether or not to deploy. The accuracy of the estimate varies, depending on the type of new technology. If it is primarily a refinement of an existing product or process, it is easier to quantify the life cycle costs.

If it is a revolutionary new product or process, it is much more challenging to estimate these costs, and sometimes we must wait until the product or process has been implemented so that we have a chance to collect historical data.

Meeting current O&M requirements?

We face a challenge here in that the funding mechanisms for developing and delivering capital improvements are not linked to the ones that fund operations and maintenance, so inventories of specialized equipment and facilities can increase without a corresponding increase in the resources necessary to operate and maintain them. We have made some improvements in this arena, by better capturing the historical operations and maintenance workload data for each inventory item, and then requesting additional resources through our budgeting process. For example, we know that historically it takes a certain number of hours per year for a Traffic Engineer to observe the operation of a signalized intersection and adjust the timing plan to ensure the smooth movement of traffic through the intersection. However, in spite of having this historical workload data to support requests for additional resources, we are sometimes under-resourced for these needs, resulting in a reduced Level-of-Service for the facility. In these days of budget shortfalls, it is becoming more difficult to sustain our existing infrastructure, let alone adding to it. We are sometimes limited to providing only the level of support that is legally required.

Consequences of failure to perform O&M?

The biggest consequence of failure to perform operations and maintenance is that the new facility may not perform at an optimal Level-of-Service, or that it may not work at all. For example, we have about 2500 Vehicle Detection Stations (VDS) deployed statewide, primarily using inductive loop technology for vehicle sensing. These VDSs serve multiple purposes, from collecting traffic counts, to detecting incidents, to providing data for estimating travel times. However, at any one time, only 70–80 percent of the stations may be reporting valid data, due to a variety of reasons. We do not have enough resources to continuously maintain the stations that go down, so we have to prioritize the stations that need maintenance based on their location, and service those at the top of the list first.

Based on this example, it is easy to see why we are concerned about the reliability of any new technology that we add to our system. We need to know that it will perform its intended function without causing additional effort for either operation or maintenance.

ANSWERS TO POST-HEARING QUESTIONS

Responses by Robert L. Bertini, P.E., Director, Oregon Transportation Research and Education Consortium (OTREC); Associate Professor, Portland State University

Questions submitted by Chairman David Wu

Q1. You note in your testimony that all OTREC research projects have a technology transfer plan. Can you provide additional detail on how those plans are developed? What would you recommend to other researchers struggling with technology transfer?

A1. In the context of the University Transportation Center (UTC) program, technology transfer means making transportation research results available to potential users in a form that can be implemented, utilized or otherwise applied. Each OTREC proposal is evaluated in terms of the quality of its plan for research implementation. For most research projects there are several key ingredients that lead to successful technology transfer, which we recommend for anyone who is considering technology transfer:

- Incorporating an external partner (transportation agency, private industry, advocacy group, etc.) into the development of the project proposal. The federal match requirements encourage this and help ensure that there is an external advocate who is interested in the project results.
- Creation of a technical advisory committee who helps develop and refine the work plan, monitors the project while the research is conducted, helps resolve any problems and avoid pitfalls, reviews project products, provides peer review of final report and assists with project implementation.
- Each proposal must include a good literature review. This helps ensure that there is no duplication of effort and also reveals where other researchers are working on similar problems. This can encourage collaboration and communication with others who are tackling similar research topics, and can aid in technology transfer through established channels.
- Provide travel funding for principal investigators developing presentations for relevant conferences such as the Transportation Research Board Annual Meeting, ITS America Annual Meeting, ITS World Congress, Institute of Transportation Engineers Annual Meeting, Women's Transportation Seminar, American Society of Engineers, etc. These conferences also provide opportunities for students to present the results of their research and receive feedback.
- Include project details in national databases including the Transportation Research Board's Research in Progress (RiP) database upon project inception, and upon completion the final report is submitted to the Transportation Research Information Service (TRIS Online) through the Bureau of Transportation Statistics' National Transportation Library.
- Each final report is posted on the OTREC web site available for free download, and sent to Northwestern University Transportation Library, Volpe National Transportation Systems Center, the Institute of Transportation Studies Library at the University of California at Berkeley, the TRB Library and NTIS.
- In addition to the final report, OTREC encourages publications for peer-reviewed academic journals, professional publications, and conference proceedings. In addition, the OTREC web site includes a project web page for each project that includes the final report and links to any other publications and presentations. We plan to include short video presentations from each researcher describing their project and its results—these videos can be submitted to YouTube for wide dissemination. The OTREC newsletter features concise, easily digestible articles summarizing the results and benefits of each project in a way that can be read by nontechnical people and decision-makers.
- Researchers are invited to present at the Portland State University Center for Transportation Studies weekly Transportation Seminar that reaches not only the local transportation community but anyone who wishes to participate via our live video stream or our archived seminar podcasts which are available free in perpetuity.
- We encourage faculty to incorporate research results into their course work and to consider developing new academic and professional courses as new topics emerge. OTREC funds development of courses and course modules, and

also works with other organizations to offer and sponsor conferences and professional development lectures, workshops and symposia.

- OTREC encourages use of new and emerging media for technology transfer.
- Close contact with university commercialization officers is also crucial to efficiently move intellectual property into the marketplace as relevant.

Q2. In order for some intelligent transportation systems to be effective in reducing congestion and fuel waste, there need to be changes in driver behavior. For example, drivers must be willing to change their route in response to real time traffic information, or must be willing to slow down in response to variable speed limits. What steps must both researchers and policy-makers take to ensure that driver behavior changes in response to intelligent transportation systems? How can you test a given technology to determine whether it works in an imperfect, real-world situation?

A2. Over the last 20 years, experience in the U.S. and abroad has shown that customers will adopt intelligent transportation systems (ITS) technologies and change behavior if there are clear benefits for doing so. These benefits may manifest themselves in the form of reduced travel time (coupled with reduced fuel consumption, greenhouse gas emissions and energy use and improved safety), improved travel reliability or information that increases user confidence in the overall transportation system. The best example is the wide adoption of electronic toll collection technology. Users are willing to adopt the technology knowing that they will not have to stop to pay a toll at a toll booth, nor will they have to fumble for change or open their window during inclement weather. A similar result has occurred in cities that have adopted smart cards used for payment of transit fares or parking fees-integrated payment systems offer clear benefits to users that are well understood through comprehensive research and evaluations in advance. In this context, another important element is inter-operability. Whether one is considering electronic toll collection; smart card payment systems, truck pre-clearance systems or any other transponder-based systems, they should be inter-operable across jurisdictional boundaries. This is an area where federal influence can help substantially.

The more broad issue of encouraging travelers to change behavior in response to traveler information (this could include both pre-trip and on-route, and can include changing a driver's route, travel mode, time of travel, or the need to travel at all) requires developing a strong trust relationship between the customer and the information provider (can be public or private). It is important that customers see the information as reliable and somewhat customized to their needs. An ongoing, continuing, proactive evaluation program that compares reported travel times on the network with actual experiences from drivers will help convey the performance of the system to users and decision-makers. Often when an ITS system is deployed, an initial evaluation will be conducted, but it is rare that an ongoing reporting system is maintained. We recommend partnerships between transportation agencies and university researchers who can help with such ongoing evaluations.

Some ITS applications aim to improve safety or reduce congestion by monitoring or reducing traffic speed. For example, variable speed limit systems have been deployed in work zones or along urban corridors that experience recurrent congestion. By reducing speeds at the appropriate times and locations, safety can be improved and increased throughput can be achieved, which provides benefits in terms of crash reductions and savings in fuel consumption and greenhouse gas emissions. For these systems, good evaluations are needed to inspire customer confidence, but the most important element is enforcement. For example, variable speed limit systems in Germany include speed cameras that can issue tickets to violating drivers. Funding for implementation of variable speed limit systems should include funds for evaluations and enforcement.

There are several key steps that are involved in testing a given technology to determine whether it works in an imperfect, real-world situation:

- Develop plan for implementing technology in a collaborative environment, preferably with key representatives of transportation agencies, the private sector, the public, decision-makers and ideally the university research community.
- Conduct a scan of international or domestic applications of similar technologies in order to gain lessons learned.
- Depending on the exact nature of the technology, tests can be conducted through customer focus groups, computerized simulations or driver simulator environments.

- Incorporate a data collection component and an evaluation plan into the initial design of the technology application, including the need for data archiving. Be sure to include a mechanism for collecting "before" data for later comparison to "after" data once the system is tested or deployed.
- Sometimes a technology application can be tested in a pilot study environment, and if this is possible it should be done in the context of an evaluation that includes a sample of potential users. The inclusion of a "feedback" look in the pilot and ultimate implementation can allow for modifications in response to users and a technical evaluation.

Many times a transportation technology can be tried with low risk, and in these cases the real-world, imperfect implementations should be seen as successful as long as lessons learned are documented and shared with others.

Q3. You discuss transportation-related education activities at partner universities. What does the typical curriculum cover? Are energy efficiency and sustainability in transportation infrastructure included? If not, do you think that these goals should be part of transportation-related curriculum, and who should be involved in developing new curriculum?

A3. The broad array of transportation professionals in the U.S. receive education from high schools, community colleges, professional schools, certification programs, as well as baccalaureate and graduate degree programs at colleges and universities. Generally speaking, there are professional organizations, accreditation bodies, and university departments and governance structures that oversee and influence curriculum development and content. Individual faculty typically work with their colleagues to develop and propose new courses that can be offered, improved, and then must be approved at departmental, college and university wide levels through the faculty senate's curriculum committee structure. Individual degree programs are accredited by national organizations that focus on specific disciplines. Often individual departments will have external advisory boards made up of industry professionals and alumni who can weigh in on course and program offerings.

Our four partner universities in our consortium offer three different undergraduate degrees that specifically prepare students for careers in the transportation field:

- B.S. in Civil Engineering (PSU, OSU and OIT): undergraduates are required to take two transportation engineering courses that include a small amount of material related to energy efficiency and sustainability in transportation infrastructure (historically not a prime focus but this is expected to change).
- B.A./B.S. in Community Development (PSU)
- B.A. in Supply and Logistics Management (PSU)

At the undergraduate level, it is clear that students are very interested in the issues of sustainability and energy efficiency. OTREC and the University of Idaho's National Institute for Advanced Transportation Technology (NIATT), the Region X Transportation Consortium, the Institute of Transportation Engineers, the Council of University Transportation Centers, and the Transportation Research Board, are all collaborating to sponsor a conference in June 2009 that will focus on improving the undergraduate transportation engineering course. We expect that new modules dealing with energy efficiency and sustainability will be developed. It is appropriate that these organizations are involved in developing new curricula. Transportation agencies and private firms who hire transportation graduates should also be involved.

At the graduate level, our partner universities offer nine degrees at the Master's level, three doctoral level degrees and one graduate certificate:

- Master of Urban and Regional Planning (PSU)
- Master of Science in Civil and Environmental Engineering (PSU and OSU)
- Master of Engineering in Civil and Environmental Engineering (PSU and OSU)
- Master of Engineering in Civil and Environmental Engineering Management (PSU)
- Master of Urban Studies (PSU)
- Master of Community and Regional Planning (UO)
- Dual Master's Degree in Urban and Regional Planning and Civil and Environmental Engineering (PSU)
- Ph.D. in Urban Studies (PSU)

- Ph.D. in Civil and Environmental Engineering (PSU and OSU)
- Graduate Certificate in Transportation (PSU)

Graduate degree programs offer students the opportunity to specialize and take a more diverse set of courses, as well as the opportunity to pursue individual research. Therefore, graduate students in these programs who specialize in transportation are exposed to the issues of energy efficiency and sustainability in several courses. Students are very interested in these topics so it is possible that more specific course offerings will be developed in the near future. In addition to faculty and accreditation bodies, transportation industry and agency representatives and professional organizations should be involved in developing enhanced curricula in the area of energy efficiency and sustainability. International experience in developing these types of curricula should also be included.

Questions submitted by Representative Phil Gingrey

Tech Transfer

Q1. In the end, implementation of new technologies will require local developers and planning boards to accept and cooperate in their use. Do local decision-makers have access to comprehensive and comprehensible data on potential new technologies? Are pilot projects enough to demonstrate effectiveness across the wide variety of weather and built environments?

A1. While much of the technological focus has been on State-operated freeways (where most of the vehicle miles of travel occur), it is true that ultimately regional and local agencies will be responsible for implementing new technologies that support the operation of transit systems, and. arterial and local roadways. Fortunately these agencies can take some lessons from the implementations on State-operated facilities, but there are many new and complicated issues that arise at the local level. First, local agencies have limited staff, particularly with expertise in new technologies, which requires a more broad educational and experiential background than past more traditional applications. Local agencies also have limited budgets for training and education for their staff, and very often have restrictions on out-of-state travel that prevent staff from attending regional or national conferences, workshops or other training opportunities where they can learn about potential new technologies.

In the Portland metropolitan region in Oregon, there is a regional advisory group called the TransPort ITS Advisory Committee that has been meeting monthly on a voluntary basis since 1994. Made up of staff from city, county, regional, State, and federal transportation agencies, as well as private sector and university representatives, this group has been a critical resource for sharing information and leveraging funding for collaborative technology implementations. A group such as this could be expanded to include more local agencies outside of the metro area and could become a key source of comprehensive and comprehensible information about technology deployment. State and local chapters of professional organizations such as ITE and ITS America also play important roles in this regard. Technology transfer programs implemented by State departments of transportation and university transportation centers also meet critical needs in transferring and translating information for local agency staff. In some cases, specific programs are aimed at training local elected and appointed officials (such as planning commissioners). In Oregon, the local chapter of the American Planning Association sponsors highly accessible and successful training presentations for city planning commissioners. Programs like this could be replicated and expanded through distance learning techniques. There are a lot of existing resources available from federal and State agencies and universities, but local officials may simply not know how to access them. In an age of "information overload" there are challenges in providing information in easily digestible formats.

Visible, highly documented and evaluated pilot projects that demonstrate technology applications are an effective step toward determining whether the application is appropriate across diverse weather and built environments. But one pilot implementation can never satisfy the wide diversity of environments and situations that characterize the U.S. transportation system. Looking across the spectrum from rural to urban, and from mountainous areas to coastal area, there is no one solution for all problems. But this diversity should not prevent us from implementing pilot projects as appropriate in order to test and demonstrate potential solutions to transportation problems. Often lessons learned can be transferred from (for example) an urban application to one in a rural area, with the understanding that the existing infrastructure for power supplies and communications will be very different from

one locale to another. This is why it is necessary for research and technology transfer to be conducted in both rural and urban areas, with appreciation for the similarities and differences between the two types of location.

Workforce Training

Q2. The U.S. DOT estimates that there are 349 thousand people employed in bridge, street, and highway construction. What impacts do the research activities discussed at the hearing have on these workers? Will implementation of sustainable transportation technologies require wide-scale training and education? If so, who is responsible for providing this training?

A2. For research to be truly successful, ultimately it must be implemented on the ground. The responsibility for this implementation lies with the many transportation professionals employed in construction and maintenance. The implementation of some sustainable transportation technologies will involve construction and maintenance techniques and practices that are substantially similar to the more traditional types of transportation projects. In these instances, ongoing training should continue to be provided by transportation agency, industry and professional organizations, along with educational institutions at various levels. There will be situations where sustainable transportation technologies that result in life cycle cost and energy savings will require new construction and maintenance techniques. It should also be noted that new financing mechanisms such as public private partnerships that involve more focus on construction quality assurance may also require new training and education. In these cases, training should continue to be provided by the agencies, industry and professional organizations, with educational institutions as key partners. Training and education offerings can be coordinated both within states and across State boundaries. A set of shared calendars for training opportunities should be developed along with a central clearinghouse for collecting and organizing training needs. Breaking down barriers and erasing concerns about "turf' will help making these opportunities available to all who need them.

At a broader level, if agencies implement a strong culture of continuous improvement, they will need to encourage and foster an environment that appreciates and rewards an appreciation for ongoing education and training at the individual employee level. This kind of culture can inspire employees to better themselves and their team by seeking more training and education. Rewards in terms of promotions, salary step increases, and other incentives that are tied to educational accomplishments should be considered and implemented.

Coordination

Q3. How can RITA and the other agencies of the Department of Transportation increase the coordination within the research community and awareness of research results in the broader community?

A3. Within the traditional transportation disciplines, there are several existing systems that help coordinate ongoing research and allow for efficient dissemination of research results. For example the TRB RiP database is a good example of a system that allows researchers to conduct queries about ongoing projects. Of course, any database is only as good as the data that are entered—so there is a risk that some projects are not entered in a timely fashion, are not updated or are not entered at all. The committee structure of TRB allows researchers in a particular narrow area to be aware of ongoing research and results that are relevant to that particular subdiscipline since researchers usually want and need to present and publish their work. USDOT agency personnel typically participate in TRB committees and their meetings and activities. Further, TRB committees also often develop research problem statements that are later submitted through the AASHTO research selection process for NCHRP projects. The TRIS database is an excellent resource for learning about completed, published research results, and this includes research conducted by State departments of transportation, university transportation centers and all federally sponsored research. Moving toward adding full text documents (e.g., PDF format) for all TRIS entries would help make research results more transparent and available. Many TRIS entries include links to full text documents but some only provide abstracts. There may not be funding available for this but it should be considered in the future, under the auspices of the National Transportation Library.

Now that transportation research is being conducted by increasingly diverse, multidisciplinary researchers, there is a risk that dissemination of results may occur through other channels not monitored by traditional transportation researchers. There has been an example in the physics community where valuable contributions

have been made to the transportation field but published in the physics journals which traditional transportation researchers may not be aware of.

RITA and other USDOT agencies are already working toward coordinating research activities and promoting awareness of research results within the context of their relatively limited resources. RITA requires the UTCs to aim toward solving national-level research priorities by partnering with USDOT agencies. Further efforts toward developing a concrete, "official" means of collaboration between UTCs and federal agencies would help improve this coordination and would leverage research funding toward improved products.

Question submitted by Representative Adrian Smith

Q1. When using recycled materials in road pavement, how much does this change the cost of construction?

A1. There are cases when considering life cycle costs that the inclusion of recycled materials in road pavement can reduce the cost of construction. In other cases, the construction cost may increase slightly but would provide other benefits in terms of user costs (noise, ride quality, safety) or reduced maintenance costs.

ANSWERS TO POST-HEARING QUESTIONS

Responses by Gerald F. Voigt, P.E., President and CEO, American Concrete Pavement Association

Questions submitted by Chairman David Wu

Q1. You discussed in your testimony the four voluntary environmental goals adopted by member companies, which include implementing an auditable and verifiable environmental management system. Can you provide more details on this environmental management system? What are the impediments to implementation? In addition to environmental protection, are there other benefits or detriments to companies that implement these systems?

A1. It is important to note that the cement industry began to address climate change in the mid-1990s—one of the first industries to do so. Today, the cement industry accounts for less than 1.5 percent of U.S. CO_2 emissions, well below other sources such as electric generation plants (33 percent) and transportation (27 percent). The voluntary reduction targets for key environmental performance measures are a part of the progress that has been made, which will continue into the future. ACPA member companies, which also comprise the members of the Portland Cement Association (PCA) represent over 98 percent of the cement clinker production in the U.S., which means that the voluntary action is truly an industry-wide initiative.

In the 1990's, the cement industry joined the USEPA Climate-WISE program. This voluntary program assisted companies in improving energy efficiency and reducing CO_2 emissions. As part of this program, an MS-Excel spreadsheet was developed for the calculation of CO_2 cement plant emissions. This effort was used to develop an international emission calculation spreadsheet. U.S. cement manufacturing companies are using this international consensus-developed spreadsheet to calculate current and past CO_2 emissions.

The environmental management system is a benchmarking process that U.S. cement manufacturers are performing to track their progress. By 2020, the industry aims to reduce CO_2 emissions by 10 percent below 1990 baseline levels. To achieve this goal, the cement industry has adopted the following strategies:

1. Improve the energy efficiency by upgrading plants with state-of-the-art equipment.
2. Improve product formulation to reduce energy of production and minimize the use of natural resources.
3. Conduct research and develop new applications for cement and concrete that improve energy efficiency and durability.

The industry fully recognizes and discloses that emission of CO_2 is a part of the cement manufacturing process, regardless of what energy source is used for production. The chemical reaction that converts limestone and other raw material ingredients to cement clinker—calcination—releases CO_2. However, it is also our industry's view that these emissions are outweighed dramatically by the energy-savings and sustainability benefits derived from concrete compared to alternative building products, such as asphalt for pavements. To understand this point, it is important to recognize that cement represents only a small fraction of the volume of concrete—roughly about eight percent of the volume of a typical concrete paving mixture.

The challenges we see with implementing the strategies noted above include the communication of these relationships, the cost for new or upgraded equipment, and the impact of global competition. While the U.S. cement industry is working to reduce CO_2 emissions, other countries' cement industries do not have the same dedication to environmental stewardship. In recent years, up to 20 percent of the cement sold in the U.S. has come from imported sources, including China, India and other areas with less manufacturing controls than are standard in the U.S. today. It will be difficult for the U.S. cement industry to compete under a system where there is no balance on the emphasis of environmental stewardship in manufacturing.

Despite these challenges, the environmental management system will continue to benefit the industry with a consistent tracking process and a means to more effectively measure and communicate its goals.

Q2. How do you measure the impact of light-colored pavement on urban heat islands? Does light-colored pavement have any negative impacts or associated problems? Can recycled materials such as fly ash be incorporated into light-colored pavements?

A2. The temperature of any pavement surface depends upon the reflectance and emittance of the surface, as well as the amount of solar radiation. The standard test used to measure the reflectance of a surface is American Society for Testing and Materials (ASTM) C1549, *Standard Test Method for Determining Solar Reflectance (ALBEDO) Near Ambient Temperature Using a Portable Solar Reflectometer.* The test measures "ALBEDO," the ratio of reflected solar radiation to the total amount that falls on that surface, known as incident solar radiation. ALBEDO values range from 0, for perfect absorbers, to 1, for perfect reflectors; most ALBEDO readings are expressed as a percentage.

The values for typical paving surfaces[1] are as follows:

- Concrete pavements produced with white cement have ALBEDO readings in the range of 0.70–0.80 when new, and 0.40–0.60 after significant use and accumulation of dirt, grime, etc.
- Concrete pavements produced with ordinary gray cement have ALBEDO readings in the range of 0.35–0.40 when new, and 0.20 to 0.30 after significant use and accumulation of dirt, grime, etc.
- Asphalt pavement has a typical ALBEDO range of 0.05–0.10 when new, and 0.10–0.15 after oxidation, significant use and accumulation of dirt, grime, etc., aged.

Lighter surfaces reflect more energy and do not contribute as much heat to the ambient conditions, as do darker, more energy-absorbent surfaces. To measure the impact of this additional heat requires calculation of the electric costs to cool urban buildings based on differing ambient temperature regimes, as well the corresponding reduction of pollution and other effects of decreasing the necessary energy production. Lawrence Berkeley Laboratory[2,3] studies provide this type of indication, estimating that $5 billion per year can saved be through reduced cooling costs. We are also aware that Arizona State University's Center for National Center of Excellence on SMART Innovations for Urban Climate and Energy is working to refine these relationships.

There are no known negative impacts or associated problems with the light-colored pavement surfaces. In addition to reducing the impact of urban heat islands, they also improve on-road visibility from both vehicle headlights and street lights, resulting in enhanced vehicle and pedestrian safety.

Recycled materials, such as fly ash (from coal combustion) and slag cement (a by-product of the manufacture of iron) are easily incorporated into concrete paving mixtures. Fly ash, although typically somewhat darker than ordinary gray cement, does to our knowledge not lower ALBEDO appreciably. This may be related to the fact that fly ash is typically incorporated into concrete pavements in percentages (by weight of cementitious materials) less than 20 percent. However, slag cement, also routinely used where locally available, sometimes in percentages as high as 50 percent (by weight of cementitious material), generally elevates concrete's ALBEDO. Concrete containing slag may yield ALBEDO readings in the ranges similar to those made from white cements.

Questions submitted by Representative Phil Gingrey

Tech Transfer

Q1. In the end, implementation of new technologies will require local developers and planning boards to accept and cooperate in their use. Do local decision-makers have access to comprehensive and comprehensible data on potential new technologies? Are pilot projects enough to demonstrate effectiveness across the wide variety of weather and built environments?

A1. Generally speaking, local decision-makers do have access to comprehensive and comprehensible data to evaluate and implement new technologies, although there are considerable challenges in educating and transferring technology to a con-

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[1] Adapted from: Levinson, R. and H. Akbari. 2001. "Effects of Composition and Exposure on the Solar Reflectance of Portland Cement Concrete," Lawrence Berkeley National Laboratory Report LBNL–48334, Berkeley, CA.

[2] Akbari, H. "Energy Savings Potentials and Air Quality Benefits of Urban Heat Island Mitigation," First International Conference on Passive and Low Energy Cooling for the Built Environment, Athens, Greece, May 17–25, 2005.

[3] Pomerantz, M., B. Pon, H. Akbari, and S.-C. Chang. 2002. "The Effect of Pavements' Temperatures on Air Temperatures in Large Cities," Lawrence Berkeley National Laboratory Report LBNL–43442, Berkeley, CA.

stantly-changing workforce. Attrition in the public sector, along with limited funding for training, as well as state-imposed restrictions on travel for training, makes this even more challenging.

Access is only one variable in the equation, however. To truly adapt energy conservation and sustainability practices throughout the transportation-construction community, the culture of considering "lowest first cost"—a culture that remains in many State Departments of Transportation (DOTs)—must change to impact the use of innovative and current materials that are more sustainable. Traditionally, State DOTs have considered the construction and maintenance/preservation of a roadway as two separate operations, with separate funding levels assigned to each. Sound public policy should ensure public monies are being invested with the optimum return on the investment through all phases of the pavement life cycle.

Furthermore, when evaluating return on investment, true first costs and life cycle costs should be evaluated for highways, as well as other facilities in our nation's surface transportation infrastructure overall. These evaluations should be made on actual performance data and using true costs to the agency, including all factors such as material price escalators.

Pilot projects are not enough to demonstrate the effectiveness of new technologies, particularly noting climatic differences, as well as other regional variables, whether man-made or naturally occurring. However, in road-building, one of the largest hurdles is getting previously unspecified technology to be used on a project, and pilot projects are extremely beneficial to overcome these hurdles. Never-the-less, it is our considered opinion that the requisite approaches to the "tech transfer" challenge include several concerted efforts, including:

- Applied research to evaluate and validate new technologies;
- Pilot programs for proving the new technologies;
- An adequately-funded clearinghouse for research findings that is specific and germane to the transportation-construction community. This clearinghouse should include research findings from various stakeholders and should be available to persons in the public sector, private sector, and academia.
- A formal, technology transfer and implementation program, specifically centered on training public- and private-sector stakeholders in best practices associated with energy conservation (and within it, fossil fuel reduction) and sustainable highway construction. We feel this program should be executed equally by the Federal Highway Administration and co-equally by the concrete and asphalt pavement industries for purposes of educating State agencies and the private sector. Industry should have the responsibility for providing training to contractors and others in the private sector, as well as academia.

Workforce Training

Q2. The U.S. DOT estimates there are 349 thousand people employed in bridge, street, and highway construction. What impacts do the research activities discussed at the hearing have on these workers? Will implementation of sustainable transportation technologies require wide-scale training and education? If so who is responsible for providing this training?

A2. The research and development activities discussed at the hearings will have a material impact on workers, but only if there is adequate training, positive incentives and a framework that guides State and federal agencies to embrace both emerging and existing technologies associated with energy conservation and sustainability.

We look forward to the continued support of Congress on pavement research and development in future transportation funding bills, and we thank you for supporting these provisions in past bills. We also recommend that a significant focus of future efforts be placed on technology implementation. It is our observation that implementation has been overlooked in the spectrum of research and development. It has been said by those in the public and private sector alike, that it takes as many as 10 to 15 years to see new technology implemented into wide-spread practice across the 50 states. This record must be improved and this can only be achieved by training those who have to work with the technology in the field.

We believe the responsibility of training should be shared, because of both the scale and scope of the training required. In our view, the responsibility of training private sector workers should rest primarily with the industry associations and other organizations like ACPA, with support provided from the Federal Highway Administration and Federal Aviation Administration.

The agencies of the U.S. Department of Transportation should shoulder the load for training workers of the State departments of transportation with support from industry. A significant challenge now exists with the education of State workers. Most states prohibit their employees from traveling across State lines for education and training. This burdens the process of training (and ultimately the speed of implementing new technology) as it limits the sharing of experiences and slows the process within available resources. These barriers must be addressed so that the education and training can be made more efficient and effective.

Coordination

Q3. How can RITA and the other agencies of the Department of Transportation increase the coordination within the research community and awareness of research results in the broader community?

A3. RITA and other agencies of the U.S. Department of Transportation (DOT) can increase the coordination within the research community and awareness of research results in the broader transportation-construction community by working more closely with local and State agencies and the industry to educate, inform, and otherwise support efforts to implement energy conservation and sustainability practices.

Pooling research funds is an excellent mechanism to leverage resources and efforts, as well as involve more people through the process and bridge the gap for implementation. When we learn and put technology to use together, it simply works better and faster.

RITA and other agencies of the U.S. DOT also can have a positive and profound effect by changing the culture and reducing our nation's dependency on fossil fuels through a balance of policies, training, and outreach to all stakeholders in the transportation-construction community.

ANSWERS TO POST-HEARING QUESTIONS

Responses by Christopher M. Poe, P.E., Assistant Agency Director; Senior Research Engineer, Research and Implementation Division–Dallas, Houston, Texas Transportation Institute, Texas A&M University System

Questions submitted by Chairman David Wu

Q1. You discuss special asphalt mixtures called porous friction courses (PFC) in your testimony, noting that this material contributes to energy efficiency and sustainability by filtering runoff and extending the lifetime of the pavement? How much fuel does it take to lay a lane-mile of PFC compared to conventional paving materials? What are the impediments to deployment of PFC?

A1. Rainwater travels along the surface of most pavements until it reaches the edge of the pavement where it drains into ditches or storm water utility systems. Porous friction courses (PFC) are different in that they are about a two inch thick asphalt surface with a very high air void content that allows the water to quickly penetrate into the surface. The storm water then travels within that surface layer to the edge of the pavement. This increases safety by helping to reduce the risk of hydroplaning and wet skidding and also decreases splash and spray from vehicle tires. Because this type of surface also acts as a filter, the quality of the storm water runoff can be improved since many of the suspended solids and pollutants will be trapped within the asphalt layer. And because of the high air void content within the surface, there is a significant reduction in traffic noise which is the primary reason for their increasing use in Europe.

There is no documented fuel savings associated with porous friction courses and there is no extended pavement life. Their primary reason for use is for improved wet weather safety and the noise reduction benefits. Impediments to the use of PFC include the following:

- The potential life of PFCs is unknown but indications are that their life is shorter than conventional paving mixes (mainly because of the effects of water in the layer which can have a negative effect on pavement performance).
- It is unknown how long PFCs can remain "functional." In other words, how long will these mixtures maintain their drainability and noise reduction benefits before they become clogged with dirt and particulate matter?
- PFC paving mixtures are more expensive than conventional mixes. At a time when highway construction and maintenance budgets are stretched, it may be difficult for engineers to justify using a paving surface like PFC when long-term performance and functionality is unknown.

Questions submitted by Representative Phil Gingrey

Tech Transfer

Q1. In the end, implementation of new technologies will require local developers and planning boards to accept and cooperate in their use. Do local decision-makers have access to comprehensive and comprehensible data on potential new technologies? Are pilot projects enough to demonstrate effectiveness across the wide variety of weather and built environments?

A1. Pilot projects that include a formal technology transfer component are effective at disseminating information. In addition, published material, webinars, conferences, and training session are all complimentary to the technology transfer efforts. In addition to demonstration of technology effectiveness, local decision-makers and transportation professionals need life cycle costs of new technologies. To make sound transportation decisions, the ongoing maintenance costs, replacement costs, and time to replacement are all needed to adopt and implement technologies.

Workforce Training

Q2. The U.S. DOT estimates that there are 349 thousand people employed in bridge, street, and highway construction. What impacts do the research activities discussed at the hearing have on these workers? Will implementation of sustainable transportation technologies require wide-scale training and education? If so, who is responsible for providing this training?

A2. We believe wide-scale training and education will be necessary to mainstream new technologies and research results. As with much of the training of new transportation ideas and technologies, training will come from a variety of sources including the Federal Government (often geared towards State DOTs and MPOs), the private sector, and academia. What is often overlooked is the time and resources required to develop good quality training. Pilot tests and research do not inherently result in the production of training materials. Resources must be dedicated to turning the results from research and pilot programs into training. There is capacity to deliver the training through public, private, and academic instructors; however, resources are needed to develop the content for the training materials.

Coordination

Q3. How can RITA and the other agencies of the Department of Transportation increase the coordination within the research community and awareness of research results in the broader community?

A3. The coordination issue is one of the concerns that led to the creation of RITA. RITA is intended to have purview over the various multi-modal research committees and councils of USDOT, and is taking a leadership role in determining research priority needs within the department. To this end, the Communities of Interest were developed, identifying several research areas and putting together groups of modal agencies, research centers and other research entities with interest in each area. The idea is to facilitate communication within these groups, get the researchers talking to each other, and stimulate new ideas as well as avoid duplication. They also take this information back to their customers/partners, which helps the transportation community to understand who is doing what, and why they are doing it.

SAFETEA–LU states that "The Secretary shall coordinate the research, education, and technology transfer activities that grant recipients carry out under this section, disseminate the results of the research, and establish and operate a clearinghouse to disseminate the results of the research." [Section 5402 (k) (1) Program Coordination] To address this legislative mandate, RITA requires UTCs to submit all research to the Research in Progress (RiP) database and to TRIS. This makes ongoing and completed research available to anyone searching the web for information on a particular transportation topic and is thought to be one of the most effective ways that research coordination and dissemination occurs.

In recent years, a partnership has been created between RITA and the Council of University Transportation Centers (CUTC), and all UTCs are strongly encouraged to join. CUTC provides center development activities as a part of its annual meeting, and provides a venue for UTCs and other transportation centers to meet on a regular basis. Because CUTC has an annual newsletter and sponsors a high-profile event at TRB, RITA's involvement increases awareness of its research activities.

In recent years, federal funding to sport TRB has been reduced. This along with the fiscal constraints on public agencies to send scientists, engineers, and transportation professionals to the premier annual meeting to disseminate research results has hindered further coordination. Funding for TRB and support to public agencies is needed to continue this coordination, technology transfer, and education.

Appendix 2:

Additional Material for the Record

STATEMENT OF THE ARIZONA DEPARTMENT OF TRANSPORTATION

Introduction

In the world of transportation, research and technology are vital to providing safer, more efficient, cleaner and less costly facilities. The challenges that the Nation faces now and in the future—congestion, safety, rising fuel costs, energy supply, economic demands, environmental impacts, climate change, and growth will require that we all look to new technologies and innovations to expand the capacity of our infrastructure, grow the economy and at the same time reduce our impact on the environment.

Arizona in particular has seen incredible population growth as one of the fastest growing states in the Nation. In the face of this growth, it is clear that the challenges presented will require innovation based on research. The demand on today's overburdened transportation facilities means that transportation professionals will be challenged to sustain the Nation's mobility. Responding to challenges in an innovative way has always been one of the things that Americans do best.

The future presents both challenges and opportunities. Rapidly advancing technology will be an essential part of the solution to new problems. Applying this technology through research will create new opportunities for improved transportation systems.

Current Research

ADOT's research program encompasses a broad spectrum of topics relative to transportation systems. The research is focused on advancing technology, solving problems and pursuing practices that will save lives and money. The primary driver in this program is the Federal Highway Administration (FHWA) State Planning and Research (SPR) funding. Other important program elements include information derived from the Transportation Research Board, FHWA research programs, and national cooperative transportation research programs, such as the National Transportation Cooperative Research Program (NCHRP) and the Transit Cooperative Research Program (TCRP). Under the American Association of State Highway and Transportation Officials (AASHTO), ADOT participates in the Standing Committee on Research (SCOR) and the Research Advisory Committee (RAC).

ADOT's Arizona Transportation Research Center (ATRC) directs the ADOT research program. Under the research program ADOT conducts transportation research on materials, construction activities, structures, maintenance, traffic, intelligent transportation systems, safety, environmental topics, planning, administration, and computer systems. ATRC publishes reports on completed research and maintains a library of transportation resources.

The following are examples of innovative research and technology applications that ADOT is using for materials and products, intelligent transportation systems and computerized information systems:

Materials and Products

– The ATRC coordinates ADOT's product evaluation program as part of the research program. The ATRC Product Resource Investment Deployment and Evaluation (PRIDE) program was established to provide a framework for introducing new products. The PRIDE program provides a centralized system for evaluating a wide range of products used by ADOT. Through the PRIDE program ADOT increases its ability to select cost-effective, safe products for use on the State highway system and roll them out throughout the agency.

– Arizona was the first state to implement a pilot in partnership with FHWA to test the noise reduction capabilities of rubberized asphalt on 115 miles of selected freeways in the Phoenix area. We have used rubberized asphalt since 1988 to resurface roads across the state, at various elevations and in different climates and found that it reduced traffic noise.

  Data collected for the pilot has shown an average noise reduction of five decibels in residential neighborhoods. By participating in the pilot ADOT aims to confirm that the noise reduction is sustainable over the average 10–12 year life of a pavement overlay. Now Illinois is piloting the use of rubberized asphalt as well.

  Rubberized asphalt consists of a mixture of aggregate combined with asphalt cement and crumb rubber from discarded tires. As a result of utilizing this resurfacing application, more than 15 million tires have been recycled in Arizona since 1988.

– ADOT has converted most of our traffic and pedestrian signals from incandescent light bulbs to LED (light-emitting diode) signals which are environmentally friendly, reduce energy costs significantly and provide cost savings to taxpayers. This has allowed us to convert the cabinets to include uninterruptible power supply and has reduced energy consumption for traffic signals by 80 percent. We also use LED lighting on most of our heavy trucks and on vehicles with emergency lights.

Information Technology Systems

– In March 2002, Arizona launched its statewide 511 System through ADOT's Traffic Operation Center. The 511 system provides information both on-line and through the phone system to motorists about road closures, restrictions, construction locations, traffic-related maintenance activities, weather-related road closures, and traffic incidents. Last year, ADOT implemented the Sonora/5–1–1 system which is the first to reach beyond U.S. borders to allow motorist to access information on traffic issues in Arizona's neighboring State of Sonora Mexico.

– An important technology that ADOT uses to inform and ensure the safety of motorist is the Variable-Message Sign. The signs are capable of quickly changing messages remotely making it a simple and quick way to inform motorists of accidents, closures, detours or most recently drive times in Metropolitan Phoenix. Our Variable-Message Signs, directional arrow signs, and weather stations all use solar power.

– ADOT uses driving simulators to train and refine operating skills on equipment such as snow plow trucks. The equipment is mobile so it may be moved from site to site. Use of the simulators saves fuel, reduces equipment wear and tear and helps to reduce accidents by providing training in a variety of simulated weather and traffic conditions. Some ADOT on-road heavy equipment is equipped with on-board crash avoidance sensors which detect front, rear and side obstacles.

– Global Positioning Systems (GPS) and Automated Vehicle Locator (AVL) Systems are now being used to track snow plows and paint striper trucks to identify equipment location, speed and productivity.

– Geographic Information Systems (GIS) are also being used to track snow plows and striper plows to identify depth and type of material used, allowing for better analysis of productivity. GIS also monitors ambient air temperatures allowing the operator to better determine the amount of material needed based on air temperature. GIS also displays information on traffic incidents so it can be seen on-line and facilitate detours and information to motorist.

Computerized Information Systems

– ADOT is among a very few State DOTs actively developing a Feature Inventory System (FISDC). This system incorporates Global Positioning System (GPS) data collection with the power of Geographic Information System (GIS) for inventory purposes and easy access and presentation of geographic and manmade features that exist within ADOT's right-of-way. The system will provide an accurate inventory for the existing features as maintained by the individual districts. After the completion of the system, the inventory will be tied to the State plane coordinate system and the data can be easily downloaded and used by planners, designers, contractors and maintenance personnel, giving districts a better tool to manage their resources and plan their maintenance activities. We were recently contacted by Maryland DOT who is seeking information on asset management systems and to learn from the experience gained by ADOT in this field.

– An innovative, state-of-the-art maintenance management system, Pecos IV, is scheduled for roll-out in March 2009. Our new system will incorporate state-of-the-art design and programming tools. Innovative features include:

  • map-based displays
  • improved information retrieval and reporting capabilities
  • improved information accuracy, audit ability, reconcilability and timeliness
  • better data entry validation

- better business processes for purposes such as indirect costs tracking and allocation, activity, equipment, and labor
- improved trend analysis
- better tracking of contracts utilization and time
- Geo-Coding of work report location

– The Maintenance Budgeting System (MBS) provides ADOT with a state-of-the practice, performance-based method for quantitatively assessing the impact of maintenance activities. Road condition is related to Level-of-Service (LOS), providing a way to link maintenance program budgeting to customer expectations and legislative interest in the maintained road network. Assessments of the existing LOS, and projections of target LOS based on ADOT priorities and desired improvements, provide a way to meet customers' expectations while allocating maintenance resources in a cost-effective manner.

  This effort involves the definition of customer-oriented levels of service (LOS), where LOS is defined in each program category as the percentage of maintained items that meets minimum criteria. The LOS concept is used to characterize the status of roadway system based upon observed conditions. Future LOS values can also be projected in relation to planned budget levels to express targets for future maintenance performance. This innovative approach enables ADOT to compare the actual level of service achieved in the future to the target LOS value that has been forecast at the approved budget level, providing accountability for the maintenance expenditures in each program.

– ADOT is beginning to fully populate the Electronic Contract Management System (e-CMS) with contract data during State fiscal year 2009 and developing safeguards in the system to promote data integrity and to assist with timely contract close-outs. These processes will result in helping to reduce the backlog by over five percent.

– A Cost-Negotiations Cross Functional Team has been formed to develop an automated tool to assist Project Managers to develop independent contract cost estimates (hours) to compare with those submitted by consultants. A standardized automated cost proposal template will also be developed and integrated into the system to be used by consultants to submit their cost proposals on-line. Once these tools have been developed and Project Managers and consultants are trained, it is expected that the time required to analyze and negotiate agreed upon estimates to do the work can be reduced by about five percent or seven (7) calendar days. Significant double digit improvements are expected in FY10 and beyond once the systems have become standard operating procedures.

– Our Statewide Project Management Office is using various web sites to host project documents, outline process descriptions, and maintain a people directory for better communication, cross functional training, higher productivity and succession planning. This group also uses blog, webinar and instant message to enhance our communication in project development. The next generation of project managers will be able to learn from project history for future process innovation. A search engine will be built to link all websites.

– ADOT's Right of Way Operations (ROW) Section is implementing two new databases. The first is an accounting database to prepare and track all non-EPS payments processed by the unit. This replaces an antiquated system that used both paper and computers. The second is a checks database to track all payments received in ROW Operations. The new systems will greatly reduce processing time for accounting transactions in Right of Way. Also, as the new system interfaces with the Department's accounting system there will be a drop in the number of errors.

– The Roadway Engineering Group is working to utilize a Portal with electronic documents and files for all studies. Information stored in the Portal is compatible with and can easily be uploaded into the Project Reference Manual once a project moves to a design phase. Within the coming months, all Predesign study documents will be transmitted electronically for reviews.

– The Roadway Engineering Group is also implementing electronic signatures on final study documents. The Drainage Section has efforts underway to scan all drainage reports so that they will be available to internal staff, consultants and other agencies. This alone will generate a large savings in time and resources. The Roadway Design Section continues to use electronic plans sub-

mittals and will be further evaluating the practice of supplying electronic design data to the contractor. The Roadway Engineering Group will also utilize electronic submittals for project cost proposals and payments for supplemental service personnel.

– The Engineering Fields Survey Section will soon utilize a PDA with a terrain navigator. The test results show that the PDA will save paperwork and facilitate survey crews in finding targets in the field.

– A cross-functional team has recommended Engineering Field Surveys pilot several major projects in FY09 to deliver design level engineering surveys before the design kickoff meetings. This effort is expected to eliminate some duplication of survey effort during the design phase of projects.

Research Issues

Technology demonstration projects are vital to ensuring we find better and more efficient ways to meet the growing demand on the transportation infrastructure. Arizona is one of the most requested states for pilots and demonstration because of our hot climate and varied terrain. When we participate in pilot or demonstrations, ADOT typically provides ongoing information on the web such as our rubberized asphalt pilot at *www.quietroads.com.* We also maintain records and reports that are provided on request.

Some of the biggest impediments to the use of new materials and technologies relate to the federal interpretation for procurement. There is a greater emphasis on ensuring competition between vendors than on innovation. Competition is important but a balanced approach that recognizes and rewards innovation is necessary.

The transportation community would be more effective at innovation if the Federal Government would allow a broader interpretation of 23 CFR Ch. 1, Section 635.411.

Over 15 State transportation departments submitted a Public Interest Finding to use a specific type of high performing sign sheeting, but were denied by the FHWA. Because the product is new and innovative the cost of the product is slightly higher but it also has a higher level of performance. Because of price the product, it is not currently allowed for use on federally funded projects. Again, balancing initial cost against long-term cost and productivity would open the door for innovation.

In addition, a demonstration or pilot on new techniques or materials does not include funding if the test does not work leaving the agency to fix or replace the problem. Failure is an important part of the innovative process and can provide valuable information. Punishment is the wrong response. In addition, federal web sites need to keep on-line information on research and pilots up to date.

In order for State departments of transportation and local governments to make use of new technologies and innovations to facilitate improvements to our transportation system, it is critical that states are provided with the flexibility to pilot and implement new technologies. University research facilities should consult with State departments of transportation on direction and needs to ensure that research supports what is happening in the field.

Research Needs

As part of our strategic plan ADOT has identified the following as vital to achieving our vision of being "the standard of excellence for transportation systems and services."

- Technology—ADOT must maximize the use of technology in all aspects of its operations.
- Congestion Management—ADOT must deploy the best mix of multi-modal strategies to manage congestion.
- Customer Service—ADOT must maintain a strong customer service focus.
- Highway Safety—ADOT must always strive to make Arizona's transportation infrastructure safe.
- Environmental Stewardship—ADOT must deploy the best environmental management techniques into its business practices. This also includes exploration of a balanced and multi-modal system.

Some of ADOT's major priorities for research are:

- Inter-operable communication systems to better coordinate with the Department of Public Safety, local police and the fire department during incidents on State highways.

- Evacuation planning to ensure that in the event of a disaster, ADOT can facilitate a quick and effective way to move people away from the site.
- Cheaper alternative recyclable pavement, materials and equipment.
- Development of alternative fuel infrastructure for E–85 fuels.

Conclusion

Research and technology play an enormous role in the transportation industry. These tools will be the most critical part of moving to a new tomorrow for transportation. For the next reauthorization increased funding for research and greater flexibility for the development and use of innovative technologies and processes are vital to meeting the Nation's growing transportation needs.

STATEMENT OF MIKE ACOTT
PRESIDENT, NATIONAL ASPHALT PAVEMENT ASSOCIATION (NAPA)

On behalf of the National Asphalt Pavement Association's 1,200 member companies, the association would like to thank Chairman Wu and Ranking Member Gingrey for holding this hearing to examine ways to reduce energy costs and environmental impacts through improved pavement technologies. I am Mike Acott, President of NAPA.

NAPA represents asphalt pavement producers and related industries at the national level. Asphalt pavement material is composed of approximately five percent asphalt cement and 95 percent stone, sand or gravel. Of the 2.6 million miles of paved roads in the United States, over 94 percent are surfaced with asphalt. Approximately 85 percent of the Nation's airfield pavements and 85 percent of the parking lots are also surfaced with asphalt pavement. There are approximately 4,000 asphalt plants located in the United States producing annually 500 million tons of asphalt pavement material and employing directly or indirectly 300,000 U.S. workers.

NAPA has a long history in developing and promoting innovations that improve sustainability, energy efficiency, and virtually every other aspect of asphalt. Today, the industry produces a sustainable, environmentally friendly material that is adaptable to different climates, traffic loads, and end-use applications.

Moreover, asphalt pavement is America's most recycled product. Each year, about 100 million tons are reclaimed, and 95 percent of that total is reused or recycled. NAPA has supported an active research program designed to answer questions about environmental issues and to improve the quality of asphalt pavements and paving techniques used in the construction of roads, streets, parking lots, airports, and other facilities.

The asphalt industry has been engaged with product improvement through technological innovation for many years. In 1986, the industry founded the National Center for Asphalt Technology (NCAT) at Auburn University, Alabama, by means of a $10,000,000 endowment from companies and individuals in the asphalt industry. Today NCAT is at the forefront of technological breakthroughs that are of benefit to contractors, agencies, and taxpayers. Its current operating budget is about $5,000,000 annually, mostly through research funding.

The NAPA Committee for Asphalt Research and Technology (CART) was formed in 1996 to provide a forum for industry-identified research topics to be discussed and put forward for funding.

Recently, CART partnered with the Federal Highway Administration (FHWA) to produce the *National Asphalt Roadmap for Research and Technology.*[1] The asphalt industry's research agenda is embodied in this document. In addition to FHWA, the partners in developing the document included the Asphalt Institute (AI), the American Association of State Highway and Transportation Officials (AASHTO), and the National Stone, Sand & Gravel Association (NSSGA). This is considered to be a living document, and already many of the research projects identified within it have been approved for funding by FHWA and the National Cooperative Highway Research Program. The asphalt pavement industry would like to see continued vigorous federal research programs to address the issues that have been identified within the *National Asphalt Roadmap.*

As requested by the Subcommittee, NAPA's testimony will answer the following questions:

1. How can paving materials contribute to energy efficiency and sustainability in the transportation sector?
2. What are the technical challenges and what ongoing or future research and development projects will improve the sustainability of pavement materials and address these challenges?
3. What actions can the Federal, State, and local governments take to overcome these impediments? What is the role for industry and academia, especially in technology transfer?

1. How can paving materials contribute to energy efficiency and sustainability in the transportation sector?

[1] *National Asphalt Roadmap for Research and Technology,* National Asphalt Pavement Association, Lanham, Maryland, 2007.

2. What are the technical challenges and what ongoing or future research and development projects will improve the sustainability of pavement materials and address these challenges?

With over 94 percent of paved roads in the United States surfaced with asphalt, even relatively small but widely applicable advances in asphalt pavement technologies could contribute greatly to energy efficiency and sustainability. Examples of such advances include Superpave and stone-matrix asphalt.

As mentioned previously, the *National Asphalt Roadmap for Research and Technology* was published in 2007. The *Roadmap* is the result of a public-private partnership and encapsulates the shared vision to "Develop improved asphalt pavement technologies that ensure the continued delivery of safe and economical pavements to satisfy our nation's needs."

Some of the intrinsic attributes of asphalt pavement make it a natural choice for sustainability. The asphalt industry has also invested heavily in making this material more environmentally friendly. The committee may wish to consider additional factors in this regard.

Recycling. The asphalt industry is America's number one recycler. Recycling saves precious natural resources and reduces the carbon footprint of pavement construction. Of the 100 million tons of asphalt pavement reclaimed each year, about 75 million tons is mixed with virgin materials and incorporated into new asphalt pavement. This is called the highest and best use because the asphalt cement in the old pavement is reactivated, becoming part of the binder for the new pavement and replacing some of the virgin binder that would otherwise be required. Another 20 million tons of reclaimed asphalt pavement, or "RAP," is reused in other ways in highway building. Aside from recycling its own product, the asphalt industry incorporates materials from other industries, including used tires, waste roofing shingles, glass, and many others, into high-quality pavements. With Portland cement, however, the binder cannot be rehydrated after its initial use. Therefore, once the steel reinforcing material is extracted from reclaimed concrete, it is a low-value material which can be used only as aggregate in limited applications.

Perpetual Pavement. Advancements in milling, recycling, and asphalt pavement technology over the last few decades have created asphalt pavements that perform better, longer, and at lower life cycle cost than was previously possible. Today's asphalt pavements can be designed literally to last in perpetuity. Total pavement reconstruction is rendered virtually obsolete with a perpetual asphalt pavement. Instead, the asphalt pavement is engineered and built to last without requiring major structural rehabilitation or reconstruction, and needing only periodic surface renewal in response to distresses confined to the top of the pavement. Perpetual pavement is environmentally friendly because it is extremely long-lasting. When the surface is renewed, the material that is removed is recycled. Perpetual pavement is also budget-friendly and has a lower life cycle cost than conventional asphalt or concrete pavements.

Studies from Kansas,[2] Oregon,[3] Washington,[3] Ohio,[4] and Minnesota[5] all show that asphalt pavements last as long as or longer than concrete pavements. In Oregon, the average age of concrete pavements on the interstates is about 30 years, the oldest being about 50 years. Asphalt pavements on interstate routes in Oregon are, on average, about 40 years old, with the oldest pavements being between 50 and 60 years old. In Washington, the asphalt pavements average an age between 35 and 40 years, with the oldest being about 50 years, and concrete pavements' average age is about 35 years with the oldest being about 50 years.

What is more, the studies from Kansas[6] and Ohio[7] show that asphalt pavements have a lower cost over their lives than do concrete pavements. Decades ago, using

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[2] Cross, Steven A. and Robert L. Parsons, *Evaluation of Expenditures on Rural Interstate Pavements in Kansas,* Kansas University Transportation Center, University of Kansas, Lawrence, Kansas, February, 2002.

[3] Transportation Research Board, Pavement Lessons Learned from the *AASHTO Road Test and Performance of the Interstate Highway System,* Transportation Research Circular E–C118, Washington, DC, July 2007.

[4] Gibboney, Willis B., *Flexible and Rigid Pavement Costs on the Ohio Interstate Highway System,* Westerville, Ohio, 1995.

[5] Lukanen, E., *Performance History of HMA Pavements with Aggregate Base and Portland Cement Concrete Pavements,* Minnesota Asphalt Pavement Association, New Brighton, MN, 2002.

[6] Cross, Steven A. and Robert L. Parsons, *Evaluation of Expenditures on Rural Interstate Pavements in Kansas,* Kansas University Transportation Center, University of Kansas, Lawrence, Kansas, February, 2002.

[7] Gibboney, Willis B., *Flexible and Rigid Pavement Costs on the Ohio Interstate Highway System,* Westerville, Ohio, 1995.

technology available at the time, an asphalt pavement would generally last 12 to 18 years before the first overlay was needed. Recent improvements brought about by better technology have been credited with extending the time to the first resurfacing of an asphalt pavement to over 20 years. And, unlike with concrete, resurfacing an asphalt pavement can be done when traffic levels are at their lowest and the road can be turned back to traffic during rush hours. This enhances safety and convenience to the traveling public by minimizing delays for motorists.

In addition, many asphalt pavements built decades ago are functioning as perpetual pavements. As mentioned above, perpetual pavements are designed so that the pavement structure will last in perpetuity. Total pavement reconstruction is rendered virtually obsolete. Instead, the asphalt pavement is engineered so that distresses are confined to the top layer of the pavement. At infrequent intervals, the surface is removed for recycling, and replaced with a smooth, safe new surface. The Asphalt Pavement Alliance has awarded its Perpetual Pavement Award to over 27 agencies since 2001. In order to qualify for this award, the agency must submit documentation showing that the pavement has lasted more than 35 years with no structural failure. These sustainable pavements use fewer resources and have a lower lifetime cost than conventional pavements.

Asphalt's Low Energy Footprint. A meaningful study of the energy footprint of any product must consider all phases in that product's life cycle. The gold standard for such analyses is the environmental performance tool provided by the National Institute of Standards and Technology (NIST).[8]

The NIST tool is based on an extensive analysis of total life cycle energy requirements and CO_2 emissions associated with different pavement types and designs. This analysis has been vetted at the highest public levels and EPA supports its use through the Environmentally Preferable Purchasing (EPP) Program, which is charged with carrying out Executive Order 13423, Strengthening Federal Environmental, Energy, and Transportation Management.

Using the NIST software to compare different pavement types, there is little doubt about the environmentally superior life cycle performance of asphalt pavements as compared to concrete.

Very little energy is required to produce asphalt, as a refinery typically expends energy to obtain products like gasoline, fuels, and lubricants; in some refineries, asphalt is the product remaining after all others have been extracted. However, the Department of Energy's Energy Information Administration (EIA) assigns energy consumption values to the production of asphalt, and these are very low. According to the EIA, all carbon in asphalt is considered "sequestered."[9] In fact, due to the perpetual ability to reclaim and reuse asphalt pavement, the carbon (and energy) embodied in asphalt will likely remain sequestered indefinitely.

Asphalt pavements contribute to an energy-conscious environment in many other ways as well. Because asphalt pavements are faster to construct and rehabilitate, construction work can be accomplished during off-peak hours, reducing traffic construction congestion and commensurately reducing use of fuel and production of emissions. Because a new or newly rehabilitated asphalt pavement can be opened to traffic as soon as it has been compacted and cooled, there is no question of waiting for days or weeks, with traffic being detoured or squeezed into fewer lanes, for the material to cure. Technologies such as rubblization of concrete pavement with an asphalt overlay save energy because the rubblized pavement does not need to be hauled away, new base material does not need to be trucked in, and landfill space is saved. In addition, the need for mining and processing of virgin materials is reduced.

In a side-by-side life cycle analysis, using the environmental performance software from the National Institute for Standards and Technology, the amount of CO_2 emissions associated with constructing and maintaining a 50-year life cycle of an asphalt pavement is only about 30 percent of that associated with a concrete pavement.[10]

Smooth Roads Save Fuel. We know that smooth roads conserve energy and extend the life of pavements. Studies at a pavement test track in Nevada have shown that driving on smoother surfaces can reduce fuel consumption in the neighborhood of 4.5 to five percent compared to fuel consumption on a rough pavement. A five

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[8] Building for Environmental and Economic Sustainability; National Institute of Standards and Technology; (*http://www.bfrl.nist.gov/oae/software/bees/please/bees_please.html.* Downloaded July 2, 2008.)

[9] The Department of Energy's Energy Information Administration (EIA) *http://www.eia.doe.gov/oiaf/1605/archive/87-92rpt/chap2.html*

[10] Prowell, Brian, Greening the Blacktop, Using Asphalt's Environmental Qualities to Compete, *HMAT Magazine,* May/June, 2008.

percent fuel saving is the equivalent of a $0.20 per gallon reduction in fuel costs, assuming that fuel costs $4.00 per gallon.[11] Experts also estimate that a 25 percent increase in smoothness can result in a 10 percent increase in the life of pavements. In other words, smooth roads conserve fuel, save money, and last longer.

Many studies have shown that, more than any other factor, pavement smoothness can help reduce fuel consumption. It is sometimes said, however, that concrete pavements provide better fuel efficiency for larger trucks. The study most often cited in support of this assertion, which was conducted in Canada, has several flaws which are noted in the body of the report. For instance, the researchers noted that the variability of the data was too great to show conclusive differences. Also, the asphalt pavement studied was considerably rougher than the concrete pavements.

In the end, the Canadian study proved what had already been shown in studies such as the one conducted in Nevada, that pavement roughness, not pavement type, is responsible for differences in fuel mileage. The Nevada study11 concluded that trucks running on a smooth pavement could save 4.5 percent on fuel consumption. Smoother pavements also result in longer pavement life by as much as 10 to 25 percent, resulting in lower maintenance costs. As a rule, asphalt pavements are smoother than concrete pavements. Smoothness measurements on interstate highways in Oregon and Washington showed that asphalt pavements are on average 33 percent smoother in Oregon, and over 50 percent smoother in Washington.[3]

Smoothness also means that truck tires don't bounce on the pavement and deliver the kind of impact loading they would on a rougher pavement. Some experts estimate that increasing pavement smoothness by 25 percent results in a nine percent to 10 percent increase in the life of pavements. Long life contributes to asphalt's sustainability.

Urban Heat Island Effect. Urban heat island mitigation is not a black and white issue. According to the United States Environmental Protection Agency, "there is no official standard or labeling program to designate cool paving materials, and research in this area is in an early stage. While studies show that pavements can affect the urban heat island and resulting air quality, results are complicated by several factors. These include the impact of shadows from nearby structures; changes in pavement characteristics over time; and the absorption by buildings of solar radiation reflected from the pavement surface." [12]

Density, heat capacity, thickness, porosity, and a myriad of other factors affect pavement surface temperature as well. In 2005, the co-directors of the National Center of Excellence: SMART Innovations for Urban Climate and Energy, published an article in *Public Works* magazine emphasizing that factors other than pavement color play a large role in urban heat island mitigation.[13] EPA sponsors and looks to the National Center as leaders in this area. Not specifically mentioned in the *Public Works* article, but clearly identified in a satellite image illustrating the article, the hottest surface temperature signature in Phoenix is the airport with its 23-inch-thick concrete runways. In the same article, the authors point out that open-graded asphalt pavement surfaces placed on top of concrete freeways are highly successful in reducing pavement surface temperature. EPA also recognizes that "[p]orous, or permeable, pavements benefit from the cooling effect of evaporation." [12] In addition, open-graded pavement systems have been shown to reduce the amount of pollutant loads.[14]

Role of State Departments of Transportation in Pavement Type Selection.

NAPA's view is that State DOTs do an outstanding job of providing the best possible infrastructure for local conditions, and the asphalt industry whole-heartedly supports them. It is our strong opinion that a federal pavement selection policy is not a prudent way to approach sustainability. The challenges faced by agencies throughout the U.S. demands that those administrators have the autonomy to choose the paving material that best suits their needs.

Legislating one standard for dissimilar environments removes the flexibility necessary to build the most environmentally and economically sustainable, highest-per-

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[11] Sime, M., et al., *WesTrack Track Roughness, Fuel Consumption, and Maintenance Costs.* Tech Brief published by Federal Highway Administration, Washington, DC. January 2000.

[12] USEPA Heat Island web site, Cool Pavements: (*http://www.epa.gov/heatisland/strategies/coolpavement.html* Downloaded July 2, 2008)

[13] Golden, Jay S., and Kamil E. Kaloush, A Hot Night in the Big City, How to Mitigate the Urban Heat Island, *Public Works Magazine,* December 1, 2005. (*http://www.pwmag.com/industry-news.asp?sectionID=760&articleID=268116&artnum=1* Downloaded July 2, 2008.)

[14] Barrett, Michael, et al., *Pollutant Removal on Vegetated Highway Shoulders Center for Transportation Research,* The University of Texas at Austin, October 2005, Rev. January 2006 (*http://www.utexas.edu/research/ctr/pdf_reports/0_4605_1.pdf, Downloaded July 2, 2008.*

forming, safest roads. It is our opinion that Congress and the Federal Government should not dictate pavement selection.

The DOTs are highly professional organizations which are assembling factual information so that they can perform life cycle cost analysis. NAPA supports the use of life cycle cost analysis based on factual information.

NAPA's position is that local conditions require the existing oversight of the State and local governments to remain in place. The asphalt pavement industry is proud to be a partner of the State DOTs, the American Association of State Highway and Transportation Officials (AASHTO), and the Federal Highway Administration (FHWA) in these agencies' quest for continuing improvement in providing pavements that meet the Nation's needs.

In addition, consider the following:

Reducing Congestion. Highway work zones reduce the capacity of a road to handle traffic, especially during rush hours. Asphalt pavements can be designed so that they only need periodic resurfacing, and the work to accomplish this can be scheduled during non-rush hours, facilitating the movement of vehicles through the work zone, reducing fuel consumption, and improving safety. Since asphalt does not need to cure in order to have the strength to support traffic, new or newly rehabilitated pavements can be opened to traffic as soon as they have been compacted and cooled.

Safety. Open-graded asphalt surfacings are widely used on highways to enhance safety. Ensuring the safety of our highways is always a top priority with agencies and contractors alike. Using porous friction courses on pavement surfaces helps to eliminate tire splash and spray in rainstorms. Not only does this enhance tire-to-pavement contact, and therefore safety, it also improves drivers' visibility. In a high-accident area in Texas, replacement of a typical non-porous surface with porous friction course reduced wet weather accidents by 93 percent and reduced fatalities by 86 percent.

Porous Asphalt Pavement. The same open-graded pavement type that is used to surface highways can also be used in porous asphalt pavement systems for stormwater management. Placing a porous asphalt pavement on top of a recharge bed allows stormwater to percolate through the pavement surface into the recharge bed, where it is stored until it can infiltrate into the soil. Porous asphalt pavements decrease runoff and increase filtration, improving water quality. A porous pavement parking system tested at the University of New Hampshire Stormwater Center exceeded 95 percent removal efficiency for total suspended solids. In addition, a recent study by the Texas Department of Transportation found a 90 percent reduction in total suspended solids by using a porous asphalt surface on a highway pavement.

Open-graded and porous pavements hold great promise for water quality improvement. To date, a successful concrete open-graded surfacing material for high-speed pavements has not been developed because concrete's brittleness causes it to crack and ravel under traffic. Porous asphalt pavements of both types—open-graded surfaces for highways, and porous pavement systems for stormwater management—have been used widely for over 20 years with an excellent record of success. We need research to better quantify the benefits of porous asphalt pavements and to better design these environmentally friendly pavements.

Quiet Pavements. As developable real estate becomes increasingly scarce in the urban and suburban landscape, more residents find themselves in closer proximity to high-speed highways and their noise. A major component of that noise is generated at the tire-pavement interface. Many times, very expensive noise walls are constructed between the development and the highway. Often times these walls cost as much as $50,000 per affected household. However, such noise walls have very limited effectiveness in reducing noise from the roadway, especially for residents living farther away. Using a low-noise asphalt surface means that the volume can be turned down at the source, and that noise walls can be reduced in height. For every one decibel reduction, the noise wall can be reduced by three feet. If one considers all the miles of urban roadways in the U.S., the savings could be in the hundreds of millions dollars or more. It has been shown that asphalt pavements in the U.S. are quieter than concrete, anywhere from one to 10 decibels.[15,16,17] This reduction in noise is of great importance to those residents' quality of life. It is an important

[15] Hansen, D.I., R.S. James, and B. Waller, *Tire/Pavement Noise Study for Arkansas APA,* Asphalt Pavement Alliance, Lanham, MD, January 2005.

[16] Hansen, D.I., R.S. James, and B. Waller, *Oklahoma Tire/Pavement Noise Study,* Asphalt Pavement Alliance, Lanham, MD, January 2005.

[17] Hansen, D.I., R.S. James, and B. Waller, *Kansas Tire/Pavement Noise Study,* Asphalt Pavement Alliance, Lanham, MD, June 2005.

societal and budgetary issue that researchers continue to find ways to mitigate roadway noise through better surfacing materials.

Rubblization. When confronted with reconstruction or major rehabilitation of a concrete pavement, rubblization in place of the concrete with an asphalt overlay is the easiest, lowest cost, and most effective way to rehabilitate the pavement in the shortest amount of time. The State of Arkansas estimated that it saved $1.3 million per mile on rubblization projects totaling over 318 miles as compared to removing and replacing the existing concrete pavement. However, rubblization's benefits go beyond just the considerable money saved in construction; it also saves time and money for road users because they spend less time in traffic during the rehabilitation of the road. Spending less time in traffic means that vehicles produce a lower level of excess emissions. In addition, rubblization conserves stone by reusing the old concrete roadbed as the new road's base. Because the old roadbed does not have to be hauled away, and new material trucked in, further fuel savings and emission reductions are realized.

Warm-mix Asphalt Technologies. The asphalt industry is keenly interested in processes that improve its energy efficiency and environmental friendliness. In addition to recycling, the industry is working on a new set of technologies to reduce the production temperature of its material. Known as warm-mix asphalt, these technologies reduce emissions and lower energy consumption. They also offer the potential for better performance and an extended paving season. Continued research and demonstration projects will be required to assist in the full implementation of warm-mix asphalt.

Automation of Construction Practices. Another facet of research needed is in the automation of construction practices. Such improvements may improve not only efficiency, but also worker safety at plants and in the roadway work zones. Gains in efficiency would translate into less fuel consumption and lower production of greenhouse gas emissions. NAPA is very supportive of national efforts such as the development of intelligent compaction, automated sampling and testing, and other tools to enhance worker safety.

3. What actions can the Federal, State, and local governments take to overcome these impediments? What is the role for industry and academia, especially in technology transfer?

The planning, design, construction, and operation of highways have changed dramatically and will continue to evolve. Historically, State departments of transportation, in cooperation with the Federal Highway Administration, have been the public-sector leaders in defining contracting procedures, material specifications, and construction specifications. The procedures of State Departments of Transportation (DOTs) are often adopted by county and local governments and in many cases are also used in private construction activities.

Many changes have occurred in the technology associated with asphalt pavements over the last 50 years. These changes have led to the continuous improvement of asphalt pavements through new products, analytical tools, and testing procedures.

As many of our nation's highways and bridges exceed their design life, they will require significant improvements. An ongoing research and technology program aimed at continuous improvement in the performance of asphalt pavements is vital to the national interests.

Federal Research Program. Significant progress in asphalt pavements can only be achieved through a federally led, nationally coordinated research and implementation effort. In addition, an inclusive, well-coordinated national effort is necessary to foster a strong legacy of technological advancement in asphalt pavement knowledge. A focused program for asphalt research should be based on broad intellectual competition, should be of substantial breadth and depth, and should be directed by a consensus of stakeholders.

As Members of this subcommittee know, research also leads to a better educated workforce. There is an ongoing need for hiring and retaining engineers and technicians to design and analyze asphalt pavements. The training of professors, engineers, and technicians is facilitated by research.

Within the next 30 years, improved asphalt pavement technologies must be developed to ensure the continued delivery of safe, environmentally sustainable, economical pavements that satisfy our nation's needs.

As previously stated, with over 94 percent of the roads and highways in the United States surfaced with asphalt, even relatively small but widely applicable advances in asphalt technologies through a robust research and technology program could save many more millions of dollars, enhance sustainability, and result in a

pavement infrastructure system that serves the Nation's economy and citizens in the years ahead.

NAPA respectfully urges the Committee on Science and Technology to reauthorize the existing asphalt research program under the Federal-aid Highway Program and increase the funding to achieve the vision as outlined in the *National Asphalt Roadmap for Research and Technology.* A strong federal partner with adequate funding will foster asphalt pavement research and implementation as outlined in the *Roadmap,* resulting in a more sustainable, environmentally friendly pavement.

Thank you for your time and attention. NAPA appreciates the opportunity to submit this testimony on these important issues and is available to discuss these issues further with the Subcommittee at your convenience.

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