

Researcher

VOL. 44 | NO. 1 | 2008

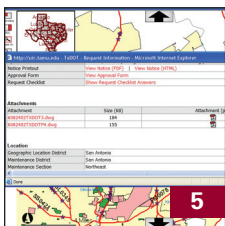
Finding Solutions

*A vibrant research program is
vital to our transportation system*





ON THE COVER: The role of research has an important place in future transportation projects.



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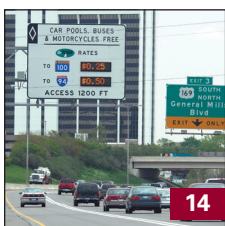


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Researcher

A PUBLICATION OF

Texas Transportation Institute
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Texas Transportation Researcher is published by the Texas Transportation Institute to inform readers about its research, professional and service activities. Opinions expressed in this publication by the editors/writers or the mention of brand names does not necessarily imply endorsement by the Texas Transportation Institute or The Texas A&M University System Board of Regents.

Texas Transportation Researcher (ISSN 00404748) is a quarterly publication of TTI Communications, Texas Transportation Institute, The Texas A&M University System, 3135 TAMU, College Station, Texas 77843-3135. For more information or to be added to the mailing list, contact the address below, call (979) 458-8834 or e-mail Nancy Pippin at n-pippin@ttimail.tamu.edu. Periodicals postage paid at College Station.

TTI.RESR0803.0508.3800

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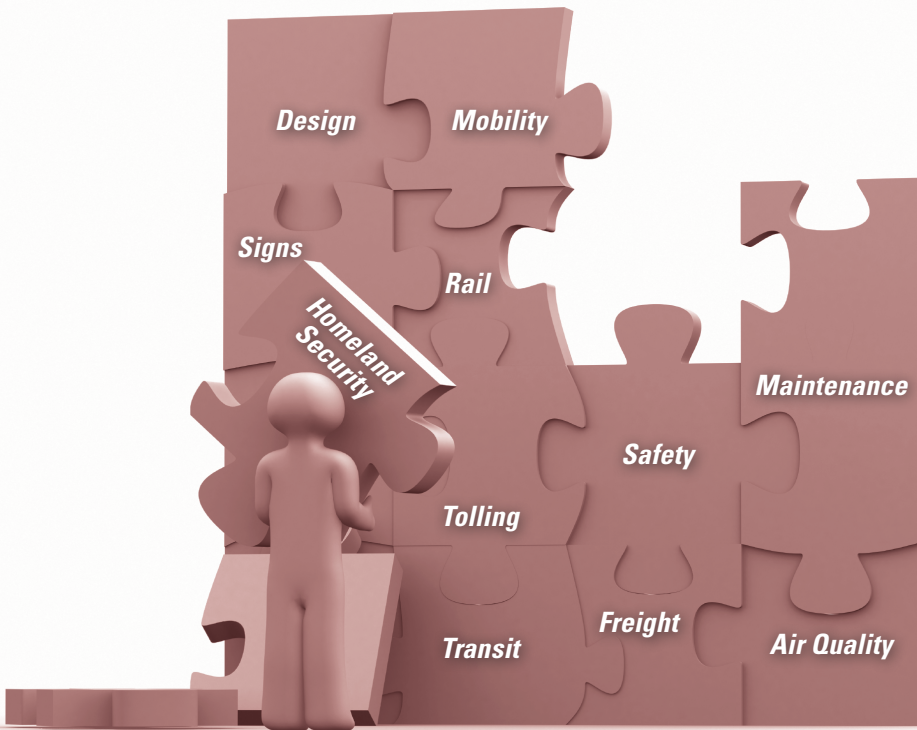
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82nd
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Innovation through research



by David M. Laney
Former Chairman, Texas
Transportation Commission
Former Chairman,
Amtrak Board of Directors

relative obscurity. That's largely because the research process, in all its complexity, doesn't typically involve much fanfare.

Simply put, it goes like this: Identify a problem, find the best practical solution, implement the solution and go on to the next problem. No front page headlines. No TV ads on Super Bowl Sunday. Just do the job. As the saying goes, lightning leaves the credit for the thunder.

Given the staggering transportation challenges we face in the years and decades ahead, our job of problem solving has never been more important. Roads and bridges are aging. Resources are shrinking in the face of growing demand. Our population is booming, especially in already congested urban areas.

These and many more issues leave us faced with very serious questions. How can we continue to provide a transportation system that is safe and efficient, and do so within limited financial resources? How will future energy supplies affect our mobility and the system that makes that mobility possible? How do we ensure that our system supports our economy in a way that protects our position of leadership, locally, regionally and in a fiercely competitive global marketplace?

We don't yet know the answers, but we do know that the right approach must include sustained, robust research. It's a familiar and proven approach, the same one that gave us better ways to light our homes, preserve our food and move about more quickly and safely. All of these improvements resulted from a process of almost constant innovation through research.

To be sure, innovation has its price. But so does the *absence* of innovation — and that's a price we simply cannot afford to pay. ■

Consider for a moment light bulbs, plastic and transportation. An unusual mix, but they share two important common characteristics.

Each, in some way, impacts every day of our lives, to the point that we can scarcely imagine doing without them. And each evolved from crude beginnings, with the original idea bearing little resemblance to what we know and use today. That's true because of research.

Research is the reason light bulb filaments burn for hundreds of hours instead of just a few hours, as they did in 1878. Research is the reason "Parkesine" evolved from a primitive, heated and molded rough material to become the plastic we now use for everything from food wrap to medical supplies. And research is the reason transportation is safer, smoother and more cost-efficient than it's ever been.

The transportation system in America has long been the envy of many nations, but it didn't turn out that way by chance. It turned out that way because industry leaders knew decades ago that our system would require constant improvements to serve society's chang-

ing needs. They made these improvements through a sustained investment in research and innovation, and the return on that investment has been substantial.

Take for example:

- Refined pavement mixtures help ensure that roadways last longer, which is critical at a time when rising construction and maintenance costs collide with shrinking revenues, creating a perfect financial storm.
- Technology applications make freeway operations increasingly more efficient, saving time for motorists, ensuring more reliable delivery times for shippers and shortening response times for emergency workers.
- Improved guardrail designs now allow drivers and passengers to walk away from crashes that would have been fatal less than a decade ago.

These and countless other scientific success stories have saved untold lives, time and money, but they've done so in

> BUILDING THE SYSTEM



This five-level interchange, known as the Dallas High Five, was completed nine months ahead of schedule.

Between 1953 and 1962, the Texas Highway Department (THD) approved the construction of almost 16,000 miles of highway, bringing the state's total system to 59,300 miles (more than any other state in the nation), and more than doubling the yearly construction and maintenance budget. Through the Cooperative Research Program and its partnership with THD, the Texas Transportation Institute's (TTI) research contributions in the areas of freeways, prefabricated concrete beams and girders, new asphalt and aggregate testing procedures, and new highway materials provided valuable guidance and technology to the department during this rapid expansion of highways and freeways. Today, with upwards of 80,000 miles supporting a population of 23.5 million*, Texas Department of Transportation (TxDOT)—sponsored research at TTI has helped save millions of dollars in costs associated with planning, constructing and maintaining Texas' roads and bridges.

*<http://quickfacts.census.gov/qfd/states/48000.html>

It was a rainy afternoon on November 25, 2007, when Garrett Placke was traveling toward College Station on State Highway 47, ironically, not far from the entrance to Riverside Campus where the ET 2000™ guardrail was designed. He was returning home from his niece's christening when his 2005 pick-up truck began hydroplaning. "My truck was heading off the road, and I no longer had control," Placke recalls. "I knew I was going to hit the guardrail head-on at 65 [miles per hour], so I was expecting a really big slam. Remarkably, my truck stopped very quickly, and I couldn't believe I wasn't hurt." The guardrail absorbed the truck's impact and prevented it from heading over a steep embankment into Johnson Creek. The guardrail is a TTI-designed end terminal called an ET-PLUS manufactured by Trinity Industries.



Efficiency matters

A 2008 survey by the U.S. Census Bureau shows that Texas contains four of the 10 fastest growing cities in the United States with Dallas-Fort Worth Metroplex leading the pack.

To accommodate booming growth and soaring travel in the Lone Star State at a time of increasing uncertainty in transportation funding, it has become paramount to find innovative ways to manage, deliver, operate and maintain projects effectively. To address this critical need, researchers in the Infrastructure Management Program at TTI have been engaged in proactive, cutting-edge research to optimize engineering data management procedures during the entire lifetime of a transportation facility.

"We know that streamlined project delivery is a critical requirement to achieve the goal of a more efficient transportation system. Many factors can cause delays during project development and construction."

*Cesar Quiroga,
TTI Research Engineer*

What does that mean? In simpler terms, it means that building and operating a modern roadway involves collecting and organizing an almost bewildering array of information, from where transportation facilities are planned or designed to honing down the time and effort it takes to review and process permits to accommodate utilities within the right of way. Efficiency at each step of the process can cut timelines and costs alike.

TTI Research Engineer Cesar Quiroga leads research in this area and has pioneered geographic information system (GIS)-based models and systems to manage engineering and supporting

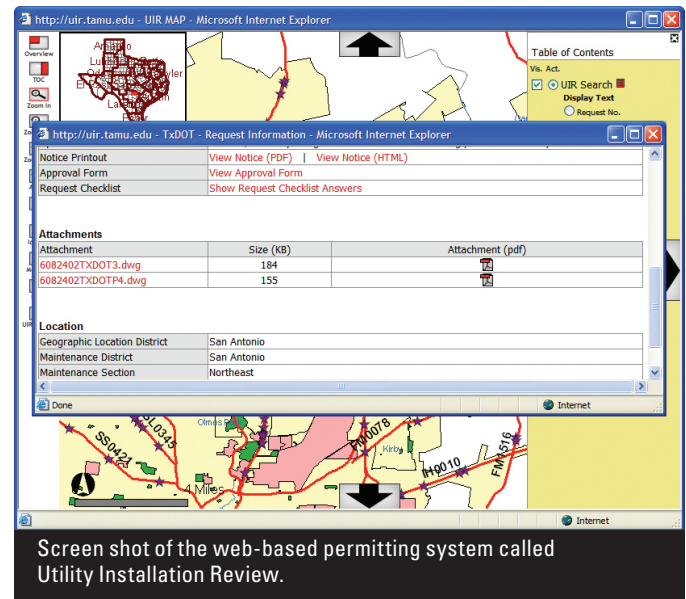
documentation in ways that can contribute to significant increases in productivity and reductions in cost. The research has been hailed at both district and division levels alike at TxDOT, and Quiroga is already looking at new ways to improve on this research.

"We know that streamlined project delivery is a critical requirement to achieve the goal of a more efficient transportation system," says Quiroga. "Many factors can cause delays during project development and construction. For example, transportation agencies produce enormous amounts of engineering data in a variety of formats with varying levels of accuracy and resolution on several types of storage media.

"Transportation agencies nationwide recognize the need to implement strategies to ensure data usability and integrity. However, the amount of data those agencies use is growing steadily, making effective management of it increasingly difficult. In addition, although transportation officials have a wealth of data at their disposal, frequent lack of data integrity, accessibility, quality control or plain awareness makes it unnecessarily difficult to put the data to good use. These inefficiencies result in redundant collection efforts, contribute to project delays and can make projects more expensive than they should be."

A portfolio of progress

Quiroga's research has filled an efficiency gap in the management of



Screen shot of the web-based permitting system called Utility Installation Review.

transportation data and information. Here are two examples:

- GIS-based model and guidelines for managing engineering design data in the project development process. The model integrates disparate pieces of information into a coherent structure that handles projects, documents, and existing and proposed ground features. As an immediate result of the research, TxDOT made changes to its electronic document management system content library structure (Project 0-5246).
- Web-based permitting system called Utility Installation Review (UIR) for automating the submission, review and approval of utility permits at TxDOT. UIR is currently operational at five TxDOT districts, with plans for expansion to the rest of the state in the short term. Implementing UIR has resulted in dramatic reductions in the amount of paperwork; savings on plan reproduction, courier costs and mailing costs; more reliable utility permit documentation management and archival; and shorter utility permit review and approval times (Project 5-2110-03).

THE CHALLENGE TO KEEP BUILDING THE SYSTEM...

TxDOT estimates that by the year 2030:

- The Texas population will increase by 12 million people.
- Road use will increase by 214 percent.
- Highway freight traffic will increase by 77 percent.



MORE INFORMATION

For more information, please contact Cesar Quiroga at (210) 731-9938 or c-quiroga@tamu.edu.

Integrating advanced technology

Thanks to research, the toolbox of technologies for transportation decision makers has never been better stocked



Early on the morning of July 23, 2003, a truck hauling sodium hydroxide stalled on a highway-rail grade crossing in Sugar Land, Texas. Thanks to a rail monitoring system developed by the Texas Department of Transportation (TxDOT) and TTI, police dispatchers were immediately able to see that a train was approaching the grade crossing at 44 miles per hour. The police dispatcher immediately alerted the railroad and police units to the situation. Dispatchers continued to monitor the train's location and speed as it drew closer to the disabled truck. Alerted in part by flares placed on the railroad tracks, the train crew was able to safely stop the train before a collision occurred.

Rapid, effective deployment of technology seems always at the forefront of modern transportation research. Texas Transportation Institute (TTI) researchers developed some of the first sophisticated and precise computer programs devoted to urban traffic management and the first implemented freeway surveillance and control systems in Houston and Dallas. TTI also pioneered ALERT — Advanced Law Enforcement and Response Technology — in the mid-1990s and has consistently undertaken research to integrate safety, technology and data collection. The early efforts in this area strove to clear crash scenes more quickly, enhance safety for police officers and ensure the accuracy of traffic crash data. That work continues today.



The cyber solution

The events that follow the crunch of metal and glass in a traffic crash yield critical information for transportation decision makers. Details from the crash scene might describe an intersection in need of improvement (better lighting, signage or pavement) or a section of roadway where drivers need a bit more attention from law enforcement. In the past, details and drawings from crashes were handwritten by crash scene officers and later entered into a database system.

Passing handwritten data from source to source can lead to delay and unintended data entry errors. If, based on a wealth of crash data, decisions do need to be made, city traffic engineers and others require timely, reliable data so they can make improvements quickly.

TTI Research Engineer Robert Benz is working on just such a method, one that involves accurate data reported quickly.

"The Texas Department of Transportation and the Texas Department of Public Safety have worked together on the Crash Records Information System, a database that collects crash information statewide," says Benz. However, the sheer volume of crash data for a state the size of Texas, with literally billions of pieces of information to sort through, can lead to systematic delays in searching. "We're working with the Houston-Galveston Area Council's Regional Safety Council to create a query tool that will speed up searches for information by sifting out the bulk of the statewide data they don't need in order to make local decisions."

A tool like that can reduce searches for crash data on problem areas from hours — even days — to minutes.

"In other words, we're taking this whole universe of crash data statewide and drilling local decision makers down to a level where they can request a specific subset of records," says Benz. "We're also surveying local law enforcement officers to see what technologies they have that could improve the accuracy and timeliness of the data."

For example, Benz says that crash officers frequently have to estimate where exactly a crash occurred along a roadway. Global positioning systems (GPS) in the officer's vehicle — or a handheld device — could provide more precise location information. In addition, approximately

Technology wages war on the "average" commute

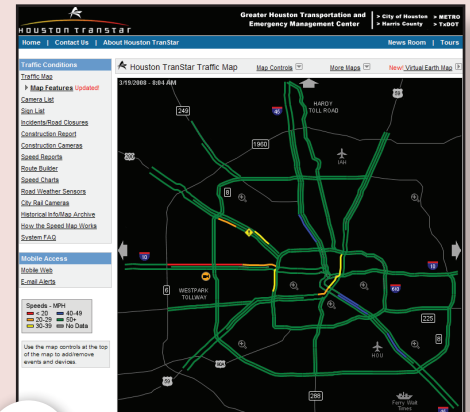
The morning cell phone beep of an instant message or the chime of an email around quitting time can be a commuter's best friend when the message is a traffic alert about the drive ahead. That warning — making it possible for you to take an alternate route around a travel snag — can keep you from missing a meeting at work or a hot meal at home.

Mike Vickich, senior systems analyst for TTI's Research and Implementation Office in the Houston region, developed the software system that gathers speed and congestion data and converts those values into useful travel times. This information is then sent to dynamic message signs on roadways, a traveler information website, and subscriber cell phones and email accounts.

Housed within the sophisticated Houston TranStar traffic management center, TTI-developed software and technology have provided area commuters with vital traveler information since 1995.

"We help develop many of the traveler information components that TranStar provides to the area — the most visible component being the Houston TranStar website," says Vickich. "The website offers people peace of mind so drivers can plan a route and know what to expect on the roadway, even before they leave."

Area commuters keep the website servers humming at TranStar. Approximately 375,000 unique visitors click on the site each month to



Visit <http://www.houstontranstar.org/>.

peruse the real-time traffic map and keep an eye on speeds, cameras, freeway signs and lane closures.

"Commuters who travel in Houston a lot and watch the travel times listed on dynamic message signs get to know what those travel times should be under normal conditions," says Vickich. "If they see a sign that says it's 10 or 20 minutes longer than it should be, then they have the information they need to make the best travel decisions — which can help lower travel times and reduce congestion. The value of traveler information is to provide the people on the road with the information they need to make the best travel decisions possible."



MORE INFORMATION

For more information, please contact Mike Vickich at (713) 686-2971 or m-vickich@tamu.edu.

60 percent of Houston-area officers have a mobile data terminal (MDT) laptop in their vehicle. Officers could immediately enter crash information on their MDTs instead of relying on the older handwritten system. This should significantly reduce error due either to miskeyed information by clerical staff or the misinterpretation of an officer's handwriting.

"The idea is to see where we stand in the realm of technology in the field," says Benz. "The value for local agencies

is that when they get a concerned call about an area, they can dig up the data and see if there's a crash pattern and an engineering solution. Engineers could get on the phone with citizens, look at the data and respond more quickly with transportation decisions."



MORE INFORMATION

For more information, please contact Robert Benz at (713) 686-2971 or r-benz@tamu.edu.

TTI experience inspires careers, saves lives



Students in the 2006 Texas Summer Aviation Academy check out a Boeing 767 cockpit.

At any given time, 200 students are employed by the Texas Transportation Institute (TTI). Most of them, either graduate or undergraduate, are working on actual research projects funded by the Texas Department of Transportation (TxDOT), Federal Highway Administration and research programs administered by the Transportation Research Board (TRB) and other sponsors.

TTI supplies the vital hands-on experience that gives the students an edge in the competitive employment race, and the students have become a vital part of the transportation research process. This symbiotic relationship works well for both parties, but the real winner is anyone that relies on the advancement of transportation to improve the way they live — in other words, each and every one of us.

“Without TTI hiring students to help with research projects, students would begin their career with less practical experience and less professional preparation,” says Gene Hawkins, associate professor in the Department of Civil Engineering at Texas A&M University. Hawkins also serves as a research engineer at TTI. According to Hawkins, “the practical and professional lessons learned through student participation in TTI research

Profile in success: Sarah Benavides

At 16, Sarah Benavides demonstrated an aptitude for math. So she was asked by her Falfurrias, Texas, high school counselor if she wanted to attend a two-week program called the Summer Transportation Institute (STI). The high school sophomore reluctantly agreed, even though she knew it was geared toward identifying possible engineering students. After all, she was going into communications.

During the 2002 program held on the Texas A&M University–Kingsville campus, something life changing happened. “I found myself very impressed with something I never considered before,” she recalls. “My eyes were opened to a possible career in engineering. It really did change my life.”

After high school, Sarah became a civil engineering student at Texas A&M University–Kingsville. She was hired by the coordinator of STI to work on another TTI outreach program, this one called Go Girl! “I was the Go Girl! camp counselor/director for the middle school–aged girls,” she said. “I had a unique perspective because I was in charge of making engineering fun for them. It was easy because I was able to see through their eyes. I was in their shoes when I was 16.”



Sarah Benavides at the 2002 Summer Transportation Institute.

Sarah graduated with a civil engineering degree in December 2007. That was on a Friday. On Monday, she started her career as an engineering assistant with the Texas Department of Transportation in the Corpus Christi District Office. “It’s funny how things turn out,” Sarah said. “Years ago, I had no idea I would become an engineer. I know that without my high school counselor or the outreach programs from TTI, it wouldn’t have happened.” ■

mean that these students can make a more immediate contribution to the transportation profession upon graduation.”

As any supervisor can tell you, learning on the job costs money. When tomorrow’s professionals get real-world experience at school, the training pays dividends for the rest of their careers. And, in the case of graduates who go on to serve in the public sector, that investment saves taxpayers real dollars. More experience also means better decisions, and better decisions mean a safer and more reliable transportation system.

TTI’s Jerry Ullman, senior research engineer, echoes Hawkins’ feelings. Ullman has worked with students on numerous research projects during the past 20 years. “The students are as crucial to us as we are to them,” Ullman says. “Today’s students are tomorrow’s transportation leaders, and the relationships we establish with the students while they are here often continue throughout their careers.”

Alex Borgan, an undergraduate student working on a research project in TTI’s Signs and Markings Program, says his resume caught the eye of his future employer. “The transportation design firm that I’ll work for when I graduate knows of TTI,” Borgan says. “The research experience I’ve received has allowed me to see the big picture, not to mention the fact that it helped me enhance my education and my value to an employer.”

Hawkins says that one of the most important roles TTI plays is to inspire young people to get involved in transportation as a profession. “It is a great feeling to see these students get excited about their future career, especially when they want to work in the transportation field,” Hawkins says. “The faculty and TTI researchers obviously have the power to impact these students’ lives. The research work experience that our students gain at TTI is the icing on the cake that builds upon the lessons they learned in the classroom. And it certainly gives them a head start on their careers.”



Dr. Gene Hawkins teaches Texas A&M students, infusing his lectures with his real-world experiences in transportation research.

Some would argue that inspiring the next generation of transportation professionals is the most important educational impact TTI has. A recent TRB study suggests that as much as 50 percent

“Without TTI hiring students to help with research projects, students would begin their career with less practical experience and less professional preparation. The practical and professional lessons learned through student participation in TTI research mean that these students can make a more immediate contribution to the transportation profession upon graduation.”

*Gene Hawkins,
Associate Professor,
Department of Civil Engineering at
Texas A&M University
and Research Engineer, TTI*

of the transportation professionals at state agencies will be eligible for retirement soon. Programs like TTI’s Summer Transportation Institute, Go Girl! and On the Move are all designed to get young people interested

in transportation jobs ranging from construction to research.

“These programs have a successful record in motivating middle school and high school students at a time when they are getting interested in a possible career,” says TTI Associate Research Scientist Debbie Jasek, who has coordinated all the programs. “Without these programs, it’s safe to assume that most of the students would never have the opportunity to even consider a career in transportation.”

TTI Research Engineer Paul Krugler has a unique perspective about the impact that student researchers have on transportation. Before coming to TTI, Krugler was the director of the Research and Technology Implementation Office at TxDOT. “Having students work on research projects is not only good for TxDOT and TTI during the research. Overall transportation improvements are the end result,” Krugler says. “It is truly a win-win situation.” ■



MORE INFORMATION

For more information, please contact Gene Hawkins at (979) 845-9294 or ghawkins@civil.tamu.edu.

12 Ways TTI Initiatives Impact Transportation



TEENS IN THE DRIVER SEAT

To address the growing crisis of teen deaths from driving, TTI developed Teens

in the Driver Seat (TDS), a peer-to-peer driving safety program unlike any safety program in Texas or the nation. TDS relies upon young drivers themselves to create safety messages and then serve as the messengers to make their peers aware of the risks of teen driving.



IMPROVED MOBILITY

The Transit Mobility Program at TTI provides research and technology transfer expertise in all aspects of public transportation planning, management and operations.



HIGHWAY CRASH CUSHIONS

In 1991, the TTI-patented ET 2000™ guardrail end treatment was developed. Over 325,000 units have been shipped throughout the United States since then.

HOMELAND SECURITY

TTI has helped assess the performance of antiram bollards and antiram walls for the U.S. Department of State for use as antiterrorist protection barriers to be installed around U.S. embassies and other government buildings.



INTELLIGENT TRANSPORTATION

TTI's intelligent transportation research has been implemented in several major Texas cities for train detection and analysis, have expedited emergency signal operation and

BORDER CROSSINGS

TTI and a team of other research agencies have developed a prototype border crossing that promises to significantly reduce the delays and congestion for trucks crossing the border.



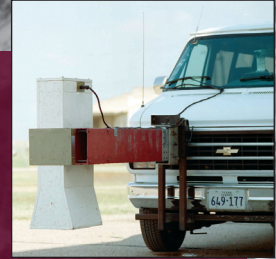
UNIVERSAL FREIGHT SHUTTLE

The Universal Freight Shuttle consists of electrically powered vehicles that travel on a specialized, derailment-proof guideway similar to the "people movers" operating at some major airports and cities. Researchers say the major benefits include the low operational costs and the promise of congestion relief.



GROUND-PENETRATING RADAR

This innovation allows pavement problems to be diagnosed without closing down lanes of traffic — a remarkable boon to mobility and a measurable savings in time and money.



MANAGED LANES

This multi-year project represents a forward-thinking way of utilizing our current roadway capacity to move people and goods in the most efficient manner possible.



RETROREFLECTIVITY

Using research test beds throughout the country, TTI researchers have developed standards for the type and placement of retroreflective traffic control devices, a critical component of safe driving at night.



IN SYSTEMS

Transportation system implemented in Texas. Real-time analysis systems enhance emergency vehicle dispatch, enhanced emergency response, and averted major accidents.



WORK ZONE SAFETY

TTI researchers focus on improving motorist safety, worker safety and traveler mobility in all types of highway work zones.



MOTORCYCLE SAFETY

TTI teamed up with other agencies in Texas to develop a statewide motorcycle safety awareness campaign known as "Look, Learn, Live."



SAVING LIVES

Living to tell about it — there's nothing our researchers take more seriously

When Charlot Finnigan came to TTI's Child Safety Seat "checkup" event in December of 2005, she had no idea it would become perhaps one of the most important decisions of her life. The next month, as Finnigan and her husband were driving south on Texas Avenue, a car pulled out from a parking lot, causing a collision that totaled their automobile. Immediately, Finnigan and her husband checked the backseat and the health of their 4-month-old, 11-pound daughter, Jasmine. Inside and secure in her infant child safety seat, she was fine. "Before I went to the safety seat 'checkup' event, I didn't know how to install the seat," says Finnigan. "Without knowing how to do it right, Jasmine could have been hurt."



Nationally, in 2006, there were 5,973,000 police-reported motor vehicle crashes, which killed a total of 42,642 people — 3,475 right here in Texas.

Here are some sobering national numbers from 2006:

- 13,470 people were killed in alcohol-impaired-driving crashes, nearly 32 percent of all crash-related deaths;
- 61,000 pedestrians were injured in traffic crashes; 4,784 pedestrians were killed — down 12 percent from a decade prior; and
- 4,810 motorcyclists were killed — a 5 percent jump in crash fatalities over 2005.

As startling as these statistics are, the numbers were much more alarming 60 years ago. In fact, thanks to the construction of the interstate highway system, the fatality rate on those roads is 60 percent lower than that of the rest of the roadway system. On the safety-research front, projects sponsored by the Texas Department of Transportation (TxDOT) and conducted at the Texas Transportation Institute (TTI) have produced numerous life-saving discoveries, such as the "breakaway" sign concept and specifications for improved safety of roadside structures. Through performance of countless crash tests over the last 50 years, Texas has led the way to implementation of safer signs, light and utility poles, medians, mailboxes and guardrails all across the nation.

"Safety innovations like the low-deflection barrier make work zones safer for both motorists and construction personnel. Less deflection in an impact translates to more operating space for cars and workers. Ease of installation, inspection and repair reduces exposure of workers and minimizes traffic delays. If a car goes out of control while traveling through a work zone, this barrier is designed to save the lives of both the motorists and any workers in the area behind the barrier. That's why we do this kind of work."

*Roger Bligh,
TTI Research Engineer*



The sound of safety — when hearing is seeing

Navigating through a construction zone is dicey enough for drivers under the best circumstances, but the stakes rise considerably for pedestrians trying to make their way, even through familiar territory. For visually impaired pedestrians, the challenge can be life threatening.

TTI Assistant Research Engineer Brooke Ullman recently undertook a study, sponsored by TxDOT, to find out how pedestrian traffic is being handled in work zones and to see if any safety improvements can be made for disabled pedestrians.

“The signing that’s available right now for pedestrians may say a sidewalk is closed,” says Ullman. “But, what if it’s not closed for another two blocks? We studied the kind of information pedestrians have said they want and need, and then we took it a step further to consider audio messages that would give information to walkers who are visually impaired.”

The research generated a handbook practitioners can use to consider what signs or audio messages they need using a decision table.

Ullman’s team also identified design points they recommend when verbal safety messages are created to assist in guiding visually impaired pedestrians. For example, “alternate route” messages should clearly state where they are leading the pedestrian, and blocks or landmarks are better indicators of distance than feet or mile measurements.

“If a person who’s visually impaired doesn’t have information about what’s going on in a work zone — even an area they’re familiar with — what’s to stop them from walking into an unsafe area?” asks Ullman. “What if, for some reason, there’s no barricade? It’s important to warn people that conditions are different from what they’re expecting — especially when they’re not able to see that for themselves.” ■



MORE INFORMATION

For more information, please contact Brooke Ullman at (979) 862-6636 or b-ullman@tamu.edu.



During field studies conducted to validate audio message content, study participants were accompanied by TTI Assistant Research Scientist Nada Trout, to record how they used the message.

A low-deflection life saver

Every day portable concrete traffic barriers are saving lives. They’re trucked to construction locations and set up quickly, and before long traffic is flowing in temporary lanes. Oncoming cars are kept safely apart and in their lane of travel.

Depending on the segment length used, the low-deflection precast concrete barrier developed and tested at TTI has only 18 to 24 inches of lateral movement during a design impact, putting it in a class by itself. In full-scale crash testing performed at TTI by the Roadside Safety Program, the low-deflection precast barrier proved exceptional at safely shrugging off the impact of a 4,409-pound pickup truck smashing into it at more than 60 miles per hour and 25 degrees. The barrier successfully contained the pickup, redirected it and kept it upright, all necessary criteria when evaluating safety and impact performance.

According to TTI Research Engineer Bligh, the F-shape barrier showed another characteristic that engineers were eager to achieve — when impacted by a vehicle, the barrier didn’t shove aside, or “deflect,” nearly as much as other portable barriers in common use. In fact, use of an innovative cross-bolt connection provides this new barrier with the

lowest design deflection of any approved free-standing portable concrete barrier. This finding allowed researchers to recommend the low-deflection precast concrete barrier for use in restricted construction sites, where quarters are cramped and workers run the risk of being hit by a barrier being shoved into the work zone in a collision.

“The new barrier achieves the objective of low dynamic deflection without sacrificing constructability,” says Bligh. “The low deflections associated with the cross-bolt connection make it ideal for use in restricted work zones where it is desirable to minimize the required buffer space between the barrier and the work activity area. TxDOT has implemented the new F-shape barrier as a state standard, and other state departments of transportation are evaluating the barrier as well.”

And the adaptability of the cross-bolt connection to other barrier shapes makes it versatile as well as functional. ■



MORE INFORMATION

For more information, please contact Roger Bligh at (979) 845-4377 or rbligh@tamu.edu.

Increasing efficiency

How do we maximize the transportation system we already have?

Through research.



I-394 MnPASS Express Lanes, Minneapolis, Minnesota.

For over 20 years, through support from the Texas Department of Transportation (TxDOT), multiple states and metropolitan planning organizations, the American Road and Transportation Builders Association and the U.S. Department of Transportation University Transportation Centers Program, the Texas Transportation Institute (TTI) has helped battle the traffic congestion problem by tracking and developing mobility data for major urban areas across the nation. Recent expansion of the study to include all 437 urban areas and an improved methodology have broadened the scope of the work to include recommended strategies for agencies, businesses and commuters to help implement solutions to the congestion problem. Since the 1970s, when it became clear that a single solution of building more roads would not keep pace with the congestion problem, TTI/TxDOT cooperative research has produced advances in freeway operations; lane management; signal timing; intersection, sign and roadway design; and public transportation that have all been implemented in Texas' major urban areas.

"Congestion caused urban Americans to travel 4.2 billion hours more and to purchase an extra 2.9 billion gallons of fuel for a congestion cost of \$78 billion. This was an increase of 220 million hours, 140 million gallons and \$5 billion from 2004."

The 2007 Urban Mobility Report, TTI

Studying traffic's big squeeze

Traffic congestion burns enough fuel every year to fill 58 supertankers and erodes enough time to consume 105 million weeks of vacation. Each one of us wastes nearly a week's worth of time, 26 gallons of ever-more-costly fuel and a whopping \$710 — all because of congestion.

TTI Research Engineer Tim Lomax and Associate Research Scientist David Schrank are at the forefront of identifying the mobility-busting characteristics that choke off traffic flow in cities across the country. Their research culminates in widely utilized reports on urban mobility, which identify solutions that maximize the efficiency of existing infrastructure and provide alternatives to combat the multi-headed problem.

A tool used nationwide

"Using the mobility data we gather has proven helpful to planning and transportation agencies in just about every part of the country," says Lomax. "Reports indicate that our data and performance measures are used in efforts to communicate technical information to the general public in ways that non-technical audiences understand."

The 2007 Urban Mobility Report contains a number of recommendations to address the mobility problem, including:

- providing more travel options — using the Internet to telecommute, value pricing toll lanes and encouraging increased use of transit;
- adding capacity — adding lanes, buses and new roadways, improving roadway designs, adding rail service, etc.;
- managing the demand — building more "car free" communities and adding more bike and pedestrian options; and
- increasing the efficiency of the system — maximizing timing of traffic signals, managing special events (e.g., sporting or music events), metering freeway ramp, etc. ■



MORE INFORMATION

For more information, please visit: <http://mobility.tamu.edu/> or contact Tim Lomax at (979) 845-9960 or t-lomax@tamu.edu or David Schrank at (979) 845-7323 or d-schrank@tamu.edu.



Managed lanes research shows broad reach

The managed lanes strategies that maximize existing roadway use and help minimize the need for new construction were first deployed in just four places — two in Texas and two in California. A look at the list today reveals 39 projects nationwide that already exist, are under construction or are in development.

More than 816 miles of roads — and millions of commuters — are either already benefiting or soon will benefit from managed lanes research at TTI under the leadership of Senior Research Engineer Beverly Kuhn and Research Engineer Ginger Goodin.

"When we started the managed lanes project at TTI in 2000, there were only four domestic facilities in operation, and hardly any on the

"What managed lanes are supposed to do is preserve some portion of a facility, to set it aside for special users and provide them with a reliable trip. It provides users with an option that they didn't have before in a traditional, congested corridor. Drivers may not make the choice every day, but it's there — when before it wasn't."

*Beverly Kuhn, Division Head of
TTI System Management Division*

books," says Kuhn. "Now there's been an explosion of these facilities. And because of the interest being generated in the subject, a new Managed Lanes Joint Sub-



Left: speed harmonization display controls at traffic center in Germany.



Right: speed harmonization in a work zone in Copenhagen, Denmark.

committee was created in 2004 under the Transportation Research Board's (TRB) HOV Systems Committee to address research needs and issues specific to managed lanes."

TTI Research Engineer Ginger Goodin was first to chair the joint subcommittee.

Strategies from abroad

After nearly a decade of research and crafting the comprehensive *Managed Lanes Handbook*, the research team looked overseas for additional strategies and best practices.

With sponsorship from the Federal Highway Administration, American Association of State Highway and Transportation Officials and the National Cooperative Highway Research Program, a group of transportation professionals from around the country, including Kuhn, observed managed lane operations and strategies in Denmark, England, Germany and the Netherlands.

"They've taken the next step in managing their facilities," says Kuhn.

"They're managing the entire facility in an active manner. They implement temporary shoulder use, speed harmonization (variable speed limits) and other strategies. As congestion builds on a facility, those strategies can be implemented to better manage the entire corridor."

Speed harmonization involves an automated system that uses an algorithm for measuring speeds, congestion and other factors to determine the best speeds to set along a corridor to encourage flow, or throughput. Speeds are adjusted ahead of congestion automatically, and drivers see speed limits for roadway sections displayed on changeable signs above the road.

The team observed a work zone in Copenhagen that benefited from this technique — with no increase in accidents during the work zone, a benefit local agencies tied directly to speed harmonization.

"Strategies like this — called active traffic management — represent the next evolution of managed lanes," says Kuhn. "And the trip where we saw these deployed got me thinking, 'Why can't we do this here?'"

TRB'S MANAGED LANES JOINT SUBCOMMITTEE IDENTIFIED:

39 managed lanes projects

- 7 are currently operating
- 2 are under construction
- 30 are under development

Managed lanes in Texas

- Houston
- Austin
- Dallas/Fort Worth

Managed lanes nationally

- Atlanta, Georgia
- Denver, Colorado
- Maryland
- Miami, Ft. Lauderdale, Florida
- Minneapolis, Minnesota
- Portland, Oregon
- Raleigh/Durham, North Carolina
- Salt Lake City, Utah
- San Diego, Orange County, San Francisco Bay, California
- Seattle, Washington
- Virginia



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Visit <http://managed-lanes.tamu.edu/>.

TTI researchers active in TRB

Throughout its history, researchers at the Texas Transportation Institute (TTI) have actively participated in the Transportation Research Board (TRB) of the National Academies and served in leadership positions. This tradition of participation and leadership continues today.

TRB is the focal point for transportation research in North America. The mission of TRB is to provide leadership in transportation innovation and progress through research and information exchange, conducted within a setting that is objective, interdisciplinary and multimodal. TRB conducts numerous activities to accomplish this mission, including managing the Cooperative Research Programs and the Strategic Highway Research Program, and conducting special studies directed by Congress, federal agencies and other groups.

The best known parts of TRB, however, are probably the Annual

Meeting held in Washington, D.C., every January, the approximately 200 standing committees and task forces, and the specialty conferences, workshops, seminars and webinars. The TRB Technical Activities Division is responsible for these efforts, which provide forums for transportation professionals to identify research needs, share research results and facilitate technology transfer.

The committees and task forces, which are responsible for organizing and conducting these activities, are considered the lifeblood of TRB. From the early days of the Institute to the present, TTI researchers have played key roles in TRB

“The participation of TTI researchers in TRB committees and other activities over the years has been very positive. The contributions of numerous TTI researchers have enriched the multimodal research portfolio, outreach efforts and technology transfer activities at TRB.”

*Robert K. Skinner,
TRB Executive Director*

committees, sections, groups and the Executive Committee.

“The participation of TTI researchers in TRB committees and other activities over the years has been very positive,” notes TRB Executive Director Robert K. Skinner. “The contributions of numerous TTI researchers have enriched the multimodal research portfolio, outreach efforts and technology transfer activities at TRB.”

Currently, TTI researchers hold TRB group, committee chair and committee secretary positions. Agency Associate Director Katie Turnbull serves as the chair of the Planning and Environment Group and is a member of the Technical Activities Council. Research Engineer Paul Carlson, Research Scientist Sue Chrysler, Research Engineer Ginger Goodin, Senior Research Engineer Beverly Kuhn, Research Engineer Shawn Turner and Senior Research Engineer Jerry Ullman serve as committee chairs. Ullman is also the official TRB University Representative for TTI and Texas A&M University. Other TTI researchers serve as official secretaries, chair subcommittees and hold other positions.

“Participating in TRB activities is both professionally and personally rewarding,” notes Turnbull. “Individual researchers and TTI as a whole benefit greatly from involvement in TRB committees, conferences, the Annual Meeting and other activities.” ■



The following TTI researchers have received TRB paper awards, distinguished service awards and distinguished lectureships.

Roy W. Crum Distinguished Service Award

- ❖ Herbert H. Richardson
- ❖ William J. Harris, Jr.

W.N. Carey, Jr. Distinguished Service Award

- ❖ Charley V. Wootan
- ❖ William J. Harris, Jr.

D. Grant Mickle Paper Award (current TTI researchers)

- ❖ Conrad L. Dudek
- ❖ Brooke R. Ullman
- ❖ Dominique Lord
- ❖ James A. Bonneson

K.B. Woods Paper Award (current TTI researchers)

- ❖ Roger Bligh
- ❖ Dean Alberson
- ❖ Nauman Mansoor Sheikh
- ❖ Akram Y. Abu-Odeh

Fred Burggraf Paper Award (current TTI researchers)

- ❖ Paul L. Carlson
- ❖ Kay Fitzpatrick
- ❖ Jerry Ullman
- ❖ Dennis Christiansen

Bridges leaves legacy of excellence, compassion



Transportation professionals in Texas and across the country are reflecting on the lifetime achievements and visionary guidance of G. Sadler Bridges, who passed away April 16. Bridges' career spanned five decades and included a pioneering transportation appointment with the Texas governor's office, accolades from a U.S. vice president and debts of gratitude from numerous colleagues whose careers he helped inspire.

Bridges was first hired by the Texas Transportation Institute (TTI) in 1967 after receiving degrees in business administration and economics at Texas A&M University. Bridges also pursued doctoral studies at Southern Methodist University. He was an assistant professor of economics at Texas A&M before he began his 40-year career at TTI.

"In many ways, Sadler is responsible for shaping and influencing programs and initiatives within the Institute that helped us develop into a world-class organization," TTI Director Dennis Christiansen said. "The impact Sadler had on the people and programs at TTI and beyond will secure the G. Sadler Bridges name a rightful place in transportation history. We owe him an enormous amount of gratitude."

Bridges' accomplishments are numerous and far reaching. He was an integral part of federal, state and local transportation initiatives, including:

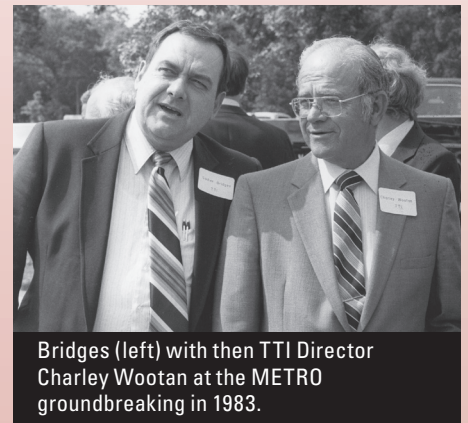
- The landmark National Grade Crossing Inventory Project, a database that contained all known railroad grade crossings in the United States. The database later became a significant component of the U.S. Department of Transportation's successful railroad safety program.
- Intelligent Transportation Society of America
- National Transportation Studies for Texas
- Southwest Region University Transportation Center
- Mobility 2000 Group

Within TTI, Bridges was responsible for the success and innovation of several programs. He was the director of the Intelligent Vehicle Program, which developed ALERT™, an advanced vehicle project that was recognized by Vice President Al Gore with the National Performance Review Hammer Award.

Bridges is credited with bringing TTI into the computer age by conceptualizing and directing the Institute's initial implementation of a computer and information systems infrastructure. He was also instrumental in developing TTI's intelligent transportation system laboratory, TransLink®. During his career, Bridges held several leadership positions at TTI including associate director and interim agency director.

Bridges received the Charley V. Wootan Career Achievement Award in 2004. He retired from TTI in August of 2007 and was named executive associate director emeritus by the Texas A&M Board of Regents the following month.

"Sadler had a profound impact on my career," says Assistant Agency Director Steve Roop. "Fifteen years ago, he urged me to begin a new rail research group. That ultimately developed into the Multimodal Freight Transportation Program here at TTI and allowed me to develop in ways I otherwise would not have. Sadler provided an option to me, and I know he provided many other individuals at TTI a similar growth opportunity. Maybe most importantly, he was genuinely happy when those he helped along succeeded." ■



Bridges (left) with then TTI Director Charley Wootan at the METRO groundbreaking in 1983.



Bridges (far right) at the unveiling of the ALERT vehicle in Phoenix.

Williamson eulogized as "one of a kind"



Ric Williamson, chairman of the Texas Transportation Commission, was eulogized by Governor Rick Perry and Texas Department of Transportation Executive Director Amadeo Saenz

when several hundred people gathered inside the Weatherford High School auditorium for Williamson's memorial service January 3.

Texas Transportation Institute Director Dennis Christiansen and Associate Agency Director Bill Stockton attended the service. "We wanted to pay our respects to Williamson and his family," says Christiansen. "He was a driving force in Texas transportation and was extremely dedicated to his work."

Williamson, 55, died December 30, after suffering a heart attack at his home in Weatherford.

Governor Perry, who shared an apartment with Williamson when they were freshman legislators in the mid-1980s, described the chairman as "probably the most persuasive individual I've ever been around in my life." Perry said Williamson was like a brother and convinced him to run for lieutenant governor.

Saenz told the crowd that, although Perry will name a replacement, no one could really take Williamson's place. ■

Consolidated Transportation Center to serve Metroplex

After more than three years in the making, the Texas Department of Transportation (TxDOT) held grand opening ceremonies January 23 for the new *DalTrans* Transportation Management Center. The new 54,000-square-foot building, located along Interstate Highway 80 in Mesquite, replaces a much smaller facility and now brings all three operating agencies (TxDOT, Dallas Area Rapid Transit [DART] and Dallas County) under one roof.

The new center expands *DalTrans'* capabilities and becomes the central traffic operations center for all highway management and intelligent system integration for 30 cities in the Metroplex.

DalTrans' complete intelligent transportation system includes 200 cameras that monitor more than 1,000 square miles. Through the use of dynamic message signs, Internet information and media traffic reports



Officials attend the grand opening of the new *DalTrans* Transportation Management Center. Left to right: TxDOT Dallas District Freeway Management Engineer Rick Cortez, TxDOT Traffic Operations Division Director Carlos Lopez, DART President/Executive Director Gary Thomas, TxDOT Dallas District Engineer Bill Hale, Dallas County Sheriff Lupe Valdez, North Central Council of Governments Director of Transportation Michael Morris and TxDOT Dallas District Architect Tommy Johns.

from radio and television, motorists have access to real-time travel information.

Courtesy patrol trucks, dispatched when help is needed, are operated each day on 300 miles of Dallas County roadways. In 2006, the courtesy patrol responded to more than 97,000 incidents. The Texas Transportation Institute also occupies a three-office suite in the new building that will support researchers working on transportation operations and intelligent transportation system projects. ■

AAPO Honors TTI with Vision Award

Texas A&M University's African-American Professional Organization (AAPO) presented Texas Transportation Institute with a "Keeping the Vision" Award during the organization's Scholarship Gala March 29.

"An active supporter of the African-American Professional Organization, TTI has been steadfast in its commitment to improve the diversity of Texas A&M University," said AAPO President Albert Broussard in presenting the award. "TTI staff consistently supports the organization by volunteering to schedule meetings, laying out the bi-annual newsletter, and training webmasters to update and input information to the website and AAPO list-serve. We will be indebted for many years to TTI for its assistance."

TTI hosts the AAPO website, which was developed and designed by Network and Information Systems staff who worked with the organization's website committee. The "Keeping the Vision" awards were designed to publicly recognize the individuals, departments and organizations that actively support AAPO's goals and mission. The award is based on supporting the imperatives of the university's Vision 2020 program. ■



AAPO presents TTI with its "Keeping the Vision" Award for TTI's commitment to improving the diversity of Texas A&M. Left to right: AAPO President Albert Broussard, TTI Associate Agency Director Katie Turnbull, TTI Chief Information Officer and Director of Information Systems Cassandra Agee-Letton, TTI Assistant Agency Director Gene Butth, TTI Information Technology Manager Cliff Murphy and TTI Executive Associate Agency Director Don Bugh.

Motorcycle Safety Forum addresses disturbing fatality rate

At a time when automobile deaths are on the decline in the United States, the number of motorcycle fatalities is skyrocketing. That sobering information has placed even greater emphasis on this year's Motorcycle Safety Forum held in Austin February 13.

In his opening remarks to the 100 attendees, Center for Transportation Safety (CTS) Director John Mounce said motorcycle fatalities have increased for nine straight years and, for the first time, have outnumbered pedestrian deaths. "Rider fatalities now account for 11 percent of total fatalities (up from 5 percent in 1997) and dramatically affect the nation's overall highway fatality rate," says Mounce. "This trend is perhaps the greatest highway safety challenge our nation faces today."

Over 100 people from all over Texas attended the meeting, which included safety advocates representing riders, trainers, law enforcement, engineers, educators, military, health professionals, and federal and state motorcycle safety organizations. This is the third CTS-sponsored Motorcycle Safety Forum in as many years, which was organized in response to the ever-

increasing fatality rate. This year's forum was co-sponsored by the Texas Transportation Institute with the Texas Department of Transportation (TxDOT), Texas Department of Public Safety and Brown Distributing Company as participating agencies.

The day-long forum included presentations on crash trends, rider training, share the road programs, funding and strategic planning. Associate Research Scientist Patricia Turner discussed the new TxDOT motorcycle safety public awareness campaign entitled "Look. Learn. Live," developed by TTI.

"This forum was the best attended and most successful Motorcycle Safety Forum we've had," Turner said. "We are all working together, seeking ways to reverse the growing number of motorcycle fatalities." Senior Research Scientist Quinn Brackett also spoke at the forum, presenting "Countermeasures to Reduce Motorcycle Crashes in Texas."

As a result of the increase in fatalities, a Motorcycle Safety Coalition is being formed to come up with strategies to reduce motorcycle crashes. The volunteer members are planning their first meeting. ■

Dallas Little selected to give transportation engineering lecture



Little

Dallas Little delivered the Kent Distinguished Lecture in Transportation Engineering at the University of Illinois at Urbana-Champaign (UIUC)

April 10. Little holds the E.B. Sned Chair Professorship in materials engineering in the Zachry Department of Civil Engineering at Texas A&M University. He also serves as associate director of the Center for Aggregates Research and as a senior research fellow at the Texas Transportation Institute.

Little spoke about recent studies, including breakthrough work at UIUC, that have demonstrated the impact on even short recovery periods between load applications in the fatigue damage process of asphalt materials.

The Paul F. Kent Distinguished Lecture, initiated in 2007, honors outstanding leadership in the field of transportation engineering. Paul Kent was a 1920 graduate of the University of Illinois in civil engineering. ■

RITA administrator applauds TTI in inaugural visit

President Bush appointee Paul Brubaker, administrator of the U.S. Department of Transportation's (DOT) Research and Innovative Technology Administration (RITA), told Texas Transportation Institute employees, "The world is going to look very, very different in 10 years." Brubaker was referring to the nation's growing and shifting population, the price of oil and the challenge of financing infrastructure projects. As RITA administrator, Brubaker is responsible for coordinating the DOT's \$1 billion research budget and is charged with advancing technologies that will improve the nation's transportation system.

It was Brubaker's first TTI visit since he was sworn in as RITA administrator last summer. His associate administrator for research, development and technology, Jan Brecht-Clark, accompanied him on the tour. Brecht-Clark oversees the University Transportation Centers program, which includes the Southwest University Transportation Center (SWUTC) and the University Transportation Center for Mobility (UTCM), both located at TTI.

"TTI is on the cutting edge of transportation research, and I want to thank you for the work you do," Brubaker said during his visit December 11-12. He pointed out that transportation costs for American families exceed health care and food costs. Only housing costs more. "We need to

find better ways to finance transportation because the gas tax is insufficient." Brubaker endorsed public-private partnerships as one solution to the financing challenge.

Brubaker and Brecht-Clark were briefed on TTI, SWUTC and UTCM, and toured TTI's TransLink® Laboratory, the Materials Laboratory and TTI's Proving Grounds Research Facility. The visit also included a tour of the Bush Presidential Library.

"Dr. Jan Brecht-Clark and I found the briefings and exchanges very useful to understanding the major contributions the Institute is making to improve the safety and performance of our national transportation infrastructure. Moreover, TTI is performing a great service to the nation and the state of Texas by training the next generation of national, state and local transportation leaders," Brubaker said. "The commitment and passion of the Aggie community to creating a world-class transportation research facility at Texas A&M was evident from all of the people we met." ■



Paul Brubaker, RITA administrator for the U.S. Department of Transportation.

TECHNICAL REPORTS

"Heavy-Duty Flexible Bases: Field Performance and Draft Specifications," by Tom Scullion, **0-4358-4**, February 12, 2008.

"Inventory of Utilities — Summary Report," by Cesar Quiroga, **5-2110-01-4**, January 29, 2008.

"Hurricane Evacuation Traffic Operations," by Andy Ballard, **0-4962-1**, April 9, 2008.

"Crash Testing and Evaluation of F-Shape Barriers on Slopes," by Nauman Sheikh, **0-5210-3**, March 18, 2008.

"Improving Lab Compaction Methods for Roadway Base Materials," by Stephen Sebesta, **0-5135-2**, March 6, 2008.

"Truck Instrumentation for Dynamic Load Measurement," by Emmanuel Fernando, **0-4863-1**, January 9, 2008.

"Assessing the Ability of Fog Seals to Seal Pavements, to Rejuvenate in Situ Binder, and to Retard Binder Oxidation," by Nikornpon Prapaitrakul, **0-5091-3**, January 9, 2008.

"Guidelines on Construction and Maintenance of Porous Friction Courses in Texas," by Cindy Estakhri, **0-5262-2**, February 22, 2008.

"Evaluation and Recommended Improvements for Mix Design of Permeable Friction Courses," by Alex Alvarez Lugo, **0-5262-3**, April 9, 2008.

"Driver Comprehension of Signing and Markings for Toll Facilities," by Susan Chrysler, **0-5446-2**, February 28, 2008.

"Regional Public Transportation Coordination in Texas," by John Overman, **0-5542-1**, February 28, 2008.

"Investigating Pedestrian Components in Temporary Traffic Control," by Brooke Ullman, **0-5237-1**, February 13, 2008.

"Studies to Improve Temporary Traffic Control at Urban Freeway Interchanges and Pavement Marking Material Selection in Work Zones," by Jerry Ullman, **0-5238-2**, April 9, 2008.

"Managed Lane Strategies Feasible for Freeway Ramp Applications," by Beverly Kuhn, **0-5284-2**, March 3, 2008.

"Enhancements to PASSER V Signal Timing Optimization Program," by Chi-Leung Chu, **0-5424-1**, February 21, 2008.

"Integration and Consolidation of Border Freight Transportation Data for Planning Applications," by Juan Villa, **0-5339-1**, January 10, 2008.

"Engineering Design Data Management — Practices and Framework Development," by Cesar Quiroga, **0-5246-1**, March 25, 2008.

PRODUCTS

"Rehabilitation Projects Construction Video," by Tom Scullion, **5-1731-01-P2**, January 16, 2008.

"Guidelines for Hurricane Evacuation Signing and Markings," by Brooke Ullman, **0-4962-P1**, January 11, 2008.

"User's Manual for Database," by Tom Scullion, **0-4822-P1**, February 20, 2008.

"TxDOT Public-Private Feasibility Analysis Model: User Manual," by Roco, Craig, **5-4565-01-P2**, January 9, 2008.

"Checklist for Accommodating Pedestrians in Temporary Traffic Control Areas," by Kay Fitzpatrick, **0-5237-P1**, January 9, 2008.

"PASSER V Training Material," by Nadeem Chaudhary, **0-5424-P2**, February 29, 2008.

"PIA System Installation and User Guide," by Hassan Charara, **0-5507-P2**, February 12, 2008.

"Prototype Engineering Data Management Processes and Procedures," by Cesar Quiroga, **0-5246-P1**, March 25, 2008.

"Prototype Engineering Process Integration with the GAIP GIS Architecture," by Cesar Quiroga, **0-5246-P2**, March 25, 2008.

TTI PUBLICATIONS

A full catalog of TTI publications and other products is online at <http://tti.tamu.edu/> publications. You can find the publications by searching for either the title or publication number listed here. Most of these publications are available as free downloads in portable document format (PDF).

Printed, bound versions of these reports are also available through the URL above. Publication prices vary depending on length. The Texas Transportation Institute accepts checks, money orders and credit cards.