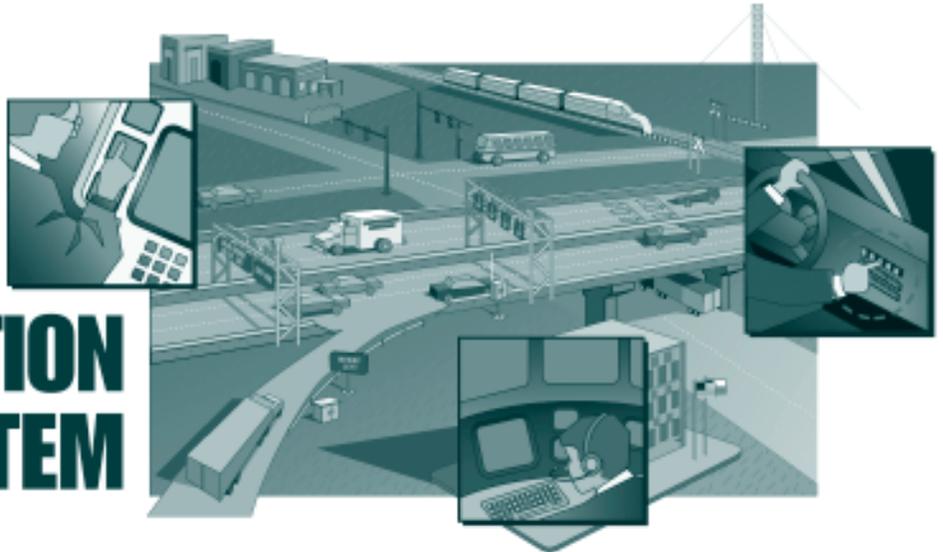


# Researcher

A Publication of the Texas Transportation Institute • Member of The Texas A&M University System • Vol. 37 • No. 2 • 2001

## A SEAMLESS TRANSPORTATION SYSTEM



*TTI's Intelligent Transportation Systems (ITS) research is directed toward easing congestion and improving emergency response*

### **The alarm sounds . . .**

*"Station 4. House Fire at 1910 Elm St. Engine 6 and Ladder 2 respond."*

*The firefighters at Station 4 immediately head for the trucks. In this business, a matter of minutes can mean the difference between life and death. The truck is almost there, only one block to go. As the truck approaches the last intersection, a train arrives, blocking the route. If the dispatcher had known exactly when the train would cross the intersection, the dispatcher could have directed the trucks to take a different route or may have been able to dispatch other trucks . . . but now, all anyone can do is hope for the best.*

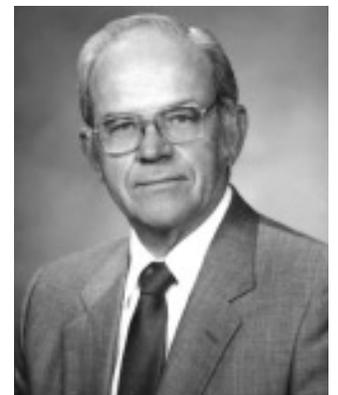
"Many of the transportation problems that we face in our

communities today stem from the fact that the transportation system does not operate as if it is one seamless system — as if it is under single ownership and management," says Tom Urbanik, associate agency director and head of the Transportation Operations Group (TOG) at Texas Transportation Institute (TTI). "For example, if fire dispatchers had a complete picture of the transportation system as the result of communication and information technology, we could save lives and property. If cities' traffic signal systems and the state's freeway management centers supported emergency vehicle dispatch, lives, time and money could be saved."

### **LINKING TRANSPORTATION ELEMENTS**

Intelligent transportation systems (ITS) establish ways for agencies to share information and work together to improve operational efficiency and safety of the entire system. In working toward this goal, TOG is developing

—continued on page 2



**Charley V. Wootan**  
**1926 – 2001**

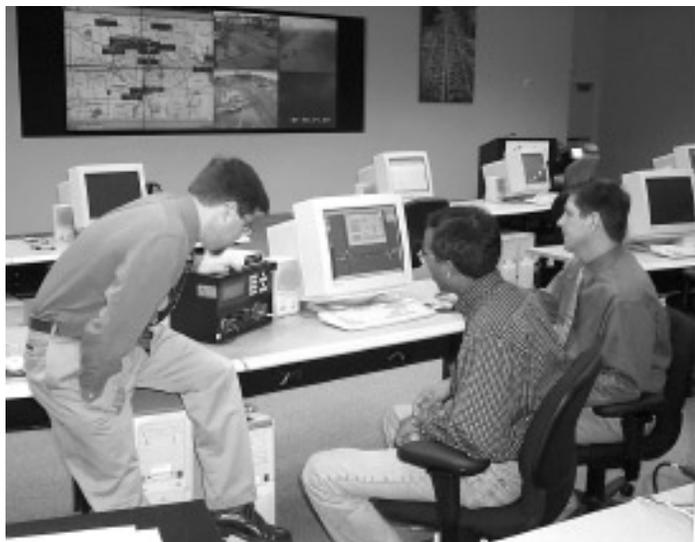
—see tribute beginning on page 7

### INSIDE THIS ISSUE

*Archiving  
ITS Data*

*Managed  
Lanes:  
the future  
of freeway  
travel*

*Dynamic  
Message  
Signs*



## Seamless transportation, cont.

innovative approaches for linking all elements of the transportation network.

Researchers have been studying methods of monitoring train movements and predicting arrival and departure times at highway grade crossings. This information is being used to better operate the traffic signals and improve emergency response.

Other areas of research focus on improving and enhancing roadway sensors, motorist information systems and incident management processes, and better coordination of ramp metering and traffic signal operation.

### TRANSLINK® LABORATORY

TTI's laboratory facilities, field test beds and research tools serve as settings for ITS research. One facility, the TransLink® Research Laboratory located in Texas A&M University's Research Park in College Station, Texas, is a state-of-the-art lab designed to promote and facilitate research and training in transportation operations. TTI researchers use TransLink to design, develop and evaluate new technologies and concepts for measuring and improving operations.

Through the use of simulation equipment and real-time connections to traffic management centers, researchers develop and test new concepts and strategies for managing almost every aspect of the surface transportation system, including:

- traffic signal systems
- highway-railroad grade crossings
- deployment of emergency vehicles
- transit operations
- freeway management

Once ideas are developed and tested under controlled laboratory conditions, they are taken to TTI's test beds for real-world refinement. This systematic approach provides products and methods ready for implementation. Trans-

Link facilities can also be used for professional development and training purposes following implementation.

### NEW ITS DIRECTIONS

TTI is pursuing new initiatives such as the Center for Transportation Infrastructure Management during Emergency (CTIME). The focus of CTIME is to optimize the use of the transportation infrastructure during major emergencies through the application of existing technology, development of new technologies and unified inter-agency response. This effort will focus primarily on two major areas of need:

- major military deployments
- natural disasters

Military branches continue to modernize, work toward improved efficiency and assume new responsibilities. These new responsibilities include the Army's recently established 96-hour deployment goal and the new Joint Task Force for Civil Support. Both of these new initiatives call for U.S. military personnel (in conjunction with numerous other agencies in the case of the latter example) to "do more with less," actively collaborate and cooperate with other operating agencies and integrate and/or exchange real-time data across physical and jurisdictional boundaries. ITS provides a means of accomplishing these goals in regard to transportation issues.

ITS research also responds to needs that arise as a part of hurricane evacuations. Roughly one out of every five Americans resides in an area at direct risk for hurricanes. The latest statistics indicate the number is rising, with an estimated 3,500 persons per day (fueled primarily by retiring baby boomers) relocating to at-risk coastal regions. Given these conditions, massive evacuations such as the one experienced during Hurricane Floyd in 1999 will become more commonplace. The evacuation

**The TransLink® Research Laboratory located at Texas A&M University is a state-of-the-art lab designed to promote and facilitate research and training in transportation operations.**



TTI Assistant Research Scientist Bob Brydia gives a presentation to TransLink partners on state-of-the-practice review of alternative methods of data entry.

(Opposite page, top and center photos) TransLink partners participate in a training session on railroad preemption.

(Opposite page, bottom photo) TransLink researchers preparing hardware-in-the-loop simulation experiment.

resulting from Hurricane Floyd was the largest evacuation in American history and involved an estimated six million people. ITS technologies tested in the lab can ensure smooth operations during these types of emergencies.

## IMPROVING THE FUTURE OF TRANSPORTATION

“Through these efforts and others, TTI research is contributing to development of a surface transportation system that operates seamlessly while maximizing the effectiveness and efficiency of the movement of people and goods,” says Urbanik. “Using intelligent transportation systems, we can make sure the correct people have the correct information to make the correct decision in a timely manner.”



For more information, contact **Kevin Balke** at (979) 845-9899 or [k-balke@tamu.edu](mailto:k-balke@tamu.edu)

# State officials honor ‘Father of Texas highway system’

On May 31, state transportation officials paid tribute to the man considered to be the father of the Texas highway system when they inducted Dewitt C. Greer into the Texas Transportation Hall of Honor.

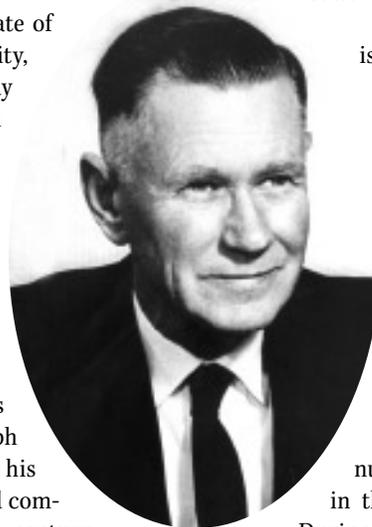
“The impact he had on the state’s transportation system — not just the on roads but on the industries that help build the roads — and the method and structure he used to put together this system were masterful,” Texas Transportation Commissioner Robert Nichols said during the induction ceremony.

Greer, a 1923 graduate of Texas A&M University, joined the Texas Highway Department in 1927 and served as the engineer-director of the department from 1940 until his retirement in 1968. He then became a member of the Texas Highway Commission from 1969 until 1981, serving under Governors Preston Smith and Dolph Briscoe. At the time of his death in 1986, Greer had completed more than half a century of service to the state.

“Mr. Greer spent the majority of his life developing, constructing, maintaining and administering over 72,000-plus miles of highway system in this state. He was dedicated to developing the best transportation system possible for the state of Texas,” said Luther DeBerry, retired director of the Texas Department of Transportation. “He not only served Texas, by developing a great highway system, he also touched the lives of people all over the world as an advisor on transportation. Leaders sought his ideas and advice.”

The Texas Transportation Hall of Honor recognizes individuals whose vision and leadership made possible the transportation system Texas enjoys today.

“Dewitt Greer was a man of exceptional honor, vision and integrity,” Texas Transportation Institute Deputy Director Dennis Christiansen said in announcing Greer’s selection. “All of us who travel the highways of Texas today have him to thank for the prosperity and quality of life those highways have brought to our great state.”



Greer was the chief administrator of the Texas Highway Department during the construction of the interstate highway system. The Colson-Briscoe Act, of which Greer was the chief architect, allocated funds for statewide farm-to-market roads. With the help of federal funds, the legislation enabled the department to nearly double the number of paved rural roads in the state within two years.

During Greer’s tenure, the number of miles of paved roads in Texas grew from 22,000 to more than 72,000.

Ray Barnhart, former member of the Texas Transportation Commission and former administrator of the Federal Highway Administration, noted, “It is fitting that Dewitt Greer be inducted into this hall of honor. For truly if ever a man’s life epitomized the meaning of that word, it was his. In the instance of the man called Mr. Greer, words such as honor, principles, integrity and dedicated public servant are not hyperbole. They were intrinsic to his being and to his leadership.”

# Innovative use of ITS technology reduces pavement damage and improves safety

A big rig driving at full speed down a rural highway approaches a traffic signal at an isolated intersection. The light turns yellow and the truck driver applies the brakes. Can the driver stop the truck in time? Will the truck jackknife or roll through the intersection instead of stopping safely? How much damage will the truck do to the highway pavement during the stop? A Texas Transportation Institute (TTI) project has provided a way to reduce problems associated with signalized intersections having high truck traffic.

“Pharr, Texas, District Engineer Amadeo Saenz was looking for ways to improve truck operations along the Texas-Mexico border,” says Tom Urbanik, TTI associate director. “We proposed the truck priority concept as a means to address several concerns of Mr. Saenz.”

In many cases, intelligent transportation systems (ITS) are providing just such a means of applying innovative solutions to chronic problems that have been difficult to solve with traditional methodology. The “simple solution” in this project was a way to reduce the number of stops trucks made at a rural traffic signal.

Minimizing the number of truck stops reduces pavement damage, lowers traffic delay for all vehicles and improves safety. Using a vehicle classifier connected to

a personal computer, researchers developed a system that detects when a truck approaches an intersection and relays that detection to the computer. The computer sends a message to the signal controller to take appropriate action, such as delaying a light change from green to red to give the truck time to clear the intersection safely.

TTI Assistant Research Engineer Srinivasa Sunkari and Hassan Charara, associate research scientist, headed up a project team that modified traditional classifier operation and installed a test unit at Sullivan City, Texas, near the state’s border with Mexico. The project has been selected for presentation at the annual meeting of the Institute of Transportation Engineers in Chicago this summer.

“A classifier traditionally stores information about vehicle classification for later download,” explains Sunkari. “What we did here was to get the classifier to report vehicle classifications immediately to a computer, which monitors and changes the signal operation where appropriate.”

The project found inductive loops connected to a classifier very accurate in detecting and classifying trucks and measuring their speeds. The resulting system cut the number of truck stops by at least four percent, resulting in reduced fuel con-

sumption and pavement wear and tear.

Since implementation of the North American Free Trade Agreement, some highways in Texas, particularly in border areas, have seen an increase in truck traffic. The concept developed and tested in this project provides a way to moderate some of the problems associated with this increase.

“This project broke ground because it was the first effort to look specifically at truck traffic in regard to this problem,” notes Sunkari. “A subsequent project now underway is looking at signal operations at isolated signalized intersections from an overall perspective, which will give us comprehensive data for continuing development and implementation.”

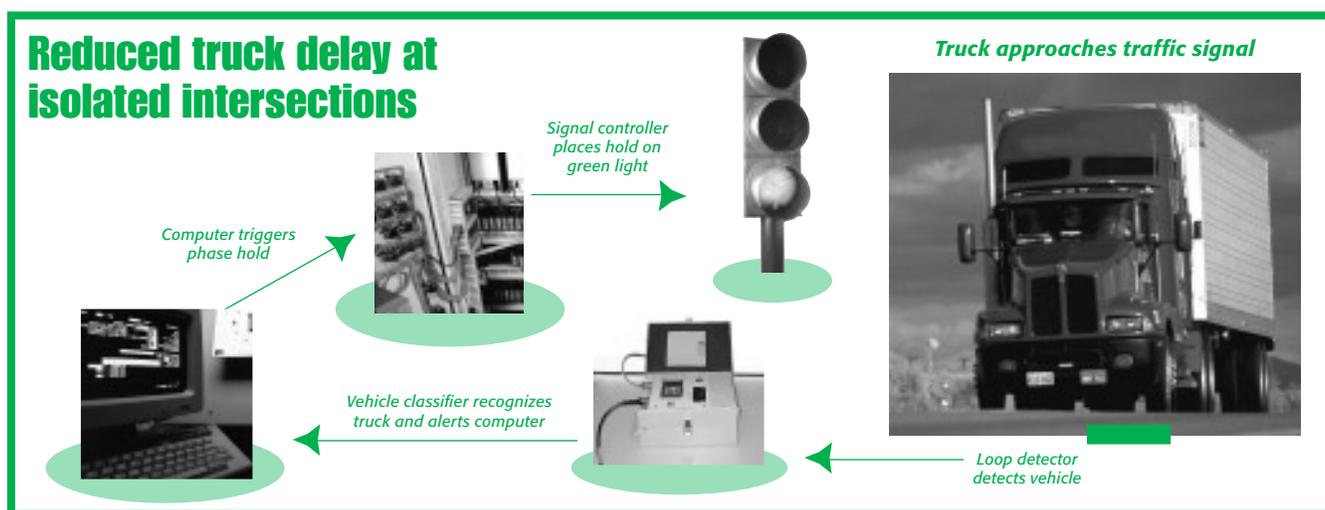


For more information, contact **Srinivasa Sunkari** at (979) 845-7472 or [s-sunkari@tamu.edu](mailto:s-sunkari@tamu.edu)

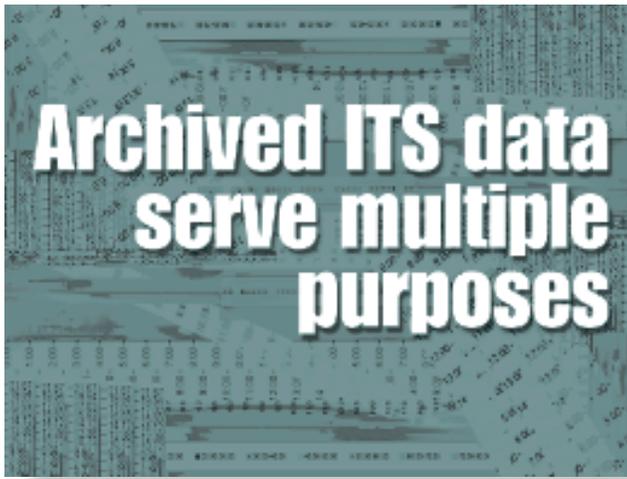


**Hassan Charara** at (979) 845-1908 or [h-charara@tamu.edu](mailto:h-charara@tamu.edu)

Related publication: Report 1439-8, *Reducing Truck Stops at High-Speed Isolated Traffic Signals*



Using a vehicle classifier connected to a personal computer, researchers developed a system that detects when a truck approaches an intersection and relays that detection to the computer. The computer sends a message to the signal controller to take appropriate action, such as delaying a light change from green to red to give the truck time to clear the intersection safely.



*Planning, designing and operating the transportation system are data-intensive sciences. Today's intelligent transportation systems (ITS) collect vast amounts of data to help transportation officials create the best system possible. Vehicle detectors, for example, collect information about vehicle volumes and speeds. Global positioning systems and radio/cellular phone triangulation determine vehicle location. Automatic vehicle identification systems collect travel times of vehicles. And the list goes on.*

Each year, the Texas Department of Transportation (TxDOT) and other agencies collect data from hundreds of sensors about travel times, vehicle volumes, speed, traffic mix and other aspects of travel. Typically, the data collected are used in "real-time" and then filed away or discarded and not used again. If the information could be reused for other transportation planning, design, operation and research needs, it would provide a base for multiple design and implementation needs.

New data archiving methods under investigation by the Texas Transportation Institute (TTI) provide a way to store, organize and access the wealth of transportation information collected by ITS equipment. The purpose of this research is to identify what types of data are already being collected that could be put to work in other areas of transportation system development.

### IDENTIFYING MULTI-PURPOSE DATA

"Our experience shows a demand for archived ITS data in a number of different types of analyses," says Shawn Turner, researcher on several TTI data archiving projects. "For example, TTI's Annual Mobility Report is just one of several transportation projects that will soon be using archived data" (see related story on page 14).

Researchers in TTI's TransLink® lab are developing possible ways to use stored travel data through a process called ITS Data Archiving. The work done at TransLink® has focused on providing general guidance in terms of what type of data might be saved, what level of detail to save and how to set up a database that is easily accessible. Once identified and organized, enormous amounts of information can be made available for utilization in the data-hungry science of transportation.

Archiving provides a cost-effective way to gather information that can be used for a number of purposes and make it accessible to those who need it. Transportation agencies can reuse data for numerous transportation planning, design, operations and research needs. Retrieving information from database archives can produce significant cost savings over having to re-collect even a small percentage of the data using manual methods or special studies.

### STORING AND ORGANIZING

Working cooperatively with traffic management centers, Texas A&M University departments, TxDOT districts and other groups, TTI researchers developed a prototype system that demonstrates techniques for archiving data. The prototype gives access to a test audience using the world wide web. As a result, several TxDOT districts and traffic management centers are beginning to archive data in a way that will permit access to a wide audience of transportation agencies.

The TransGuide® system in San Antonio archives ITS data, and TTI researchers worked with TransGuide to analyze data quality and determine how data could be archived more effectively. Houston TranStar® is in the process of developing a full-scale data warehouse accessible to other agencies, and several TxDOT districts are beginning projects to archive data and make it available through regional information clearinghouses.

"We see data archiving as a way to maintain information for planning purposes," says Natalie Bettger with the North Central Texas Council of Governments (NCTCOG). "It would give us access to regional information to feed into our planning models and validate our decisions." NCTCOG plans to test an archiving system this year that would collect information from some regional agencies — including TxDOT districts and the City of Fort Worth.

### MAKING DATA ACCESSIBLE

If archiving ITS data is such a good idea, why isn't it being done everywhere? Data archiving has been limited due to a number of factors, including:

- **Data quality.** To be useful, archived data must meet certain standards for quality, weeding out suspect or erroneous data, missing data and inaccurate data.
- **Compatibility.** Compatibility problems exist among methods and software used to store data in different agencies and workgroups.
- **Distribution.** Until recent advances in the use of computers, the internet and world wide web, distribution of and access to data — even when archived — were difficult.
- **Proprietary concerns.** Data ownership, maintenance or control claims may cloud the issue.
- **Resource allocation.** Archiving takes additional time that must be accounted for in planning efforts and budgets.
- **Awareness.** Project managers may not recognize the utility of their data to other applications.

The TransLink project deals specifically with resolving problems associated with data quality, compatibility and distribution.

"The ultimate aim is to have a system that will let transportation professionals use archived ITS data to make better decisions and communicate information to the public," says Turner. "These systems give us an effective way to provide more predictive, more personalized traveler information and make better decisions about managing existing facilities or investing in a wide range of infrastructure improvements."



For more information, contact **Shawn Turner** at (979) 845-8829, or [shawn-turner@tamu.edu](mailto:shawn-turner@tamu.edu)

# Researchers recommend “quick fix” for safer rail crossings

It’s the stuff of the movies — the hero’s car is stuck on the railroad tracks with the oncoming train looming large. In Hollywood, the hero always gets off the track and out of the train’s way in time, even if his car doesn’t. Outside of Hollywood, though, cars trapped on the tracks with an oncoming train are in very real danger. In 2000, in Texas alone, 52 people died and 163 were injured in vehicle/train crashes. One potential cause of these crashes could be a phenomenon known as the “preempt trap.”

Texas Transportation Institute (TTI) researchers, working through the TransLink® Research Program, are investigating and developing solutions to the problem and have recommended a “quick fix” to the Texas Department of Transportation (TxDOT).

## What is the preempt trap?

When a train approaches a highway-railroad grade crossing, the computer controlling a nearby traffic signal receives a “preempt” call. This “call” starts the traffic signal sequence that is designed to clear vehicles from the railroad tracks and allow for the safe passage of the train. The track clearance phase — the green light that clears vehicles from the railroad tracks — ends, ideally, after the warning lights have flashed for a few seconds and the crossing gate arms have just descended to a horizontal position.

A preempt trap occurs when the green light to clear the railroad track ends before the warning lights start to flash and the crossing gate

arms start to close. Because the warning lights have not been activated and the gates are still vertical, vehicles can continue to cross and become trapped on the railroad tracks in the path of the approaching train.

## What’s being done to prevent preempt traps?

In November 1999, TTI TransLink® researchers began research into the causes and possible solutions to the preempt trap. According to Roelof Engelbrecht, lead researcher, there are guidelines available that address traffic signal preemption. However, these guidelines usually do not address the effect of variations in warning times or train arrival times.

“Engineers usually design for the worst case scenario — what happens if the train arrives at the earliest expected time. But that approach doesn’t consider what happens if the train slows down and arrives later than expected, after the track clearance phase is complete. That kind of gap can create the preempt trap,” said Engelbrecht.

## What’s the quick fix?

As a short-term solution, researchers have discovered a quick fix. “If you extend the track clearance green phase, at least until the gate arms start to descend and, ideally, until the gates block the path of approaching vehicles, says Engelbrecht, “you reduce the probability of the preempt trap.” A good rule of thumb is that the track clearance green duration should be equal to the expected advance preemption time — plus 15 seconds. Of course, there are no guarantees with this strategy because of train speed variations, but it is based on federal grade-crossing requirements and is a good interim prevention measure. TTI is proposing additional research to investigate more long-term solutions to prevent the preempt trap and its resulting dangers from occurring.

“We hope that future research in this area will result in a more guaranteed solution,” says Engelbrecht. TxDOT is currently reviewing the research findings for possible further research and future implementation in the districts.



Vehicles can become trapped on railroad tracks if the green light ends before warning lights flash and the crossing gate closes.



For more information, contact **Roelof Engelbrecht** at (979) 862-3559 or [roelof@tamu.edu](mailto:roelof@tamu.edu)

---

# Charley V. Wootan

*A Lifetime in Transportation*

*A life well lived*

---



---

**1926 – 2001**

---

*“He was among the few people I have known who never said a superior word to me. He thought more of me than I deserved, and that made me behave better than I naturally wanted to.”*

*– paraphrased from *The Virginian*  
by Owen Wister*

---

## A tribute to Charley Wootan

Texas and the nation lost one of its greatest citizens March 24, 2001. A giant in the field of transportation, a devoted family man, an influential mentor and educator, a beloved friend to so many—Dr. Charley Wootan, director emeritus of the Texas Transportation Institute (TTI), passed away at his home after a long battle with cancer. Dr. Wootan's accomplishments in the transportation and education communities, and his outstanding human character, are best illustrated by the heartfelt words of his friends and colleagues as they have shared their thoughts and memories through a remembrance page on the TTI web site (<http://tti.tamu.edu>). His lifetime contributions to the state of Texas and the nation are so massive in number and significance—they could easily span a book. A standard profile article in this newsletter really cannot do him justice. So using the words of those who knew and loved him, and historical photos collected here at TTI through the years, this feature presents an overview of his career in transportation and education, what he did for TTI, and who he was as a person. Our hope is that it will stand as a tribute to Dr. Wootan, his family and his memory.



## In honor of his memory

Father of 2. Grandfather of 5. Beloved husband of 50 years to Doxie. Golfer. Fisherman. Hunter. Gardener and expert steak connoisseur. Hundreds attended Dr. Wootan's funeral services on March 27, as well as an April 24 memorial celebration of his life. There, Dr. Herb Richardson presented the Wootan family with a resolution from the Senate of the State of Texas, 77th Legislature extending its sincere condolences to the bereaved family and stating that when it "adjourns this day it will do so in memory of Charley V. Wootan." Speakers included former engineer-director of TxDOT Mark Goode, current Executive Director Wes Heald, Director of the Transportation Research Board's (TRB) Cooperative Research Programs, Bob Reilly, and five longtime TTI employees, many of whom worked with Wootan for over 25 years.



In his closing remarks, Dr. Dennis Christiansen, TTI deputy director announced the creation of the Charles J. "Jack" Keese – Charley V. Wootan Memorial Fellowship Fund (see related item on p. 11). He also shared the contents of a letter from John W. Johnson, chairman of the Texas Transportation Commission:

"Texas owes a great debt of gratitude to Charley. We are proud of our transportation system and we know that it is a system without peer. We should be — and are equally proud — of the selfless role that people like Charley Wootan played in making it so . . . We will miss Charley, and on behalf of the Texas Transportation Commission and the Texas Department of Transportation, thank you for sharing him with us."

## PERSONAL THOUGHTS ...

*Too many times, great men who make great accomplishments in this life become prideful and unapproachable. Charley was never guilty of these faults. He was as humble and approachable as anybody I have ever known. . . . He was one of the finest men I have ever known. My prayers go out to Doxie and the family for that comfort which only God can provide.*

—Joe Button, division head, Texas Transportation Institute

*Most of us thought of Charley as a member of the department . . . His participation on a national scale brought to us a broader and more up-to-date knowledge of transportation research.*

—Mark Goode, former engineer-director, Texas Department of Transportation

*It was Charley's constant pleasant and positive approach to daily events that I most readily recall. Most memorable are the mentoring efforts he provided to me. . . His words and wisdom often helped guide my professional development decisions. His willingness to assist so many, so readily, so freely, demonstrates the impact his life has had on those he touched.*

—John Mason

He encouraged without commanding, he made one find their best without imposing, and he expanded horizons without imposing his own. He was the gentlest person and manager I have ever known. It was difficult to discern where Charley the boss stopped and Charley the friend began. To him there was no difference, he was the same in every circumstance. I do not think he ever recognized any difference between management and friendship. That attribute, I think, was why he had the respect of everyone that ever encountered him. I will miss him, as all do . . .

—Sadler Bridges, special assistant to the agency director, Texas Transportation Institute





*Knowing Charley Wootan has been one of the great pleasures of my now very long career in transportation. We worked together on many occasions and he would always move things along with a smile rather than a fist! He was central*

*to the CUTC (Council of University Transportation Centers) founding and growth. He was a pivotal figure for me as we worked to start PTI (The Penna. Transportation Institute.) When I wanted career guidance, I could, and did, call – knowing I would get honest, no-varnish advice (and even over the phone I could see the twinkle in his eyes!). Perhaps what I want to say most is that his was a life well lived. We should all take lessons, and hope to approach the living of just such a life.*

**—Tom Larson, former administrator, Federal Highway Administration**

*I have many good memories of Charley Wootan, both personally and professionally. He was one of those rare personalities that perhaps come along once in a lifetime. Professionally his contributions to transportation were extremely important to TxDOT and to the citizens of Texas. Equally important, and perhaps more significant, was how his personality influenced so many people. Charley had a warm friendly disposition, wit, humor, integrity, was respectful to others and always had such a positive attitude. Time seems to fade many memories, but I will always remember Charley Wootan as Mr. TTI.*

**—Charles W. Heald, executive director, Texas Department of Transportation**

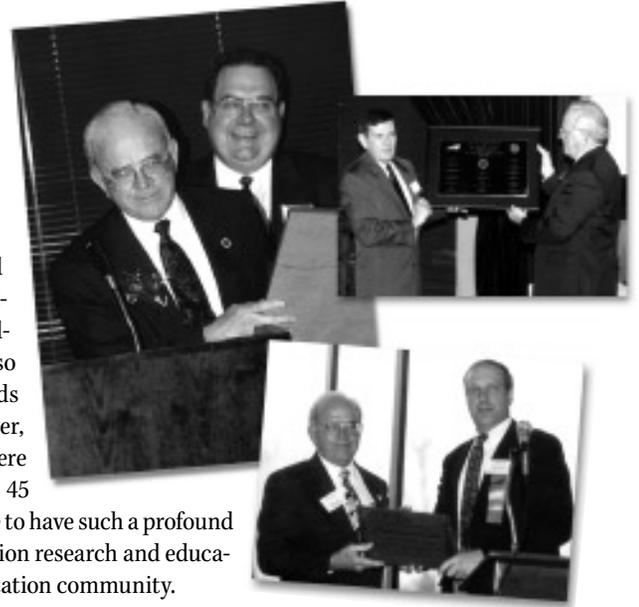
*Since becoming active in the early 1960s, Charley held virtually every volunteer leadership position Transportation Research Board (TRB) has, and he earned our top awards. Charley was talented and hardworking, but he was so much more. An unassuming member of the Greatest Generation, Charley was remarkable for his generous spirit, quiet confidence, and good humor. When Charley took on an assignment for TRB, we knew we were fortunate; now we are fortunate to have so many unforgettable memories of him.*

**—Bob Skinner, Executive Director, Transportation Research Board**

## *A Friend and Mentor*

Education was at the heart of almost everything Dr. Wootan did. He was a firm believer in the value and importance of a good education. In fact, by 1991, throughout his service to TTI, over two thousand Texas A&M students had worked on TTI research projects. Since 1983, he served on the boards and in leadership positions for the Greater Texas Higher Education Authority, Greater East Texas Higher Education Servicing Corporation, and the Texas Guaranteed Student Loan Corporation.

He was a friend to so many—probably too many to count. What is amazing is the number of people who worked with and for him who considered him, not only a boss, a colleague, and an advisor, but also a very good friend. Their words speak volumes about his character, why he was able to take TTI where he did, and how, throughout his 45 years in the business, he was able to have such a profound impact on Texas, on transportation research and education, and on the entire transportation community.



## *A Visionary*

TTI was not the only organization to benefit from Dr. Wootan's involvement. He took the concept of a cooperative research program between universities and state departments of transportation and, working with the Texas Department of Transportation, saw that become a national model of how DOTs and universities can work together to solve transportation problems. Charley Wootan tirelessly contributed invaluable service to many national transportation associations and organizations throughout his career. He served as chairman of TRB executive committee in 1980 and continued accepting chairs and task force memberships over the twenty years following.

Charley was an idea guy. In 1963 he had the idea for holding a refresher seminar for members of the International Right of Way Association (IRWA). He got the right people together, made it happen and directed an annual gathering of land acquisition agents, public utilities and railroad companies from all over the world.

“Dr. Wootan was an integral part of the IRWA for so long that, when he retired, we could not imagine the A&M Seminar without him. He was always there to greet us with a friendly smile and we looked forward to his welcome at the opening ceremony each year,” said Rita Cavaness, IRWA Region 2 Chair. Dr. Wootan was also partially responsible for the idea of a Council of University Transportation Centers (CUTC). He, along with former Federal Highway Administrator Tom Larson and others, was involved in creating, nurturing and growing CUTC, and twice over the past 25 years served as its president.

At the 2001 TRB Meeting, CUTC honored Charley Wootan with its prestigious Career Achievement Award presented to those who have made a distinguished contribution to university transportation education and research. Tom Larson remarked that “Charley Wootan is the model of leadership. His career and life define it. He believes in and demonstrates hard work, he has vision, and he knows how to make that vision reality.”



## The early years at TTI

A marine during World War II and a 1950 and 1951 graduate of Texas A&M University, after working in New York for a few years, Charley Wootan returned to his alma mater in 1956, joining the newly established Texas Transportation Institute as an associate research economist and project leader. He was a key player in the Institute's early commodity studies and conducted valuable economic research on the effects of the interstate highway system in Texas. It didn't take Charley long to rise to the top, as he became division head of transportation economics and planning at TTI in 1961, and then associate director of the institute and professor of economics at Texas A&M in 1965. He also played a key role in strengthening TTI's cooperative relationship with the Texas Department of Transportation (TxDOT) as he took on the job of program coordinator of the Annual Transportation Short Course put on by TTI and TxDOT.

"Most of us thought of Charley as a member of the department ... His participation on a national scale brought to us a broader more up-to-date knowledge of transportation research," said Mark Goode, former engineer-director, Texas Department of Transportation.

## A Leader

Filling the shoes of former TTI Directors Fred Benson and Jack Keese would seem an impossible task for many, but Charley Wootan had no problem with it when he took the reigns in 1976. Bringing a non-specialist's eye to the engineering-dominated organization, his training as an economist helped him appreciate both the actual and hidden costs of research and its implementation. He firmly believed that all facets of transportation needed investigation, and he brought credibility to this belief through his remarkable understanding of complex engineering concepts—despite his lack of formal training in that area—and his insight into the scientific and technical challenges of research. This, along with his perpetual positive attitude and caring, "hands-off" managerial style, earned him the employee respect and motivation that was a large part of why TTI became the fastest-growing university-based transportation research organization in history. When Dr. Wootan retired in 1992, TTI was ranked the largest and one of the finest transportation research centers in the country. He served as director of TTI throughout a turbulent era in transportation research, a time of increased competition and legislative battles for research funding. Despite that, during his tenure as director, TTI's research budget grew from 3.9 to 18 million a year—a rate in excess of 10 percent a year for 17 years. TTI also received patents on eleven innovations.



## SHARED MEMORIES ...

*Dr. Wootan's style of leadership encouraged and motivated those around him. He was a man of character and he led by example. Whether he was on the mountain peak of success or near the valley of defeat, he always kept his positive attitude and his sense of humor. Those who had the privilege to work closely with him knew by the sparkle in his eye that he loved life. His chuckle and his laugh told us he loved being with people. When he spoke, we knew to listen carefully or we would miss some good advice or an interesting story. His presence will be sorely missed, but he left us a legacy for how to spend a worthwhile life.*  
—Marie Schoeneman, fiscal officer, Texas Transportation Institute

*While searching for a good doctoral program in 1978, I visited five very good universities. During my TAMU visit, I was talking to faculty members and graduate students when Charley Wootan stopped me in the hallway. In a three minute conversation he quickly put me at ease, found out what I needed, and made me an Aggie forever. These three actions describe him completely. He cared about people, and he loved TTI and TAMU. Those of us whom he helped loved him in return.*  
—Dan Turner, director, University Transportation Center for Alabama

*I came to Texas A&M University on August 15, 1978. At that time the package deal for young professors was a dictionary and a calculator, and only a meadow existed where the CE/TTI building stands today! I met Charley Wootan shortly after my arrival and have worked with him and TTI ever since. He has always struck me as someone who had this rare gift of generating a balanced atmosphere of serious business attitude and caring relaxed attention among the people surrounding him. At the same time, he always had this happy smile on his face which made you wonder what he had up his sleeve. It has always been a pleasure for me to work with him and the organization that he managed so well. On the road of life, some things are worth the stop, some are worth the detour, and some are worth the trip. For me, working with Charley and TTI has definitely been worth the trip from France.*  
—Jean-Louis Briaud, research engineer, Texas Transportation Institute

*He was largely responsible for attracting literally hundreds of researchers with national and international reputations to come to work for the Texas Transportation Institute. A great many of these people could have worked anywhere they desired, often at higher compensation levels, but they chose TTI, and a big part of the reason for that choice was our director, Charley Wootan. For some of us, we ended up spending our lives and careers in College Station, something that never would have happened had it not been for Charley. . . . He will be missed as a leader in the field of transportation and as a very close friend and advisor.*  
—Dennis Christiansen, deputy director, Texas Transportation Institute





### *TTI Remembers Charley*

On April 24, TTI colleagues and others from the local community held a special memorial service celebrating Charley's life and career.

It is clear that Charley's legacy will continue to improve our world through the ideas and characteristics that he shared with family, friends and colleagues.



*I learned a great deal from my association with Charley. On many occasions over the years I sought his advice and guidance. I thought of him as a mentor or someone I could approach on any issue within our profession. He earned the respect and admiration of all who knew him. He was an outstanding ambassador for TTI and Texas A&M University and a great Texan who I will long remember.*

—C. Michael Walton, Ernest H. Cockrell Centennial Chair in Engineering

*While no words can express my true feelings at this difficult time for all of us, I want you to know that Dr. Wootan had a tremendous influence on my life. He was a sort of administrative mentor for me when I was developing the Transportation Studies Program at Texas Southern University. I learned so much from him through his informal counseling about transportation education and research. He was a respected and influential leader in the transportation community ... One of the best! I will miss him ...*

—Naomi Ledé

*Dr. Wootan was an integral part of the International Right of Way Association for so long, that when he retired, we could not imagine the A&M Seminar without him. He was always there to greet us with a friendly smile and we looked forward to his welcome at the opening ceremony each year.*

—Rita Cavaness, International Right-of-Way Association (IRWA) Region 2 Chair

## CHARLES J. "JACK" KEESE-CHARLEY V. WOOTAN MEMORIAL FELLOWSHIP FUND

Over the past year both Jack Keese and Charley Wootan have passed away. This is a great loss to the Texas Transportation Institute (TTI) and the entire transportation community. These individuals served as Director of TTI for over three decades, and both remained active in Institute and transportation activities until the time of their death. They both held the title of Director Emeritus.

Jack and Charley were Texas A&M alumni, and they both joined TTI in the early 1950s. Jack served as Director of TTI from 1962 to 1976, and Charley led the Institute from 1976 to 1993. During this period, the size and stature of the Institute's programs grew massively. These individuals, working closely with TxDOT, were instrumental in developing and expanding the cooperative research program that has become the model followed by many other states.

In recognition of the tireless and effective work performed by these two close friends, TTI, with support from the A&M Foundation, has established the Charles J. "Jack" Keese-Charley V. Wootan Memorial Fellowship Fund. This permanent fund will be managed by the Texas Transportation Institute and will be used annually to provide a fellowship to a graduate student employed by TTI.

Donations to the fund can be submitted through TTI's web site. Both the Keese and Wootan families will be notified of each gift, and you will receive a receipt for your tax records.

[http://tti.tamu.edu/keese\\_wootan.stm](http://tti.tamu.edu/keese_wootan.stm)

Keese-Wootan Memorial Fellowship Fund  
Texas A&M Foundation  
401 George Bush Dr.  
College Station, TX 77840

# Managed Lanes

## *The future of freeway travel*

The Katy Freeway — Houston. LBJ and Central Expressway — Dallas. IH35 — San Antonio. Loop 1 and IH35 — Austin. They are a few among the many major freeway systems in Texas that are experiencing tremendous growth. Over the last ten years, in an attempt to combat the enormous increase in traffic demands, transportation professionals have been struggling to find new and innovative ways to make them operate more efficiently and handle this growth.

While adding lanes seems like a logical solution, making



**A comprehensive Managed Lanes Manual for TxDOT engineers will cover how to plan, design and operate a managed lanes facility.**

something bigger isn't always better. Today, construction costs, land consumption, neighborhood impacts and other environmental issues are major concerns in developed urban areas and often necessitate practical limits on freeway expansion projects. Adding high-occupancy vehicle (HOV) lanes or other special-use lanes is generally a viable option and does improve traffic flow at certain times of the day. But how can we maximize the effectiveness of those lanes throughout the entire day? How can we encourage travelers to use the lanes when it would best benefit them? Who should use the lanes and when? How can different vehicle groups be permitted access to the lanes on a real-time basis without creating congestion? How do we communicate the rules on usage and make sure travelers follow them? What

technologies could enhance the operation of the lanes, as well as the overall traffic flow of the entire freeway system?

These are some of the questions being addressed by a cross-disciplinary team of Texas Transportation Institute (TTI) researchers working on a multi-year effort to assist the Texas Department of Transportation (TxDOT) in optimizing the performance of freeway managed lane facilities. The project entitled Operating Freeways with Managed Lanes is a joint effort with Texas Southern University (TSU) and involves 24 tasks designed to investigate all of the issues surrounding the use of managed lanes in an urban area. The key product to emerge will be a comprehensive Managed Lanes Manual for TxDOT engineers. The manual will cover how to plan, design and operate a managed lanes facility, as well as adapt that facility to meet the changing mobility needs of a region over time.

"We're addressing very complex issues," says Beverly Kuhn, a TTI research supervisor heading the project. "Making a managed lane facility really work effectively involves multiple areas — planning, design, operations, Intelligent Transportation Systems (ITS), enforcement and safety. Everything is interrelated, and everything has an effect." The user group of a lane may drive the geometric design, which will influence the signs and markings and involve numerous safety issues. Multiple user groups may drive operations decisions and ITS needs.

According to Gary Trietsch, Houston district engineer for TxDOT, "flexibility is an important factor in optimizing mobility for targeted users of the managed lanes." For instance, if an incident occurs on the freeway main lanes, and opening the managed lane to another user group during that time would improve traffic flow, then traffic engineers need to be able make the switch, and

there needs to be a way to smoothly implement the change. "We plan to provide a multi-dimensional decision matrix that will show how to incorporate flexibility into a facility to allow that to happen."

In the first year, the research team is producing a thorough review of current practice and state-of-the-practice literature. In addition, a symposium held in February in Austin was very successful with over 90 professionals from across the state attending the one-day event featuring experts from Texas and around the country. "We wanted to begin generating a dialogue between all the potential partners, as well as provide insight into managed lanes operations," says Ginger Daniels, the TTI co-research supervisor for the project.

Other tasks that are underway include the use of simulation technology to analyze operational scenarios based on user groups, development of a concept marketing strategy and recommendations for geometric design of managed lanes. The project team is also hosting a web site (<http://managed-lanes.tamu.edu>) and publishing a quarterly newsletter to document lessons learned as the research progresses.

Carlos Lopez, director of traffic operations for TxDOT and project director for the managed lanes project, believes that "the results from this project will be of great benefit to TxDOT in handling the ever-increasing challenge of providing efficient transportation systems and serving the mobility needs of Texans in the future."



For more information, contact **Beverly Kuhn** at (979) 862-3558 or [b-kuhn@tamu.edu](mailto:b-kuhn@tamu.edu)



**Ginger Daniels** at (512) 467-0946 or [gingerdaniels@tamu.edu](mailto:gingerdaniels@tamu.edu)

# Researchers study changeable message format

NEXT RAMP CLOSED

290 RAMP CLOSED AUG 25-26

US 290 EXIT CLOSED MON-WED

Dynamic message signs (DMS) are a key component of intelligent transportation systems (ITS). Often called changeable message signs or variable message signs, DMSs display computerized messages customized to localized roadway conditions. Their effective use depends on proper sign design, placement, message design and display conditions.

DMSs convey vital information to motorists. At construction sites or during incident management, driver understanding is essential to safe and efficient travel.

## RESEARCH OVERVIEW

“We looked at specific message design and operation issues in order to determine the best approaches for TxDOT districts to take with respect to designing and using messages,” says Jerry Ullman, principal investigator on one of Texas Transportation Institute’s projects studying DMSs. “Then we developed standards and guidelines for DMS use at traffic management centers.”

As one road to discovering the best approaches, researchers conducted human factors studies in Austin, Dallas, El Paso, Fort Worth, Houston and San Antonio. They also convened a TxDOT project advisory panel to select specific questions about DMS operation and used interviews and simulations with motorists from across the state to gauge recall and comprehension of information contained in test messages.

DMS operators need ways to shorten messages so that relevant driver information fits within the limits of DMS space. Some portable DMSs limit messages to as few as eight characters per line. With spaces that tight, meaningful abbreviations can spell the difference between understanding and confusion.

“It’s important that sign messages be designed so that they will be interpreted accurately and quickly by motorists,” emphasizes Ullman.

*Which one of these messages is easiest to understand? Even simple ideas can be difficult to communicate to drivers moving at highway speeds when messages are restricted in character length. Finding out driver perceptions of phrases like the ones above helps transportation system managers effectively communicate travel information to the driving public.*

## FINDINGS

In some cases, project findings were surprising. While it might seem logical that calendar dates would provide the clearest communication, findings show that drivers understand messages better when they refer to weekday descriptions. Tests showed that fewer than one-fourth of Texas motorists understood when future roadwork was to occur if calendar dates were used. On the other hand, more than three-fourths understood days of the week.

In another discovery, the project found that flashing all or parts of the message did not make drivers pay more attention or give more importance to the sign – but did lengthen reading time. In tests, flashing a DMS message resulted in significantly longer reading times than when the same message was not flashed, revealing to researchers that more information can be displayed on a steadily lit sign.

*Other findings showed:*

- Actual days of the week (SUN-SAT) should be used for work activity that will occur within the upcoming week and instead of the term “FOR 1 WEEK.”
- The term “WEEKEND” should be used only if the work will start on Saturday morning and end by Sunday at midnight.
- When displaying current travel times on DMSs, the time of day that the travel

time was measured should be included (TRAVEL TIME TO DWNTN – 20 MIN AT 7:20 AM).

- The word “EXIT” should be used rather than the word “RAMP” when referring to an exit ramp on a freeway.

- Route or interstate designations (I-, US, SH, FM) should be used along with numbers when referring to roadways.

- The term “HEAVY CONGESTION” can be used to indicate conditions that involve more than 35 minutes of delay or downstream operating speeds less than 25 mph. The term “CONGESTION” conveys less severe conditions.

- DMS operators should use one-frame messages whenever possible and limit the use of two-frame messages.

Of the messages shown at the beginning of this article, most drivers would find “US 290 EXIT CLOSED MON-WED” easiest to understand based on project findings.

Research yielded specific recommendations about more than 40 abbreviations, combinations, appropriate terms and operating practices like the ones listed above. Researchers combined recommendations from this project with those of past studies into a set of DMS operating guidelines for use in traffic management centers throughout Texas.

“TxDOT is considering adopting the guidelines we developed in this project,” explains Ullman. “TTI will continue to work to find ways to help transportation professionals operate dynamic message signs so that they speak the same language as the motorists who read them.”

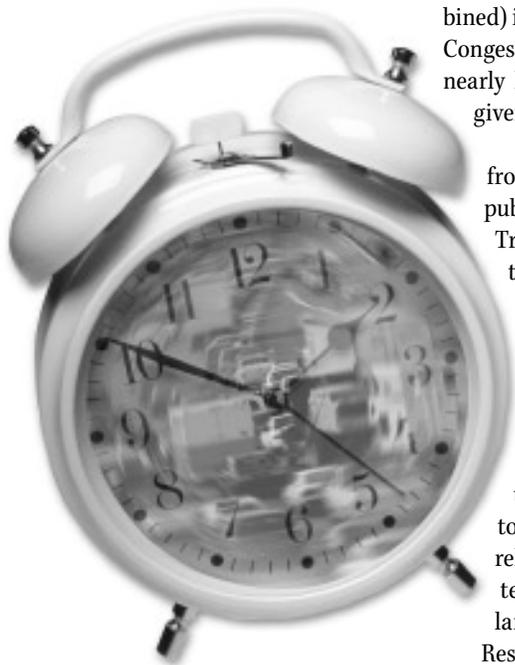


For more information, contact **Gerald L. Ullman** at (979) 845-1728, or [g-ullman@tamu.edu](mailto:g-ullman@tamu.edu).

Related publication: Report 1882-S: *Improving Dynamic Message Sign Operations*

# RUSH HOUR?

## *Annual traffic study shows it's neither*



The last time that “rush hour” actually lasted that long, Richard Nixon was President, lava lamps were popular (the first time around) and Rowan & Martin’s “Laugh-In” was the hottest show on TV.

Things — including traffic — have truly changed since 1970. In fact, the timeframe we refer to as “rush hour” in the nation’s major cities has doubled in less than 20 years, increasing from nearly three hours (morning and evening combined) in 1982 to almost six hours in 1999. Congested travel periods today consume nearly half of the daylight hours in any given workday.

That’s one of several findings from the 2001 Urban Mobility Study, published in May by the Texas Transportation Institute (TTI). In the annual study, TTI researchers David Schrank and Tim Lomax use a variety of measures to illustrate the nation’s growing traffic problem. The findings provide elected officials, policy makers and everyday commuters a collection of easily understood measures to support local decision making related to freeway and street systems, as well as a variety of other land-use issues.

Researchers say there’s no single solution to the worsening problem of traffic jams.

“Widening roads is part of the solution, but it’s only one of many elements

we need to address the problem,” Lomax says. He and Schrank stress that other means — including demand management, operational efficiency improvements and better management of construction and maintenance projects — must also be employed as part of an overall mix of solutions.

The report illustrates trends from 1982 through 1999, and this year’s statistics include a wide variety of findings from the 68 urban areas studied:

- Average rush hour delay is 36 hours per person per year.
- The average rush hour trip takes 32 percent more time than the same trip taken during non-rush hour conditions.
- The cost of traffic congestion nationwide totaled \$78 billion, representing the cost of 4.5 billion hours of extra travel time and 6.8 billion gallons of fuel wasted while sitting in traffic.

This year’s report is the product of a cooperative effort involving TTI and eleven state departments of transportation. Researchers are already looking toward development of next year’s mobility study analysis. The 2002 Urban Mobility Study will be the first one to use archived data (see related article on page 5).

Because archived data provide continuously collected statistics, researchers expect to be able to identify congestion more precisely. For example, next year’s report may be able to measure congestion by roadway or day of the week.

“Mobility studies so far have used averaged data for comparisons. Continuous data will give us more location-specific and time-specific information to work with,” says Shawn Turner, TTI researcher.

“Improvement decisions are typically made at the corridor level — so having detailed data at that level is very valuable,” adds Lomax.

---

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

**David Schrank** at (979) 845-7323, or [d-schrank@tamu.edu](mailto:d-schrank@tamu.edu)

Related publication: *2001 Urban Mobility Report*



*TTI researchers David Schrank (left) and Tim Lomax produce the Urban Mobility Study each year that provides elected officials, policy makers and everyday commuters a collection of easily understood measures to support local decision making related to freeway and street systems, as well as a variety of other land-use issues.*

**NATIONAL ACADEMY OF ENGINEERING HOLDS REGIONAL MEETING**

Some 47 members of the prestigious National Academy of Engineering (NAE) attended a regional meeting at the George Bush Presidential Conference Center on March 19. The gathering was hosted by Texas A&M University's Engineering Program and the University of Texas (UT) at Austin and included a mini-symposium entitled "Creating the New Economy — Enhancing Our Lives."

In his presentation on the Academy's role in our society, Dr. William Wulf, NAE president, said that only about one in every 1,000 engineers is elected to membership. Wulf also noted that the Academy's purpose is "telling the truth to power" by providing unbiased and authoritative reports to the federal government on critical science, technology and engineering issues. "This regional meeting was one of the

largest and most successful in NAE history," Wulf added.

Prior to their meeting, NAE members toured the Bush Library and Museum, Texas Transportation Institute's Trans-Link® Research Center and Driver Simulator, and the Offshore Technology Research Center.

In the afternoon, symposium speakers covered a range of technical topics. Dr. Yale Pratt, professor of electrical and computer engineering at UT-Austin, and Dr. Sanjay Banerjee from the UT Microelectronics Center spoke on future trends in computers and communications. Mr. Walter van de Vivier, president of Shell Exploration and Production Company, and Mr. Erle Nye, chairman and CEO of TXU Corporation, presented energy issues. Mr. Tom Larson, former

Federal Highway Administration (FHWA) administrator, and Dr. William Powers, formerly vice-president for research for the Ford Motor Company, covered transportation mobility, safety and sustainability. Panel discussions followed each session.

*Some 47 members of the prestigious NAE attended a regional meeting at the George Bush Presidential Conference Center in March.*



**TOM URBANIK RETIRES**

After nearly 25 years with TTI, Tom Urbanik has announced that he will be retiring from the Texas Transportation Institute (TTI) at the

end of June. Tom and his wife Cindy will be moving to the University of Tennessee, where Tom will become a chaired professor. It is an exciting career opportunity, and Tom will have the opportunity to contribute meaningfully to a number of programs at the University of Tennessee.

"Tom Urbanik has done an exceptional job of providing leadership and vision to the TTI research program for nearly 25 years," said TTI Deputy Director Dennis Christiansen. "He has the ability to understand both the technical detail and to see the 'big picture.' His contributions to both the Transportation Operations Group and the leadership of TTI have been greatly appreciated and will be missed."

**SUBSCRIPTION UPDATE** *To change your subscription or to be added to the mailing list, please fill out this form and mail or fax to the address or number in the shaded box.*

name \_\_\_\_\_

title \_\_\_\_\_

company \_\_\_\_\_

address \_\_\_\_\_

city/state/zip \_\_\_\_\_

phone/fax \_\_\_\_\_

e-mail \_\_\_\_\_

comments \_\_\_\_\_

**ORDERING INFORMATION**

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

Include name and address of recipient. Prices include shipping and handling when mailed in the U.S. Texas residents are required to add 8.25% sales tax or enclose a tax-exempt form with the order. Send a check or money order (in U.S. funds and through a U.S. bank) payable to **Texas Transportation Institute** to the address below.

For international orders, write or fax (979) 862-3703 to determine the air-mail shipping charge.

**Information & Technology Exchange Center**  
**Texas Transportation Institute**  
**The Texas A&M University System**  
**3135 TAMU**  
**College Station, TX 77843-3135**

For information about purchasing TTI research reports, contact:  
**Dolores Hott**  
**e-mail: d-hott@tamu.edu**  
**(979) 845-4853 fax: (979) 862-3703**



## THE BACK ROAD



Saying that transportation, and in particular traffic congestion, is “big news” is really an understatement. We’re all well aware of the problems created by a growing demand for better and faster transportation, and the difficulty of building new infrastructure to ease the congestion on our roads. Elected officials at all levels of government struggle with ways

to speed the movement of people and goods in a time when our infrastructure is overwhelmed and when transportation issues can affect a city or region’s ability to develop economically.

This issue of the *Researcher* focuses on the leading edge research being conducted at the Texas Transportation Institute (TTI) in traffic operations and management, particularly in integrating various monitoring, emergency response, freeway management and signal control operations. We call it Intelligent Transportation Systems or ITS, but for most travelers, its benefits are often unseen — except when the traffic moves more evenly and traffic accidents or incidents are cleared more rapidly. TTI researchers are working on the latest devices and processes to integrate all traffic management systems, creating an overall system that ensures that travelers get the right information at the right time to make better travel decisions. It’s exciting work, and this issue highlights several TTI programs that are at the forefront of the ITS program, including the annual national mobility analysis conducted by Dr. Tim Lomax and his research team.

We also bid farewell to our colleague Charley Wootan with a look at his distinguished career in transportation. Charley died on March 24 and his loss is felt keenly by all of us here at the Institute, as well as by his family and many friends across the country. Charley’s influence in transportation research and education was tremendous, and he leaves a legacy of accomplishment that will long endure. A student fellowship honoring Charley and former director Jack Keese has been established, and there is information on page 11 on how to contribute.

Thank you for taking time to learn more about TTI research. I hope you continue to find this publication useful and interesting, and that you’ll check our website or contact us if you’d like more information.

# Researcher

*Texas Transportation Institute (TTI)/Information & Technology Exchange Center (ITEC) • The Texas A&M University System*

**Dr. Herbert H. Richardson** *Publisher/Director, TTI*

**Susan M. Lancaster** *Editor/Director, ITEC*

**Kelly West** *Managing Editor/Writer*

**Rhonda Brinkmann** *Contributing Writers*

**Leslie Pourteau**

**Penny Beaumont**

**Kim Miller** *Designer/Production Artist*

**James Lyle** *Photographer*

**Rhonda Brinkmann** *Copy Editor/Proofreader*

*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 do 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 the Information & Technology Exchange Center, 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 this address, call (979) 845-1734, or e-mail Debra Svec at d-svec@tamu.edu. Periodicals postage paid at College Station.

Postmaster/Bulk Mail Clerk  
Send address changes to:  
*Texas Transportation Researcher*  
Information & Technology Exchange Center  
Texas Transportation Institute  
The Texas A&M University System  
3135 TAMU  
College Station, TX 77843-3135



Visit TTI on the Internet at <http://tti.tamu.edu>

# Researcher

Texas Transportation Institute/Information & Technology Exchange Center  
The Texas A&M University System  
3135 TAMU  
College Station, TX 77843-3135

Periodicals  
Postage  
**PAID**  
College Station  
Texas 77843