

TEXAS TRANSPORTATION

# Researcher

A PUBLICATION OF THE TEXAS TRANSPORTATION INSTITUTE ■ MEMBER OF THE TEXAS A&M UNIVERSITY SYSTEM ■ VOL. 42 ■ NO. 1 ■ 2006

*Texas congestion index*  
PAGE 3

*HOV time savings*  
PAGE 10

*Repairing our bridges*  
PAGE 15

## Saving little Lives

*TTI hosts child seat checkup*  
PAGE 16

# R contents



## PLANNING & FINANCING

**3** Another weapon in battle against the bottleneck

**4** A handshake and a start date

## INTELLIGENT TRANSPORTATION SYSTEMS

**6** Forewarned is forearmed: advance detection at signalized intersections

**7** Something old, something new something simulated, something improved

**8** Incident detection: find it fast, move it fast

**9** Workshop shares knowledge about ITS communications technologies



## FREEWAY OPERATIONS & MANAGEMENT

**10** Driving past delay

**12** More than "making do"

**13** TTI researchers develop HOV handbooks

## BRIDGES

**14** Smooth transitions

**15** Retrofit and repair



## IN THE NEWS

**16** Saving little lives: TTI-sponsored child safety seat "checkup" a success

ON THE COVER: 22 seats given to families in the Brazos Valley.

## RELATED REPORTS

**19** Listing of reports about topics covered in this issue of *Texas Transportation Researcher*

## TEXAS TRANSPORTATION Researcher

A PUBLICATION OF THE  
TEXAS TRANSPORTATION INSTITUTE  
and MEMBER OF  
THE TEXAS A&M UNIVERSITY SYSTEM

VISIT TTI ON THE INTERNET AT  
[HTTP://TTI.TAMU.EDU](http://TTI.TAMU.EDU)

**PUBLISHER/DIRECTOR, TTI**  
Dr. Herbert H. Richardson

**EDITOR**  
Kelly West

**MANAGING EDITOR**  
Chris Sasser

**WRITERS**  
Penny Beaumont  
Chris Pourteau  
Chris Sasser  
Dr. Katie Turnbull  
Brandon Webb  
Kelly West

**DESIGNER**  
Stacy Schnettler

**PHOTOGRAPHERS**  
James Lyle  
Dr. Katie Turnbull

**PROOFREADER**  
Beverly Gracia



*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](mailto:n-pippin@ttimail.tamu.edu). Periodicals postage paid at College Station.

TTI.RESR0629.0406.3750

**POSTMASTER, PLEASE  
SEND ADDRESS CHANGES TO:**

Texas Transportation Researcher  
TTI Communications  
Texas Transportation Institute  
The Texas A&M University System  
3135 TAMU  
College Station, TX 77843-3135

# Another weapon in battle against the bottleneck

*Texas Congestion Index offers decision makers a single number cities can use to measure congestion*

If measured against national economies around the world, the Lone Star State would rank as the 10th largest worldwide. That's an economy of staggering size. Commerce, the engine that drives Texas, depends on moving more than half of all goods in the state by truck. And that means traffic—lots of it. Factor daily commuting in with that much truck traffic, and the forecast calls for congestion.

The Texas Transportation Institute (TTI) has studied congestion trends since 1982. The study results are published annually in the Urban Mobility Report. This report is cited nationwide for its catalog of congestion delays in the nation's busiest cities, congestion costs and other related topics like the amount of fuel wasted as engines idle in traffic jams.

According to Tim Lomax, a research engineer at TTI, the Texas Department of Transportation (TxDOT) and the eight major metropolitan cities in Texas were seeking a single way, or measure, to consider congestion as a whole, thus taking into account the many factors that contribute to the problem.

"Many measures are needed to fully understand the congestion problem, but there is also some benefit to having one measure that communicates the possibilities and challenges," says Lomax.

As part of a TxDOT-sponsored project, TTI developed the Texas Congestion Index (TCI) to provide

a uniform measurement of congestion that factors in the (surface) transportation system moving people and freight by all modes in the state's eight major population centers.

The TCI estimates the amount of extra travel time Texans spend on the road during rush hours. It can be used to identify the overall transportation needs of a region and assess the congestion reducing effects of agency and private sector spending and programs.

For example, a TCI value of 1.40 would indicate a 20-minute midday trip would take 28 minutes during this rush hour (40 percent longer). Each metro region developed its own TCI target based on local conditions and expectations.

"The congestion index and the other planning tools developed in the project are improving the Department's ability to analyze projects and programs as well as improving the way we discuss these with the public," says David Casteel, TxDOT's San Antonio dis-

trict engineer. "The index is a good tool for both technical staff and general audiences."

The TCI was adopted for use in congestion planning by the Texas Transportation Commission, the eight major metropolitan planning organizations around the state, and Governor Rick Perry, who said innovative strategies are needed to relieve traffic congestion in major cities and to improve roadway safety.

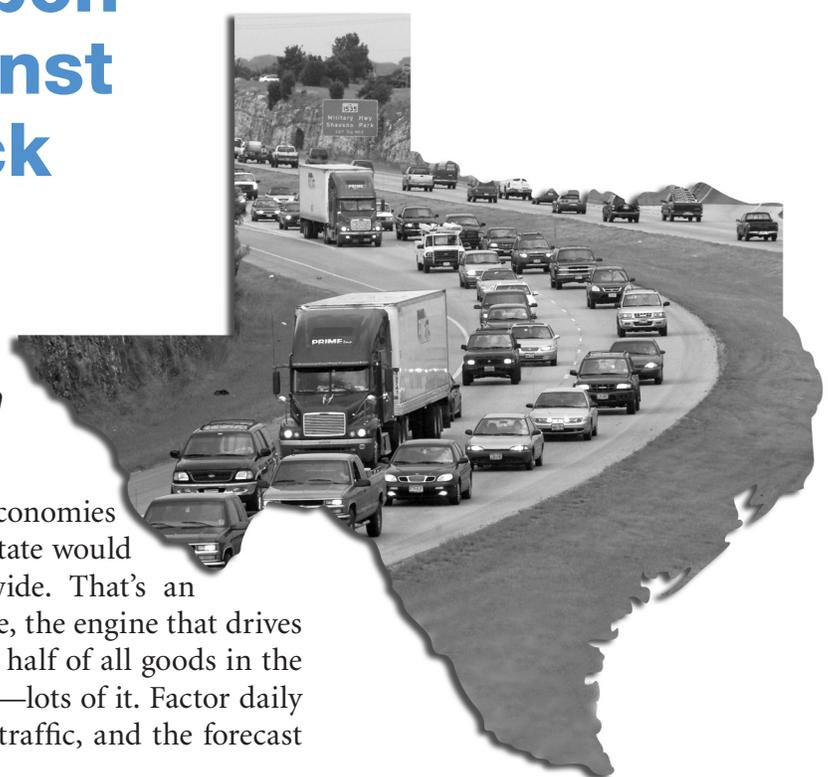
"The Texas Congestion Index methods allow regions to include a wide variety of established congestion data sources (e.g., where the homes and jobs are located, traffic speeds, travel delay, dollar value of improvements, etc.) and generate information relevant to the public discussion about transportation's importance," says Lomax. **R**



#### MORE INFORMATION

For more information, please contact Tim Lomax at (979) 845-9960 or [t-lomax@tamu.edu](mailto:t-lomax@tamu.edu).

Please see page 19 for related reports.



# A handshake and a start date

*Researchers offer funding tips, techniques to enhance and speed transportation projects*

**I**t's hard to wait for years when you need a project now. Growing communities in search of roads, bridges, or overpasses need projects quickly. The delay waiting for traditional state funding of transportation projects can lead to community frustration over congestion and lost opportunities and possibly years or even decades of limited growth. Yet the gap between available transportation dollars and the requests for those dollars for transportation projects is growing wider every year.

## Partnership tips and techniques

### *To form a partnership, you'll need to:*

- 1) Identify your specific transportation project or need (a bridge, a road, an intersection, an overpass, etc.)
- 2) Brainstorm about who could benefit from the project—this will help identify partners you can approach
- 3) Visit your TxDOT District Engineer, as well as other potential partners, to explain your need and its positive impact for everyone involved
- 4) Develop a mutually beneficial agreement
- 5) Begin the project

A set of strategies and tools sponsored by the Texas Department of Transportation (TxDOT) and developed by researchers at the Texas Transportation Institute (TTI) is offering solutions to this age-old funding dilemma.

According to Brian Bochner, a senior research engineer at TTI, state legislation passed in 2003 makes transportation partnerships one of the most effective, precise and powerful tools available to planners, developers or anyone else with a transportation need and a desire to find a solution.

“Most community leaders are looking for transportation improvements to help their communities grow,” says TxDOT project director Mark Longenbaugh. “The strategy and materials developed by TTI will provide decision makers in these communities with real-world strategies, tips and tools they can use to fund and complete transportation projects sooner—which can speed growth.”

“We’re helping TxDOT develop strategies and tools to encourage and facilitate partnering between the department and local public and private sector partners for specific transportation improvements,” says Bochner. “TTI research responds to a combined state and local need to leverage available funds to achieve

more improvements to the transportation system.”

This information was used to develop a series of brochures and other tools for decision makers in local communities. Researchers examined a wide variety of successful case studies and innovative ideas oriented to funding and finishing transportation projects now—not a few decades from now.

### How partnering works

According to Longenbaugh, TxDOT will consider almost any viable arrangement, for state highway projects anywhere in Texas, with any bona fide public or private sector partner, which means there is almost no limit to how creative a partnership can be. A city, county or developer may want to get a section of road improved faster so they help pay for the work. A city may wish to provide TxDOT with necessary engineering or environmental analysis. Or a developer could provide the necessary right-of-way (ROW) for construction, which speeds up the land acquisition process. Partnering to fund and expedite local transportation projects can take almost any form, and Bochner says such agreements can vary from the very complex to very simple, starting with a handshake which often turns into a straightforward written agreement.

The research team identified a number of traits of a successful partnership as well as the pitfalls transportation funding partnerships can encounter. Traits of successful partnerships include:

- Clearly identified local benefits derived from the project
- An obvious link between partner participation and local benefits
- Readily apparent local support for the project
- A viable/workable role for each partner

To avoid pitfalls, Bochner recommends forming partnerships from the local level up, getting local “buy-in,” developing transportation projects that are local investments with lasting value and selecting funding methods that everyone mutually agrees on.

“This research has identified from past transportation projects many partnering benefits to TxDOT and local partners,” says Bochner. “We expect it to be easier for all partners to see these benefits and to develop successful and beneficial partnerships as a result.” **R**



#### MORE INFORMATION

For more information, please contact Brian Bochner at (979) 458-3516 or [b-bochner@ttimail.tamu.edu](mailto:b-bochner@ttimail.tamu.edu).

Please see page 19 for related reports.

## More partnership tips and techniques

### Partners can agree to:

- simply “write a check”
- donate services—engineering, construction, materials
- issue bonds
- establish tax increment finance districts or create special districts
- donate land, or ROW—easements, long-term leases
- provide maintenance—repairs, overlays, long-term maintenance contracts
- offer incentives for early/on-time completion, where perhaps another entity is prohibited from doing so

### The benefits of partnering

Though every project is different and the benefits of partnering may vary, there are some broad, economic and non-economic benefits worth considering.

#### Economic

- expedite project timelines, saving construction time and cost inflation
- attract new business or other development sooner
- increase property values and tax base through improved access and development
- enhance transportation projects

#### Non-economic

- increase needed infrastructure more quickly for expansion into desired areas
- reduce congestion along corridors
- avoid or limit frustrating construction delays
- increase your community’s involvement in project development

# Forewarned is forearmed:

## *Advance detection at signalized intersections*

It's hard to argue with the idea that keeping traffic moving safely and effectively is the Texas Department of Transportation's (TxDOT) most important mandate. Efficiently and safely regulating traffic flow at intersections is one of the most visible ways in which TxDOT affects our everyday lives. In previous research for TxDOT, Texas Transportation Institute (TTI) researchers developed algorithms to help improve the regulation of traffic at intersections. Detection of approaching vehicles needs to occur between 850 feet and 1,200 feet in advance of the intersection to effectively operate traffic signals using these new algorithms. However at those distances, it becomes expensive to maintain inductive loop detectors (ILDs) as the principal method for detection.



A number of other technologies exist to help regulate flow at intersections, and TxDOT is using several of them already. TxDOT sponsored a project, Cost Effective Technologies for Advance Detection at Signalized Intersections, to investigate which technologies might be most useful and cost effective when feeding data to the algorithms developed by TTI.

TTI researchers installed and evaluated various detector technologies for their effectiveness in providing data to the algorithms that help to manage intersections. The intersection of South Highway 6 and FM 185 in Waco was selected as the test bed for the project. Not only do the technologies differ in how accurately they detect traffic, but they also vary significantly in cost to taxpayers. Even so, cost isn't the most important issue.

"It's not simply about finding the most efficient or cost-effective system," explains Srinivasa Sunkari, associate research engineer at TTI. "Promoting safety is even more important. Providing algorithms with accurate and consistent data is one way to promote safety and efficiency at signalized intersections."

Researchers found that ILDs using contact closure radios were very accurate in counts, vehicle classifica-

tion, and speeds, the three pieces of data needed by the algorithms to most effectively regulate intersections. The other detection systems were of varying value compared to the ILDs. While the ILDs cost less than their counterparts on single-lane approaches, all the systems were cost competitive for two-lane approaches.

Researchers made several recommendations to TxDOT, including installing nighttime lighting and improving their technology to provide speed and vehicle length for each vehicle. Finally, they recommended that engineers consider the overall life-cycle cost of the detection system and not solely the installation costs.

"This research has guided us toward a comparison and selection process that can be applied to each individual location to address unique field conditions," says Davis Powell, TxDOT's director on the project. "TxDOT is already benefiting from the research in an Advance Warning of End of Green project in the Lubbock District." **R**



#### MORE INFORMATION

For more information, please contact Srinivasa Sunkari at (979) 845-7472 or s-sunkari@tamu.edu.

Please see page 19 for related reports.

# SOME THING

# OLD NEW SIMULATED IMPROVED

Sometimes it just makes more sense to buy a new car instead of trying to fix the old car. But what if you could predict how your old car would operate in the future in order to decide how to keep it running most efficiently, cost-effectively and safely?

The Texas Department of Transportation (TxDOT) faces this scenario every day. The state's transportation system can always be improved, but resources are finite. Improving the existing system is often the best long-term solution, and software simulation helps TxDOT personnel test, for example, existing traffic signal controllers to optimize their operation. Sometimes actual components from the systems can be used as part of the simulation, and this is called "hardware-in-the-loop."

Hardware-in-the-loop traffic simulation uses traffic signal controller hardware to control simulated traffic. A computer model of how vehicles interact with each other, the roadway, and the control system itself helps TxDOT understand how varying any one of those factors can impact the others. Advantages to this kind of research include

- improved safety for TxDOT personnel and cost savings (as opposed to actual field studies),
- more comprehensive and wide-ranging results,
- the fact that traffic operations aren't disrupted, and
- the ability to analyze future hypothetical traffic conditions.

Researchers at the Texas Transportation Institute (TTI) developed a hardware-in-the-loop traffic signal controller evaluation system to help them with their research. TxDOT was so pleased with the system that it has begun implementing its use to evaluate and improve controllers at intersections across the state. Through project 5-1752-01, TTI is providing support to the department to help them implement this innovation.

"Transferring this technology to TxDOT is an excellent example of why transportation research is so important," says Kevin Balke, director of TTI's TransLink® Research Center. "With TxDOT's support we originally



Hardware-in-the-loop technology provides guidance for traffic engineers and signal maintenance personnel in properly synchronizing traffic signals.

developed this tool solely for research, but now the department can use it to improve traffic flow in the real world. In short, TxDOT got twice the bang for the buck."

With hardware-in-the-loop, TxDOT can test features of its traffic controllers that could not be readily tested before. Going out to a real traffic intersection and flipping switches to see what would happen has the potential for harm to say the least. But with this new simulation technology, maintenance personnel can test the controller features under near real-world conditions in a non-threatening environment. Thus, when the switches are actually flipped at that intersection to improve traffic flow, TxDOT can be confident that solid research supports that implementation.

"This technology improves the efficiency and safety of intersections by allowing engineers to test, compare and choose traffic signal controller operations using different controller parameters and features in a laboratory environment," explains Henry Wickes, TxDOT's director on this project. "It also provides an excellent training tool for engineers and signal maintenance personnel." **R**



#### MORE INFORMATION

For more information, please contact Kevin Balke at (979) 845-9899 or k-balke@tamu.edu.

Please see page 19 for related reports.

## INCIDENT DETECTION: Find it fast, move it fast



According to the 2005 Urban Mobility Report, incidents on the roadway are responsible for almost 60 percent of total motorist delay. Traffic management centers (TMCs) such as those in Houston, San Antonio, Ft. Worth, Dallas, Austin, and El Paso assist in clearing incidents from the roadway as quickly and safely as possible to minimize the impact on motorist drive times. Detecting the incident, however, is often one of the most challenging aspects of incident management. With many miles of roadway to monitor, TMCs rely on automated systems — the better the detection capabilities, the more rapid the response.

Many TMCs in Texas use the Advanced Traffic Management System (ATMS) built by the Texas Department of Transportation (TxDOT). The system is based on an algorithm that utilizes loop occupancy data from roadway loop detectors to determine the likelihood that an incident has occurred on the roadway. A TxDOT-

Detecting the incident, however, is often one of the most challenging aspects of incident management. With many miles of roadway to monitor, TMCs rely on automated systems — the better the detection capabilities, the more rapid the response.

sponsored project conducted by the Texas Transportation Institute (TTI) and headed by Robert Brydia sought to optimize the incident detection algorithm to improve detection without also increasing the number of false alarms.

Using data from 2002, 2003 and 2004 from the Austin District and a statewide assessment of operators' desires for incident detection performance, the project team analyzed the capability of the existing TxDOT algorithm. They looked at three main parameters that were interdependent—false alarms, incident detection rate and incident detection time.

The research developed an enhancement to the current incident detection algorithm that examines the vari-

ability of occupancy across all travel lanes of the roadway, not just a specific value in a specific lane. Named the cross-lane comparison (CLC), the algorithm

- decreases average daily false alarms by almost 30 percent,
- increases the incident detection rate to an average of 56 percent (from the existing algorithm's average of 26 percent), and
- decreases the incident detection time by approximately 50 percent.

“The enhanced algorithm is more sensitive to changes in lane occupancy caused by incidents,” said Brydia. “The algorithm is more efficient without being more complex.”

The project also provided a procedure to calibrate the threshold values used in the algorithm and a logical flow for this procedure.

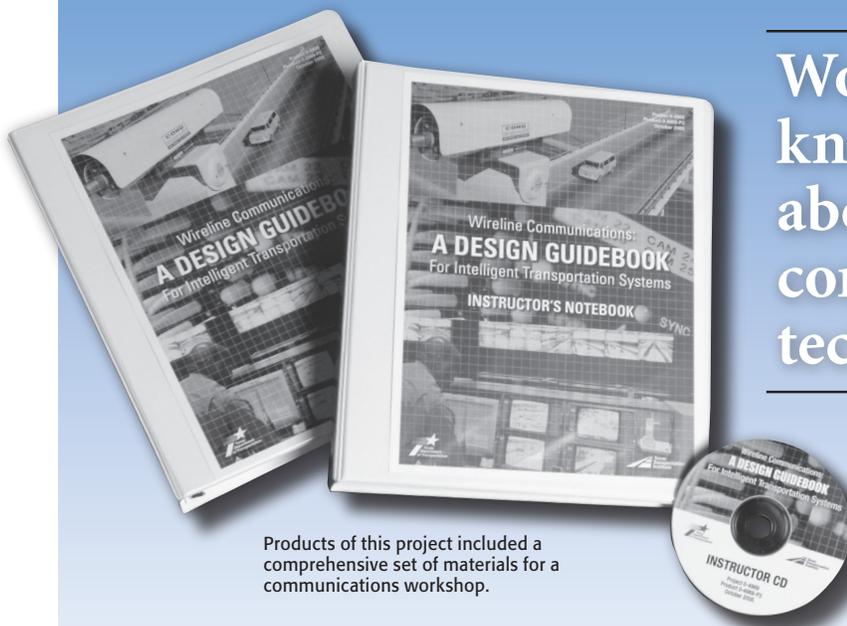
Joyce Seebock with TxDOT's Traffic Operations Division, notes “The algorithm can be implemented in the next generation of ATMS software, which will be designed to be flexible in implementing and choosing algorithms to detect and alarm incidents.” 



#### MORE INFORMATION

For more information, please contact Robert Brydia at (979) 845-8140 or r-brydia@tamu.edu.

Please see page 19 for related reports.



Products of this project included a comprehensive set of materials for a communications workshop.

## Workshop shares knowledge about ITS communications technologies

The use of intelligent transportation systems (ITS) continues to help transportation agencies manage existing infrastructure efficiently. Many ITS applications require communication systems to move increasingly large amounts of data and video. In a recent project for the Texas Department of Transportation (TxDOT), TTI researchers designed tools to aid engineers in making decisions on the communication needs of future ITS installations, both stand-alone deployments and larger, existing systems.

Using their knowledge of communications concepts and technologies and a literature survey, researchers at the Texas Transportation Institute (TTI) created a procedure for assessing the communications needs of ITS deployments.

“After the assessment,” says project manager Bob Brydia, “the procedure suggests the most appropriate communication technologies to fill those needs, for both data and video applications. It offers typical design and deployment scenarios.”

A four-hour pilot workshop presented the procedures to TxDOT personnel. The workshop discussed the most common technology solutions used in the ITS arena today, including:

- serial,
- Plain Old Telephone System (POTS),
- Integrated Services Digital Network (ISDN),
- Digital Subscriber Line (DSL),
- cable modem,
- T-1/T-3 services,
- Asynchronous Transfer Mode (ATM),
- Synchronous Optical Network (SONET), and
- Ethernet.

Especially useful to engineers are the cross-cutting tabulations of critical aspects of each technology. For example, using the tabulations, engineers can quickly compare aspects such as the bandwidth, wiring type, deployment method, distance limitations and typical costs for each technology being considered.

Because the pilot workshop was so well received, TxDOT funded an implementation project to expand the material covered. Instructors will present an eight-hour workshop at 10 locations across the state over the next 18 months.

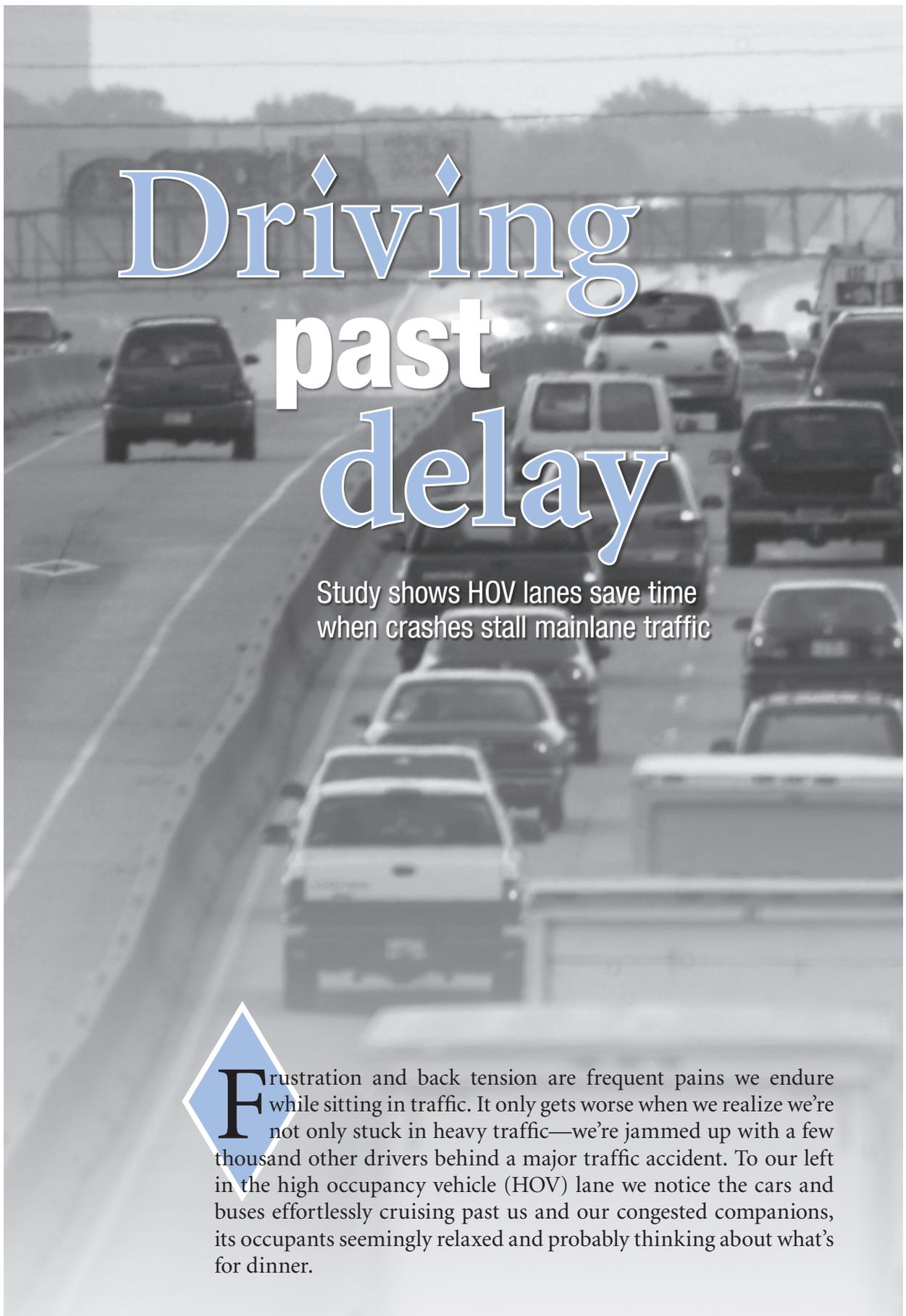
Steve Barnett, senior engineer-technician for TxDOT, sees new field technicians in the districts as an important target for the training, to familiarize them with the different technologies. “We need to better prepare them for networking equipment yet to come. Most of the smaller districts don’t yet have ITS equipment, but they probably will soon.” **R**



### MORE INFORMATION

For more information, please contact Robert Brydia at (979) 845-8140 or r-brydia@tamu.edu.

Please see page 19 for related reports.



# Driving past delay

Study shows HOV lanes save time  
when crashes stall mainlane traffic

**F**rustration and back tension are frequent pains we endure while sitting in traffic. It only gets worse when we realize we're not only stuck in heavy traffic—we're jammed up with a few thousand other drivers behind a major traffic accident. To our left in the high occupancy vehicle (HOV) lane we notice the cars and buses effortlessly cruising past us and our congested companions, its occupants seemingly relaxed and probably thinking about what's for dinner.



The time it takes to clear an incident, like the one shown above, was one of several factors TTI researchers studied to determine travel time savings for HOV lanes.

For many a solo driver the obvious benefit of traveling in the HOV lanes becomes instantly clear. Wrecks will wring the mobility right out of busy freeways, and researchers at the Texas Transportation Institute (TTI) wanted to know if the travel time savings (arriving more quickly) and trip time reliability HOV commuters experience during mainlane crashes, or “incidents,” could be studied to better quantify the actual travel time savings HOV lanes provide.

TTI Associate Research Engineer David Fenno, who works out of TTI’s Houston urban office, developed a study sponsored by The Texas Department of Transportation (TxDOT) to answer just how much time HOV drivers save while mainlane drivers sit in congestion behind wrecks.

“We know, based on studies, that if there’s an incident on the mainlane it could cause your travel time to increase by 30 to 50 percent or more,” says Robert Benz, an associate research engineer in TTI’s Houston office. Benz, who assisted on the project, says two key pieces of technology helped determine travel time savings.

“You have to know when an accident happens and gather data on travel times,” he says. “To get travel times, or how long it takes a vehicle to travel from one given

point to another, Houston has an Automatic Vehicle Identification (AVI) system.”

The system senses vehicles, equipped with a toll tag transponder, as they pass a reader station. The system transmits the time and location of these “probes” to a central computer. As the vehicles pass through successive AVI readers, software calculates average travel times and speeds for a roadway segment.

Fenno and Benz also used a database from Houston TransStar™, Houston’s transportation and emergency management center, that logs when traffic incidents occur, which lanes are blocked, how long it takes to clear the incident off the road, and other factors. Comparing how long it took HOV lane drivers and mainlane drivers to cover the same ground gave Fenno and Benz the data they needed to arrive at an average amount of time drivers in HOV lanes save when accidents occur in mainlane traffic.

After studying average time savings during morning and afternoon peak (AM and PM) periods for one year (measuring only dates with traffic incidents), Fenno and Benz found a maximum PM peak savings of over an hour when drivers use HOV lanes during a mainlane incident. The AM peak savings was close to 50 minutes. Using 2003 AVI data, researchers estimated that travelers

in the four HOV corridors studied saved approximately \$81,000 per day, or approximately \$35 million per year in travel time savings.

The researchers conducted a similar study in Dallas, where instead of having HOV lanes separated by barriers, as in Houston, the HOV lanes are “buffer separated” by painted lines. Lacking a concrete barrier means mainlane vehicles can dodge into the HOV lane during a traffic incident, which affects how much time HOV drivers (with the required number of passengers) will save during a mainlane incident.

TTI researchers in Austin have used Fenno and Benz’s research to develop a guide that transportation emergency management personnel can use during major incidents to decide when to possibly open HOV lanes to mainlane drivers to get traffic moving once again.

“This research has provided new insight on the benefits of HOV lanes,” says David Fink, transportation engineer supervisor for TxDOT. “The decision tool developed to assist traffic managers on when to open HOV lanes to all traffic during major traffic incidents is a major step forward.”



#### MORE INFORMATION

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

Please see page 19 for related reports.

# More than “making do”

*Award-winning project aims to boost efficiency on existing roads*

In the world of transportation it seems there’s a financial pinch at every turn. Whether the topic is congestion, smoggy skies, or acquiring land for new lanes, resources to “build bigger and better” are already stretched out like an east-west highway. But a major research project sponsored by the Texas Department of Transportation (TxDOT) and conducted at the Texas Transportation Institute (TTI) is offering award-winning ideas to help ease the squeeze on existing roadways through the use of managed lanes.

“The project was conceived by Gary Trietsch, district engineer for TxDOT’s Houston District, as a result of the unique challenges they were facing with the Katy Freeway reconstruction project,” says Beverly Kuhn, a research engineer and head of TTI’s System Management Division. “The district needed answers to various questions regarding how to best operate the managed lanes that will be part of the expanded freeway facility.”

Managed lanes help improve roadway efficiency by tailoring the use of one or more lanes on a facility to certain kinds of vehicles or other operating options. For example, high-occupancy vehicles or truck traffic could be confined to a specific lane along a corridor, or certain lanes may be set aside for smoother flowing toll traffic. Any strategic idea to improve efficiency of a lane, manage demand along a corridor, offer drivers travel time savings or improvement could be considered part of a managed lanes approach to roadway use.

Kuhn and fellow team leader Ginger Goodin’s research team analyzed how and where managed lanes were used successfully around the country and created a user-friendly brochure to explain the concept. The project developed more than 150 research products, including a conceptualized decision model, which spells out the information a driver might need when deciding whether or

not to use a managed lane (such as a toll lane). Other major developments include the *Managed Lanes Handbook* for use in developing managed lanes projects, a preliminary screening tool and a comprehensive website.

“The products from this research project have come at the perfect time,” says Carlos Lopez, TxDOT Traffic Operations Division director and project director. “Their timely implementation will go a long way towards helping TxDOT plan and design managed lanes to serve the mobility of Texans in the future.”

The research approach and quality of the tools

the research team developed have proven to be award-winning—twice. The Managed Lanes project (0-4160) netted a TxDOT 2005 Top Innovation award and the 2005 TTI Team Award. Goodin and Kuhn accepted the awards in recognition of their leadership of a broad, diverse team and their collaboration with Texas Southern University. Described as a “hallmark of excellent teamwork at TTI,” this was the first research team ever given the award. And their work continues.

“The team is pursuing an implementation project to develop a workshop for TxDOT staff for the *Managed Lanes Handbook*,” says Kuhn. “We’re also looking at additional research topics that emerged from this project, including working with the TxDOT research program and at the national level through the National Cooperative Highway Research Program (NCHRP).” **R**

**Managed lanes help improve roadway efficiency by tailoring the use of one or more lanes on a facility to certain kinds of vehicles or other operating options.**



**MORE INFORMATION**

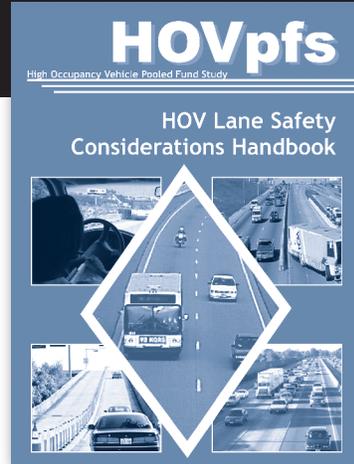
For more information, please contact Beverly Kuhn at (979) 862-2558 or b-kuhn@tamu.edu; Ginger Goodin at (512) 467-0946 or g-goodin@tamu.edu.

Please see page 19 for related reports. <http://managed-lanes.tamu.edu/>



# TTI researchers develop HOV handbooks

Enhancing the operation of high-occupancy vehicle (HOV) lanes continues to be a priority with transportation agencies throughout the country. Ten state departments of transportation, along with the Federal Highway Administration (FHWA), formed the HOV Pooled-Fund Study Group to help advance needed research and technology transfer activities associated with HOV facilities. Texas Transportation Institute (TTI) researchers have recently completed a number of handbooks and outreach materials for the Pooled-Fund Study Group.



The *HOV Lane Safety Considerations Handbook* is one of four handbooks developed by TTI.

“The intent of the HOV Pooled-Fund Study Group is to identify common issues among agencies, to initiate needed projects, and to disseminate the results,” notes Wayne Ugolik, planning and program manager, New York State Department of Transportation and current chair of the HOV Pooled-Fund Study Group.

“The handbooks prepared by TTI provide comprehensive references for transportation and public safety professionals, agency managers, and policy makers responsible for planning, funding, and operating HOV lanes.”

Neil Spiller,  
Transportation Specialist,  
FHWA’s Operations Office of  
Transportation Management

“We also assist in solution deployment and track innovations and practices.”

In addition to New York, other participating states include California, Georgia, Maryland, Massachusetts, Minnesota, New Jersey, Tennessee, Virginia, and Washington. FHWA provides assistance and helps coordinate activities for the group.

TTI was selected as part of the Battelle team through FHWA’s competitive procurement process to develop the following four handbooks and related outreach materials.

- *HOV Performance Monitoring, Evaluation, and Reporting Handbook*
- *HOV Lane Eligibility Requirements and Operating Hours Handbook*

- *HOV Lane Safety Considerations Handbook*
- *HOV Lane Enforcement Handbook*

Katherine Turnbull, associate agency director, is principal investigator on the handbooks on HOV performance monitoring and HOV eligibility requirements and operating hours. Ginger Goodin, research engineer and head of the Austin Agency Liaison Office, is principal investigator on the safety and enforcement handbooks. TTI researchers Mark Ojah, assistant research specialist, and John Wikander, assistant transportation researcher, are the primary authors on the safety and enforcement handbooks, respectively. David Ungemah, associate research scientist, prepared the marketing brochures.

“The handbooks prepared by TTI provide comprehensive references for transportation and public safety professionals, agency managers and policy makers responsible for planning, funding and operating HOV lanes,” notes Neil Spiller, transportation specialist with FHWA’s Operations Office of Transportation Management. “They provide a valuable resource for the pro-active management of HOV facilities.”



#### MORE INFORMATION

For more information on the HOV Pooled-Fund Study Handbooks, please contact Katherine Turnbull at (979) 845-6005 or [k-turnbull@tamu.edu](mailto:k-turnbull@tamu.edu); Ginger Goodin at (512) 467-0946 or [g-goodin@tamu.edu](mailto:g-goodin@tamu.edu)

The handbooks and outreach materials are available on the HOV Pooled-Fund Study Internet site at <http://hovpfs.ops.fhwa.dot.gov/index.cfm>.

# SMOOTH TRANSITIONS

TTI researchers develop cost-effective guardrail design



The above sequence of photos shows a successful crash test of the transition guardrail section developed by TTI researchers.



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

Please see page 19 for related reports.

As the automobiles on our roadways have changed from predominately passenger cars to trucks and sports utility vehicles (SUV), so must the roadway design standards used by the Texas Department of Transportation (TxDOT) change to accommodate these vehicles. Guardrail bridge transitions represent one of these areas. The increased stiffness needed in the transition to safely contain and redirect heavier trucks and SUVs made guardrail bridge transitions costly and complex to construct.

Researchers at the Texas Transportation Institute (TTI) recently completed a project for TxDOT that modified the standards for low-speed guardrail-to-bridge rail transitions. A transition is a section of guardrail that ties a roadside guardrail and bridge rail together at a bridge approach.

“If a flexible roadside guardrail is connected to a rigid bridge rail, there is a basic incompatibility between the two in terms of their stiffness,” says Roger Bligh, associate research engineer with TTI and project supervisor. “If a vehicle impacts the guardrail just in advance of the bridge rail end, the guardrail will deflect, but the bridge rail will not. So the vehicle ‘pockets’ into the end of the bridge rail, resulting in a severe crash. In this project, we designed a transition section that solves this problem by smoothly transitioning the stiffness from the flexible guardrail to the more rigid bridge rail.”

Using computer modeling, researchers analyzed several guardrail transition designs for low-speed roadways. The selected system achieved smooth transition stiffness by reducing the spacing of posts and using two guardrail beam elements.

“Initially, we looked at design alternatives using computer analysis to provide an indicator of successful impact performance before full scale crash testing,” says Bligh. “We wanted to make sure that the design being crash tested had a good probability of passing, and yet was the most economical and cost effective solution for the state.”

The project concluded with a successful first crash test that was performed on the design selected in conjunction with TxDOT engineers. TxDOT has implemented a new standard detail sheet of the design that is now available statewide for use on roadways. It has also gained some national attention.

“Safety is the top priority for TxDOT. We are always looking for ways to improve the safety of our roadway system for the traveling public,” says Rory Meza, TxDOT director of roadway design. “Research projects such as this one provide us with the opportunity to be innovative and to implement the improvements in a short time frame. The low-speed transitional section provides the added safety at a reasonable cost, using standard materials readily available in the industry.” **R**

# Retrofit and repair

TTI researchers develop efficient method of maintaining bridge rails



This photo shows a low-speed crash test of the new anchorage design for retrofitting and repairing bridge guardrails. The low-speed crash testing vehicle shown above was an important by-product of the project.

Texas has 48,920 bridges—40 percent more than any other state. Occasionally, vehicles crash into bridge railings, severely compromising the railing’s ability to redirect or keep a vehicle on the roadway. Other railings are old and in need of retrofitting to bring them up to current safety standards. Repairs to these bridge railings are often extensive and require considerable time and manpower. These repairs also expose workers to hazardous work zone conditions.

With so many bridges requiring potential maintenance, the Texas Department of Transportation (TxDOT) needed a method to repair and retrofit existing bridge structures. Texas Transportation Institute (TTI) researchers answered the challenge by developing an efficient and cost effective anchorage design for the replacement of old or damaged railings.

“The new design allows a construction crew to repair a damaged area quickly, minimizes their time on the roadway and puts the road and railing back into service,” says William Williams, TTI assistant research engineer and project supervisor. “It allows the crew to work pretty much on top of the bridge and minimize their involvement underneath the bridge.”

The new design uses an adhesive anchor that is drilled into the existing deck of the railing. The anchors are held in place by an epoxy. The

anchors can be quickly installed, and the bridge railing can then be built or repaired. Being able to use the existing deck of a bridge railing is an important element of the design and allows the repair to be performed quickly and safely.

The design was tested at the TTI Proving Grounds research facility. As a by-product of this project, a low-speed crash testing vehicle was also developed which can be used for future research. Currently, one of the retrofit designs is undergoing one last round of testing before implementation throughout Texas.

“This new design is really important for the department because there are thousands of bridges that need to be upgraded in our state,” says Mark Bloschok, special projects engineer with TxDOT. “The work that we did

with TTI is crucial for two reasons: First, it gives us confidence to move forward and retrofit our bridge rails which will increase safety; second,

“This new design is really important for the department because there are thousands of bridges that need to be upgraded in our state.”

Mark Bloschok,  
special projects engineer with TxDOT

the development of the crash testing vehicle allowed multiple tests to tell us what we needed to know about the strength of the retrofit. TTI has always watched over our transportation dollar and this project is an example of that.” **R**



#### MORE INFORMATION

For more information, contact William Williams at (979) 862-2297 or [w-williams@tamu.edu](mailto:w-williams@tamu.edu).

Please see page 19 for related reports.

The biggest health risk to children today is not the measles or the flu, but rather death or injuries from automobile crashes. That's why the Texas Transportation Institute (TTI) chose child safety seats as this year's charitable activity in association with TTI Day. Generous employee donations provided enough money to purchase 22 seats to give to needy families in the Bryan-College Station area.

The first event was held December 13 at the Bossier car dealership in Bryan, where 16 seats were distributed. Six additional seats were distributed later that same week to families in need who were unable to attend the December 13 event. Several TTI employees who are certified car safety seat inspectors spent nearly an hour with each family to make sure the seats were properly installed. "It's rare to find a seat that has been installed properly. They are confusing and complicated, and in some cases misuse can result in injuries instead of the protection the seats are designed for," says Senior Research Scientist Katie Womack, who is also a child passenger safety technician.

Another child safety seat event was held in El Paso, the location of TTI's newest regional office. That "checkup" was held in conjunction with National Child Safety Week in February. **R**

# TTI-sponsored child safety seat "checkup" a success

## BY THE NUMBERS

*Beverly Kellner of Texas Cooperative Extension supplied the following statistics from the "checkup":*

- 23** Number of children checked
- 0** Number of children found correctly restrained
- 6** Number of old/unsafe seats collected
- 16** Number of new seats distributed
- 6** Number of children arriving totally unrestrained or inappropriately restrained in safety belts



A child safety seat is removed and inspected.



TTI employees Katie Womack and Sandra Schoeneman check the straps of a child safety seat.

## Child in crash okay after TTI safety event

When Charlot Finnigan came to the Texas Transportation Institute's (TTI) Child Safety Seat "checkup" event December 13, she had no idea it would become perhaps one of the most important decisions of her life. On January 15, 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 12-year-old 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. (Jasmine is small for her age, weighing less than 6 pounds at birth). The family was later checked out at the hospital and released, found to be uninjured. "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."

In fact, the notes from the December 13 inspection of little Jasmine's seat showed some serious problems. TTI employees Katie Womack and Sandra Schoeneman jotted down these observations: "Harness is not snug," "Chest clip not at right level," and "Safety belt not secure." Child Safety Seat expert Bev Kellner of Texas Cooperative Extension says those problems are typical in the hundreds of child seat inspections annually. "These are things that can be devastating for families in



Jasmine Finnigan is fitted with a new child safety seat from the Passenger Safety Program of Texas Cooperative Extension after a serious accident. The National Highway Traffic Safety Administration recommends a new seat after a severe collision. Photo courtesy Texas Cooperative Extension.

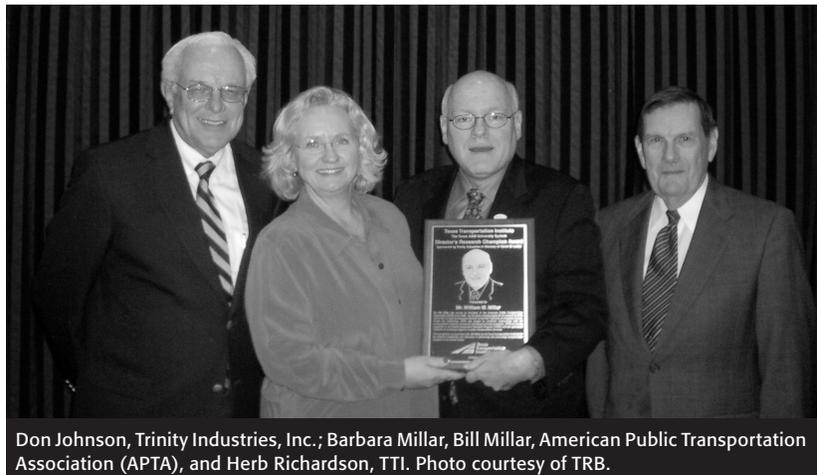
crashes," says Kellner. "Those specific items can be the cause of children being ejected from their seats."

A 2003 study conducted by the National Highway Traffic Safety Administration (NHTSA) shows 80 percent of child safety seats were found with serious misuses. "That's why we applaud parents like Charlot Finnigan who come to checkup events for that extra measure of assurance that they are using their car seats correctly, and understand that for the safety of their children the details do matter," says Womack. ■

## Millar presented Director's Research Champion Award

William W. Millar, President of the American Public Transportation Association (APTA), was presented with the 2006 Texas Transportation Institute Director's Research Champion Award at TTI's January 22 reception at the Transportation Research Board Annual Meeting in Washington, D.C. The award is sponsored by Trinity Industries in memory of Kenneth W. Lewis.

The Director's Research Champion Award recognizes individuals at the national level who have been strong and effective advocates for transportation research. Millar received the 2006 award for his leadership in advancing transportation research addressing all modes. As President of APTA and in his prior position as executive director of the Port Authority of Allegheny County in Pittsburgh, Millar has been a strong advocate of research, including projects focusing on critical issues in public transportation, and has helped advance numerous research projects, technology transfer activities and outreach efforts. ■



Don Johnson, Trinity Industries, Inc.; Barbara Millar, Bill Millar, American Public Transportation Association (APTA), and Herb Richardson, TTI. Photo courtesy of TRB.

## TRB paper awards

TTI Associate Research Engineer Roger Bligh was the recipient of TRB's K.B. Woods Award for his research paper detailing the use of guardrails on lower-speed roadways, "Guardrails-to-Concrete-Bridge-Rail Transition for Low-Speed Roadways." The paper describes the development of a less expensive guard-rail-to-concrete-bridge-rail transition which is suitable for use on roads with lower speed limits.

Associate research engineer Paul Carlson and assistant transportation



Bligh



Carlson



Holick

researcher Andrew Holick were presented with the Fred Burggraf Award, which recognizes excellence in transportation research by researchers 35 years of age and younger. Carlson and Holick co-authored a paper entitled "Maximizing Unlit Freeway Guide Sign Legibility Using Clearview Font and Combinations of Retroreflective Sheeting Materials." ■

## Richardson's final TTI Day

With about 350 employees in attendance, it was fitting that Director Herb Richardson be center stage for his last TTI Day, the annual employee gathering he helped start 11 years earlier. Richardson, who announced his retirement before the holidays, received at least two standing ovations during the event.

Deputy Director Dennis Christiansen outlined many of Richardson's accomplishments, including the improvements made to Riverside, the construction of the Gilchrist Building and a future \$10 million building to be completed in three years. "I am absolutely confident that Herb is the only leader who could have made this happen — his knowledge of the System and university, the stature he has in that community and his patience uniquely qualified him to provide us with the infrastructure that should meet our needs for many years," Christiansen said.

Before the accolades, Richardson addressed the Brazos Center audience with a "State of TTI" speech, many times giving credit to others for various accomplishments. Richardson pointed out the successes of 2005 (continued support for the Center for Transportation Safety, the development of the Pecos Research and Testing Center, establishment of an El Paso office and the future TTI building near Gilchrist) and touched upon the challenges still facing the institute. "While the overall picture is pretty rosy, there are challenges on the horizon," he said. "We still need to focus on diversifying our sponsor base, while at the same time nurturing and maintaining our special relationship with TxDOT."

During his speech, Richardson outlined several near-term opportunities for TTI including Homeland Security-related research, border research, continuing



TTI Director Herb Richardson enjoys a lighthearted moment during his final TTI speech.

education and international research. "As the world grows ever smaller, we have increasing opportunities abroad. Just this past year, the institute has been approached by organizations from several countries about bringing our expertise to their transportation problems."

Richardson told the crowd that the search committee to find his replacement will be appointed soon and that a new director will be identified by September. ■

## 2005 Employee awards

Fifteen individuals were recognized with 2005 TTI Employee Award during TTI Day.

Individual award winners were:

Kelly West  
*Administrative Professional Staff Award*

Holly Crenshaw  
*Administrative Professional Staff Award*

Cecily Sebesta  
*Administrative Support Staff Award*

Gary Lobaugh  
*Administrative Technical Support Award*

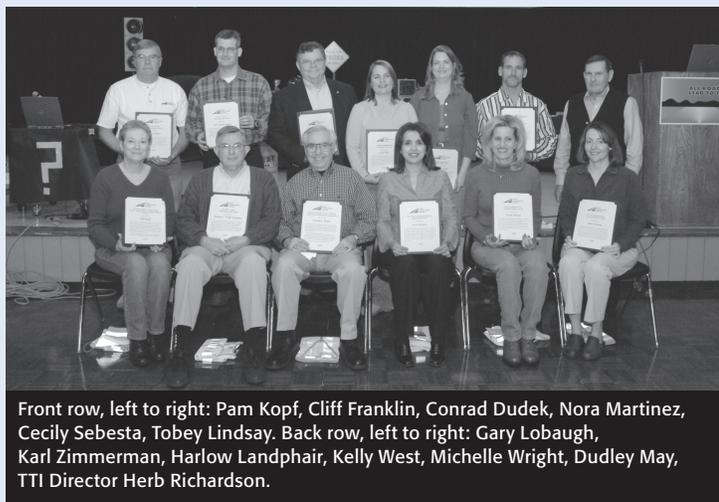
Tobey Lindsey  
*Administrative Technical Support Award*

Nora Martiniez  
*Division Administrative Support Award*

Michelle Wright  
*Division Administrative Support Award*

Dudley Scott May  
*Division Technical Support Award*

Eyad Masad  
*TTI/Trinity New Researcher Award*



Front row, left to right: Pam Kopf, Cliff Franklin, Conrad Dudek, Nora Martinez, Cecily Sebesta, Tobey Lindsay. Back row, left to right: Gary Lobaugh, Karl Zimmerman, Harlow Landphair, Kelly West, Michelle Wright, Dudley May, TTI Director Herb Richardson.

Karl Zimmerman  
*TTI/Trinity New Researcher Award*

Paul Carlson  
*TTI/Trinity Researcher Award*

Weldon C. (Cliff) Franklin  
*TTI/Trinity Senior Researcher Award*

Harlow C. Landphair  
*TTI/Trinity Senior Researcher Award*

Pam Kopf  
*Charles J. "Jack" Keese Career Achievement for Agency Support Award*

Conrad L. (Connie) Dudek  
*TTI/Trinity Charley V. Wootan Career Achievement for Research Award*

★ AWARDS ★

## THE BACK ROAD



Unlike some other academic disciplines, transportation researchers often get to see the real-world effects of their work. Early this year, that fact was brought home to several of our colleagues as they participated in a TTI-sponsored free child-safety seat “checkup” and placement program, piloted in College Station and El Paso. The funds to purchase seats for this activity were donated by TTI employees. A 2003 study conducted by the National Highway Traffic Safety Administration (NHTSA) showed that 80 percent of child safety seats were found with serious misuses. Often the best-intentioned parents are not fully aware of how to install their children’s seats, and little details like making sure the harness is snug and the chest clip is at the right level can make a huge difference. In other cases, parents may not be able to afford child seats. In December, one local family had their safety seat checked by TTI staffers who found several small but critical errors in how they were using it. Less than a month later, they were in a crash that totaled their vehicle, but left their four-month-old daughter unharmed. It was rewarding for our staff to know that their

efforts in the original research and in putting their results to work had made such a difference.

This issue of *Researcher* includes stories on urban traffic management and innovations such as improved traffic signal operations, operating freeways with managed lanes, and better quantifying the benefits of HOV lanes. There’s also a story about a unique aspect of the annual Urban Mobility Index—the development of a single index to assess various elements of metropolitan transportation services. Researchers believe that the information and analysis of several smaller indices of congestion could help TxDOT and its MPO partners better communicate to the public the need for new transportation infrastructure.

You’ll also read about new ways being proposed to retrofit bridge rails or repair those damaged by collisions as well as a new roadside crash testing program that will help ensure that existing safety devices meet current vehicle testing criteria and suggest modifications if necessary.

As always, we appreciate your interest and support for the Institute. I hope the warm spring weather will encourage you and your family to travel Texas highways and enjoy the beauties of our great state.

*Herb Richardson*

### 1<sup>st</sup> Annual **TEXAS TRANSPORTATION FORUM**

*Celebrating the Interstate’s  
First 50 years...and Meeting  
the Challenges of the Future*

**SAVE THE DATE:**  
June 8-9, 2006  
Austin, Texas

**FOR MORE  
INFORMATION  
VISIT OUR WEBSITE:**  
[texastransportationforum.com](http://texastransportationforum.com)

Sponsored by:



Cosponsored by: *Associated General Contractors of Texas,  
Texas Good Roads Transportation Association,  
and Texas Transportation Institute*

## **R** Related reports

The following reports provide information about topics covered in this issue of *Texas Transportation Researcher*. Please see back cover for ordering information. Related reports might be available or scheduled for later publication:

**Implementation Report 5-4853-01-1**, “Incorporating the Effect of Operational Improvements in the Texas Congestion Index Estimation Process,” by Timothy J. Lomax.

**Product 5-4853-01-P4**, “Developing an Emissions Index for the Texas Metropolitan Mobility Plan,” by Dennis G. Perkinson, Brian S. Bochner, Martin E. Boardman and Tongbin Qu.

**Technical Report 0-5002-1**, “Evaluation of Cost-Effective Technologies for Advance Detection,” by Srinivasa R. Sunkari, Ricky T. Parker, Hassan A. Charara, Trishul A. Palekar and Danny R. Middleton.

**Project Summary Report 0-5002-S**, “Cost-Effective Technologies for Advance Detection,” by Srinivasa R. Sunkari, Ricky T. Parker, Hassan A. Charara, Trishul A. Palekar and Danny R. Middleton.

**Technical Report 0-4770-1**, “An Investigation into the Evaluation and Optimization of the Automatic Incident Detection Algorithm Used in TxDOT Traffic Management Systems,” by Robert E. Brydia, Jeremy D. Johnson and Kevin N. Balke.

**Project Summary Report 0-4770-S**, “Improving TxDOT’s Incident Detection Algorithm,” by Robert E. Brydia, Jeremy D. Johnson and Kevin N. Balke.

**Technical Report 0-4969-1**, “Development of a Wireline Communications Design Guidebook for Intelligent Transportation Systems,” by Robert E. Brydia, Byron E. Brackin, Jeremy D. Johnson, Gary B. Thomas and Kevin N. Balke.

**Technical Report 0-4740-1**, “Quantification of Incident and Non-Incident Travel Time Savings for Barrier-Separated High-Occupancy Vehicle (HOV) Lanes in Houston, Texas,” by David W. Fenno, Robert J. Benz, Michael J. Vickich and LuAnn D. Theiss.

**Implementation Report 5-1752-01-1**, “TTI’s Hardware-in-the-Loop Traffic Signal Controller Evaluation System,” by Kevin N. Balke, Roelof J. Engelbrecht, Srinivasa Sunkari and Hassan A. Charara.

**Project Summary Report 0-1752-S**, “TransLink: Innovations in Managing the Surface Transportation System,” by Kevin N. Balke, Robert E. Brydia, Roelof J. Engelbrecht, Zong Tian, Sangita, Leonard Ruback, Hassan A. Charara and Laurence R. Rilett.

**Project Summary Report 0-4160-S**, “Findings From Texas: Five Years of Research on Managed Lanes - Summary Report,” by Beverly T. Kuhn and Virginia D. Goodin.



## REPORTS

**0-5002-1**, "Evaluation of Cost-Effective Technologies for Advance Detection," Sunkari, Srinivasa, 6-Jan-06.

**0-4419-5**, "Retrofit Railings for Truss Bridges," Buth, Carl (Gene), 6-Jan-06.

**5-4421-01-1**, "Site Selection and Preliminary Data Collection for Traffic Responsive Control on TxDOT Closed-Loop Systems," Abbas, Montasir, 6-Jan-06.

**0-4023-4**, "Amber Alert, Disaster Response and Evacuation, Planned Special Events, Adverse Weather and Environmental Conditions, and Other Messages for Display on Dynamic Message Signs," Ullman, Brooke, 9-Jan-06.

**0-5008-1**, "Evaluation of Wet-Weather Pavement Markings: First Year Report," Carlson, Paul, 11-Jan-06.

**0-4703-P1**, "Roadway Safety Design Synthesis," Bonneson, James, 13-Jan-06.

**9-1520-P2**, "Design, Construction, and Maintenance of Bridge Decks Utilizing GFRP Reinforcement," Trejo, David, 23-Jan-06.

**0-4160-21**, "Decision Framework for Selection of Managed Lanes Strategies," Goodin, Virginia (Ginger), 23-Jan-06.

**0-4745-2**, "Incident Evaluation Procedures and Implementation Requirements," Quiroga, Cesar, 25-Jan-06.

**0-4745-3**, "Incident Detection Optimization and Data Quality Control," Quiroga, Cesar, 26-Jan-06.

**0-4707-1**, "Identification and Testing of Measures to Improve Work Zone Speed Limit Compliance," Brewer, Marcus, 2-Feb-06.

**0-4728-2**, "An Assessment of Various Rumble Strip Designs and Pavement Marking Applications for Crosswalks and Work Zones," Finley, Melisa, 3-Feb-06.

**0-4297-1**, "Contract Negotiation Tools for Professional Services on Highway Projects," Ford, David, 9-Feb-06.

**0-4502-2**, "Continued Evaluation of Microcracking in Texas," Sebesta, Stephen, 14-Feb-06.

**0-5135-1**, "Investigation of Methods for Improved Precision of Test Method TEX-113-E," Sebesta, Stephen, 16-Feb-06.

**0-1707-4**, "Quantify Shape, Angularity and Surface Texture of Aggregates Using Image Analysis and Study Their Effect on Performance," Little, Dallas, 21-Feb-06.

**0-4358-1**, "Materials, Specifications, and Construction Techniques for Heavy-Duty Flexible Bases: Literature Review and Status Report on Experimental Sections," Hefer, Arno, 21-Feb-06.

**0-4468-2**, "Comparison of Fatigue Analysis Approaches for Two Hot Mix Asphalt Concrete (HMAC) Mixtures," Walubita, Lubinda, 23-Feb-06.

**5-1439-01-2**, "Development and Delivery of Research Implementation Workshops in Transportation Operations and Management," Thomas, Gary, 24-Feb-06.

**0-4240-3**, "Recommendations for Stabilization of High-Sulfate Soils in Texas," Harris, Patrick, 28-Feb-06.

**5-1752-01-1**, "TTI's Hardware-in-the-Loop Traffic Signal Controller Evaluation System," Balke, Kevin, 3-Mar-06.

## PROJECT SUMMARY REPORTS

**0-4265-S**, "Improving Safety and Operations of Traffic Signals Near Railroad Grade Crossings with Active Warning Devices," Balke, Kevin, 9-Jan-06.

**0-4728-S**, "An Assessment of Various Pavement Marking Applications and Rumble Strip Designs," Finley, Melisa, 3-Feb-06.

**0-4745-S**, "Using Archived ITS Data to Optimize Incident Detection and Management," Quiroga, Cesar, 13-Feb-06.

**0-4160-S**, "Findings From Texas: Five Years of Research on Managed Lanes — Summary Report," Kuhn, Beverly (Beverly), 13-Feb-06.

**0-4707-S**, "Summary of Treatments to Improve Work Zone Speed Limit Compliance," Brewer, Marcus, 21-Feb-06.

**0-4770-S**, "Improving TxDOT's Incident Detection Algorithm," Brydia, Robert (Bob), 21-Feb-06.

**0-4203-S**, "Recommended Resolutions to Selected Hot Mix Asphalt Related Issues," Button, Joe, 24-Feb-06.

**0-4502-S**, "Microcracking for Reduced Shrinkage in Cement-Treated Base," Sebesta, Stephen, 24-Feb-06.

**0-5002-S**, "Cost-Effective Technologies for Advance Detection," Sunkari, Srinivasa, 27-Feb-06.

## ORDERING INFORMATION

To order published reports or project summary reports listed above, please contact:

Nancy Pippin at  
(979) 458-0481  
Fax: (979) 845-7575  
e-mail: n-pippin@ttimail.tamu.edu

Report prices vary depending on the length. Project summary reports are \$5.00 each. The Texas Transportation Institute accepts checks, money orders and credit cards.

A full catalog of TTI publications and other products can also be found at <http://tti.tamu.edu/product>.