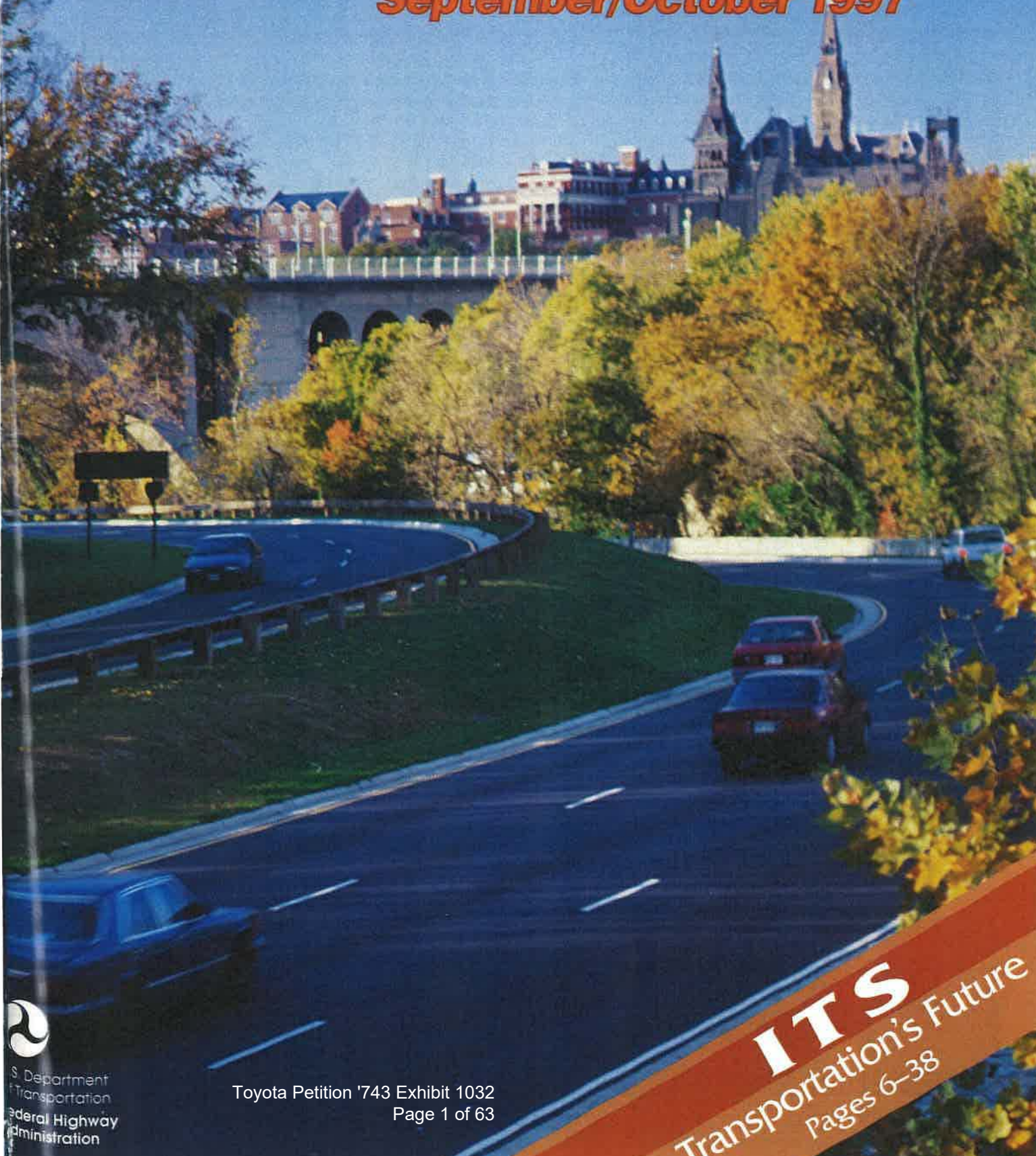


Public Roads

September/October 1997




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Transportation
Federal Highway
Administration

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Transportation's Future
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Public Roads

September/October 1997

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—featuring developments in federal highway policies, programs,
and research and technology—

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Front Cover — In the early 1930s, the George Washington Memorial Parkway on the Virginia side of the Potomac River was designed and built as the most modern and most beautiful highway in the United States. Although it retains its beauty, the parkway is now a major artery for commuters to and from Washington, D.C. The buildings of Georgetown University on the other side of the Potomac dominate the background. Photo taken by Kevin Kerdash

Back Cover — In the spring of 1993, Maryland initiated Project Cloverleaf, a public-private partnership to beautify the state highways, enhance the natural landscape, and improve the environment. These children are among hundreds of volunteers from corporations, universities, schools, scout troops, churches, and state employees to help plant thousands of trees, perennials, ornamental grasses, acorns, and bulbs every spring.

In his remarks at a wildflower garden event honoring Mrs. Lyndon B. Johnson in Stonewall, Texas, Aug. 27, 1997, Secretary of Transportation Rodney E. Slater praised former President Johnson for creating the Department of Transportation 30 years ago and Mrs. Johnson for her efforts to beautify America's highways. "Because of you, Mrs. Johnson, the country that builds the most roads, also builds the most aesthetic roads," Slater said. "From coast-to-coast, every state in the union now plants wildflowers. Your love has become America's love of flowers." Photo courtesy of the Maryland State Highway Administration



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Federal Highway Administration

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Editor's Notes:

It seems that in the last few years, transportation researchers and engineers have become more aware of the importance of "public awareness."

Like the old philosophical question about whether or not a tree falling in the forest makes any noise if there is no one around to hear it, the researchers are realizing that the value of their work is somewhat diminished if no one knows about it. For a long time, they have been writing reports and making presentations at technical conferences to share information with their researching colleagues, but now they are recognizing the need to reach a broader audience to whom they must tell their story. Especially in times of constrained funding, it is critical that the key "movers and shakers" in the budget process understand the explicit and potential impacts of these programs to radically change the face of America.

In many ways, the American culture has been shaped by the transportation developments in this century. In 1993, former Associate Administrator for Research and Development John Clements wrote, "I can't help reflecting on the dramatic and enormous changes in transportation during the 20th century ... The transportation changes of the next century will be every bit as dramatic, and the challenges are just as massive."

In early August, I flew from Washington, D.C., to San Diego to attend the Automated Highway System proof-of-feasibility demonstration. During the 5 1/2-hour flight, I thought about how 100 years ago the trip would have required weeks by railroad and months by coach. Maybe, 100 years in the future, our descendants will look back on what is now the most mobile society in the world and wonder how we survived with such an antiquated and dysfunctional (from their perspective) transportation system.

But if we are going to get there from here, the transportation research and technology community is going to have to convince the decision-makers and the general public of the significance and safety of the continuous advancement of transportation-related technologies.

At the First International Workshop on Vehicle-Highway Automation held in San Diego immediately following the demonstration, there was a great deal of discussion about the importance of gaining public acceptance and confidence in the significance and safety of AHS technologies. It is not enough to impress people and make them say gee whiz in amazement. Certainly, the participants, spectators, and media representatives at the AHS demo were impressed by the "hands-off, feet-off" operation of vehicles that were "driving" down the highway at 100 kilometers per hour without the help of a human driver. But if the public does not believe that the demonstrated technologies are safe and worth a few extra dollars when they purchase their next car, the automobile manufacturers are not going to build these technologies into their cars, and legislators are not going to appropriate government funds to pay for improved infrastructure to support these technologies.

While there are many important areas of transportation research and development, intelligent transportation systems (ITS) programs are the ones that will capture the enthusiasm and amazement of the public. Many other advancements will improve the infrastructure by making it more durable and less costly or will better protect the environment; nevertheless, they will be relatively invisible to the general traveling public. ITS programs offer possibilities for quantum leaps in mobility and reducing traffic congestion, improving traveler information and convenience, enhancing the environment, and improving safety.

In this issue of *Public Roads*, we have several articles that tell the ITS story, and in the next issue, we will continue to focus on ITS programs and activities, including the AHS demo in San Diego. Quoting Secretary of Transportation Rodney Slater, "We are in the midst of a revolution in transportation technologies that will transform our economy and our daily lives ..." But how far and how fast we go depends on our success in telling our story.

Bob Bryant
Editor



The 3:16 a.m. Syndrome

by Cynthia Burbank and
S. Lawrence Paulson

It's still known as the "3:16 a.m. table."

It was the table showing the outcome of the final compromise funding formula hammered out in the early morning hours of Nov. 26, 1991, that paved the way for the passage the next day of the landmark legislation known as ISTEA (Intermodal Surface Transportation Efficiency Act of 1991).

"There was a real battle over state funding formulas. It was very intense. We often didn't go home on weekends," recalls a staffer for then-Senate Majority Leader George Mitchell, D-Maine. It was difficult to come up with a formula — giving to one state here, taking from another state there — that was acceptable to a majority of the House and Senate.

The difficulties in agreeing on which states got how much money from the omnibus transportation bill came even though "it was in everyone's interest to get a bill passed." As Thanksgiving approached, congressional leaders turned up the pressure to get a compromise bill through both houses. Mitchell threatened to keep the Senate in session through Christmas if that's what it took to pass ISTEA. Speaker Thomas Foley, D-Wash., kept similar pressure on the House of Representatives.

The More Things Change ...

Now, six years later, ISTEA will expire on Oct. 1, 1997, and the pressure is on Congress once again to pass a surface transportation authorization bill. And just as in 1991, the single most controversial issue is how to apportion the funds among the states so that ISTEA's successor can achieve a majority in the House and Senate.

There are, of course, some differences between the current situation and the situation in 1991. The issue of state equity arose earlier in the drafting process this time around. But the fact that the controversy has had a longer run does not seem to have made the issue any easier to resolve, and the prolonged debate may have served only to harden the various positions.

Another difference with 1991 is that now the Republicans control Congress. But once again, this doesn't seem likely to have a major effect on the outcome, since differences over the funding formula have followed regional rather than party lines. For example, the two most powerful Republicans on the Senate Environment and Public Works Committee have found themselves far apart on the formula issue. Sen. John Warner, R-Va., chairman of the Transportation and Infrastructure Subcommittee, is a leading sponsor of STEP 21 (Streamlined Transportation Efficiency Program for the 21st Century), which

would direct more funds to the so-called "donor" states — those mainly Southern, Midwestern and Western states that received less in transportation funding from the federal government under ISTEA than they remitted to the Highway Trust Fund. Warner, whose home state is one of the donors, termed the ISTEA formula a "gross inequity." But Sen. John Chafee, R-R.I., chairman of the full committee, whose home state is a "donee" that receives more in benefits than it contributes in taxes, is more comfortable with the ISTEA formula. He's a cosponsor of the "ISTEA Works" legislation introduced by Sen. Daniel Patrick Moynihan, D-N.Y., a bill that generally follows the ISTEA funding formula.

Also in the running is the Surface Transportation Authorization and Regulatory Streamlining Act (STARS 2000), introduced by Sen. Max Baucus, D-Mont., which tilts the formula somewhat more to the West than STEP 21.

"Many Western states are largely owned by the federal government," Baucus notes. "Yet, there are thousands of miles of highways that cross federal lands — highways that the states must maintain and improve. And many states are rural, with low populations and vast land areas — conditions that effectively prevent them from raising all of the revenue themselves to pay for their roads and bridges without inflicting a significant tax burden." Baucus

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argues that as in other federal funding programs, "there are legitimate reasons that some states receive more in highway funds than they contribute to the trust fund in gas taxes."

The Administration's formula approach lies somewhere between the donor proposal and the donee proposals — although FHWA's first goal in proposing formula changes was to identify up-to-date, reliable factors that are clearly tied to each program's purpose. The second goal was to provide equity adjustment that recognized the valid views of both donor and donee states. DOT officials note that most donor states' funding shares would increase under ISTEA because Highway Trust Fund contributions would be a major factor in the formulas for National Highway System and Surface Transportation Program funds. In addition, NEXTEA includes a

guarantee that all states would receive at least 90 percent of their percentage contributions to the Highway Account of the Highway Trust Fund.

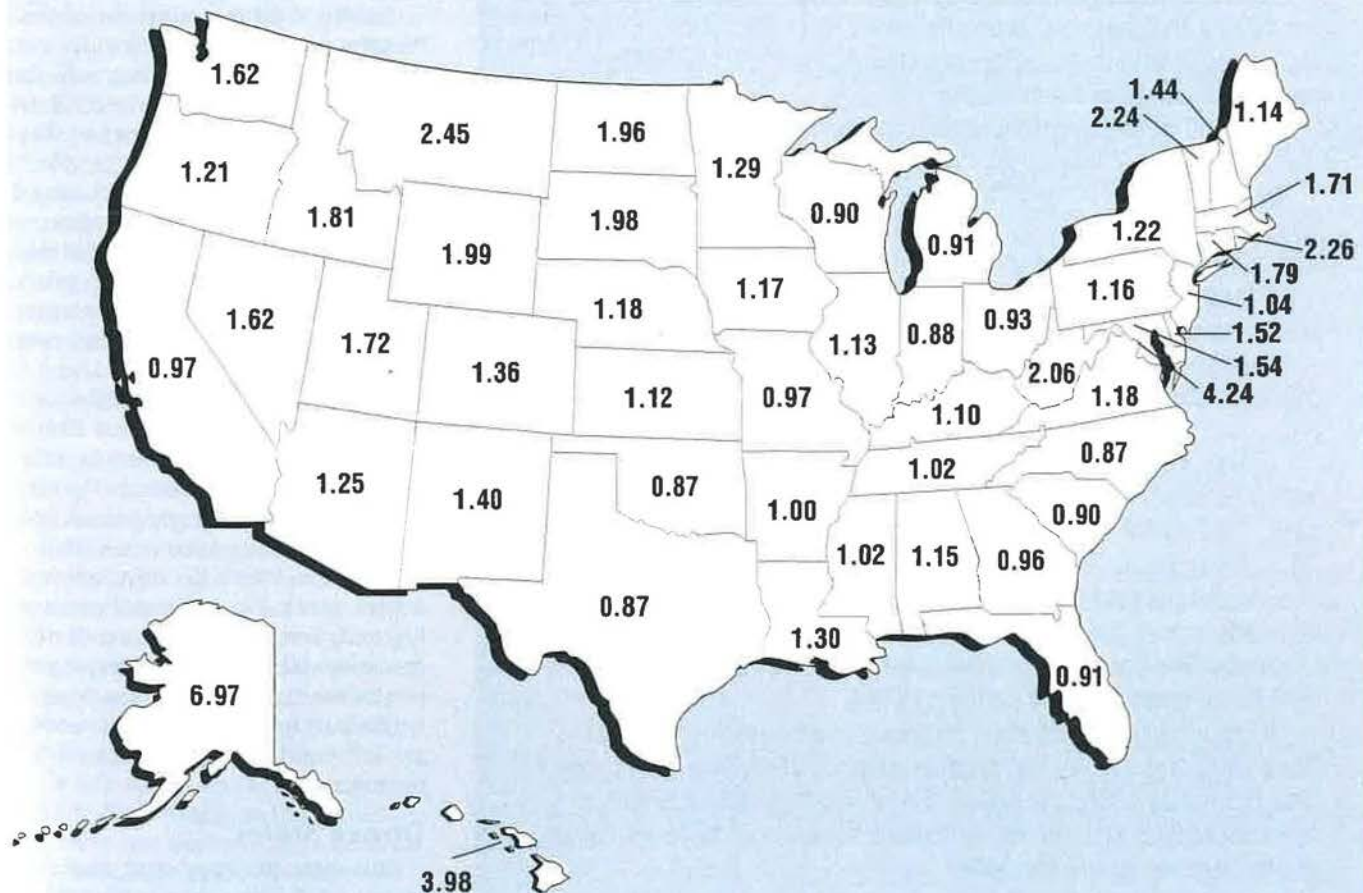
The most radical approach to the funding formula issue is taken by the Transportation Empowerment Act introduced by Sen. Connie Mack, R-Fla., and Rep. John Kasich, R-Ohio. This is a devolution bill that would reduce the federal gasoline tax by 12 cents over a four-year period. Except for a "core" federal program that would include mainly maintenance of the existing interstate system and roads on federal lands, the responsibility for funding transportation programs would be turned back to the states, which would be free to replace the federal gasoline tax with their own tax programs. Mack released a General Accounting Office report estimating that 39 states would benefit from his

devolution proposal, but the analysis assumed that each state would enact a program that obligates funds in a manner consistent with the current federal program and that states would increase their fuel taxes by the amount of the federal tax decrease.

Donor States

Who are the donor states, and what kind of case do they have? Lists of donor states vary considerably, depending on how the funding statistics are calculated and what period of time is used. In fact, estimates of the number of donor states have ranged from 14 to 27. One approach is to consider payments into and apportionments and allocations from the Highway Account of the Highway Trust Fund for the ISTEA fiscal years of 1992 to 1996. Using this method, there are 18 donor states. These states (and their ratios

Comparison of Federal Highway Trust Fund Receipts Attributable to the States and Federal-Aid Apportionments and Allocations from the Fund 1/Fiscal Years 1957-1995



THE NUMBER CRUNCHERS

If there's a formula for compromise on ISTEA's successor, Tom Weeks and his Federal Highway Administration (FHWA) team are likely to be the ones who help find it.

Weeks' Data and Formula Assistance Team provides the numbers that are fueling the debate in the House and Senate over how much states will get, under various proposed bills and scenarios. When members of Congress or their staffers want to know the effect on a funding formula of a change — for example, in the weighting of total highway miles or bridge deck surface area — they'll call on the FHWA team to run the numbers.

Since the data requests come from all sides of the ISTEA issue, it's important that the FHWA team be viewed as an honest broker.

"We're not trying to influence any outcomes at all," Weeks says. "Obviously, the NEXTEA proposal was sent forward, and that's where FHWA made its proposal known. Now we are simply responding to the requests and doing what the client asks us to do.

"Data reliability and accuracy are very important, and we stress that in all of our work. The client wants to know that the data set we're using is the most current and the most accurate that we can possibly use and that it's being used consistently."

The Data and Formula Assistance Team consists of Tom Howard from the Office of Highway Information Management, whom Weeks describes as "the focal point for data issues"; Carolyn Edwards from the Office of Policy Development, who is responsible for Highway Trust Fund analyses; and Bruce Swinford from the Office of Budget and Finance, who is the program manager for the consultants who are actually running the numbers.

"I'm kind of trying to keep it all together and manage it all on a day-to-day basis," Weeks says of his own role.

Weeks' position in the forefront of the numbers-crunching operation means he's well aware of the difficulty in arriving at a formula that will get a majority of votes in the House and Senate.

"A federal program pretty much dictates that there are some winners and losers," Weeks notes.

He believes that adding more money to the pot, as House Transportation and Infrastructure Committee Chairman Bud Shuster, R-Pa., advocates, might help the process.

"If there was a large growth in the program, then obviously it would be easier for those donor states to accept a compromise," he says. "The states do tend to look at the bottom line and their share. So, it doesn't completely eliminate the concern about shares, but if you know your total program is going up by \$50 million, you could be a little less concerned about the percentage."

Weeks says the funding issue emerged earlier in the debate over ISTEA's successor than it did over ISTEA.

"It's probably the first thing that was given attention because there were requests for technical assistance in looking at alternative factors in early 1996," he notes. "So, it's gotten early attention; it's been continuing and intense; and there's been no indication that any of that is going to end for awhile."

of payments to apportionments and allocations) are Alabama (0.86), Arizona (0.92), Florida (0.85), Georgia (0.81), Indiana (0.85), Kentucky (0.84), Louisiana (0.90), Michigan (0.89), Mississippi (0.90), Missouri (0.88), North Carolina (0.89), Ohio (0.96), Oklahoma (0.89), South Carolina (0.77), Tennessee (0.85), Texas (0.84), Virginia (0.91), and Wisconsin (0.97).

On their face, the donor states' arguments seem compelling. Warner said on introducing his bill that it "recognizes that all regions of the nation have important transportation needs. We are committed to devising a program that — for the first time — responds to our transportation needs using current needs information. In doing so, we provide a program that acknowledges that sparsely populated states with large land areas or states with small populations cannot go it alone. We are committed to continuing a national transportation system — to provide effective connections among the states. I believe the needs of these states must be addressed, and we do so in our legislation."

Debby K. Kilmer, director of the Washington, D.C., office for the state of Florida, argues that with the South and West growing faster than the Northeast, it is appropriate that "dollars should follow the people."

Backers of STEP 21 have formed the Reform ISTEA Now! coalition to generate grassroots support for the bill. The coalition is made up of 24 road-builder organizations representing asphalt pavers, general contractors, equipment dealers and consulting engineers in Southern and Midwestern states. Steve Fisher, the group's executive director, said in a June press conference, "In the coming months, our grassroots coalition will reach out to other like-minded interests who want greater equity applied to the distribution of highway funds. The citizens of donor states have been subsidizing the rest of the nation for far too long, while our own infrastructure needs are left unaddressed for lack of resources."

Donee States

But there are important arguments on the donee side as well. A study conducted by researchers at

Harvard University's Kennedy School of Government and released by Moynihan indicates that when all programs, not just highways, are considered, many Northeastern and Midwestern states pay more in federal taxes than they receive in federal spending. By this calculation, the biggest donor states on a per capita basis are Connecticut, New Jersey, Illinois, and Delaware, while the primary donee states are New Mexico, Virginia, Mississippi, and West Virginia. New York is 10th on the per capita list of donor states, but, as Moynihan noted in a letter accompanying the report, its total balance of payments deficit was second only to that of Illinois. Moynihan also called it a "mixed blessing" that the one category in which New York did well was grants to state and local governments, which includes transportation, "in which New York does very well indeed." Preserving the ISTEA formula "will be the fight of our lives," Moynihan said.

Also cited by supporters of the current funding formula is a DOT "comparative level of effort" study showing that Southern and Midwestern states invest less of their own state resources in transportation than other states. An update to the ISTEA-required study, requested by Republican and Democratic staff members of the House Surface Transportation Subcommittee, ranks states by their efforts in four categories: highway spending as a percentage of total state and local government spending, state and local transportation spending compared to total transportation spending in a state, highway spending compared to total taxable resources income, and equivalent motor fuel tax rates for highway-user revenues distributed for highway.

Subcommittee ranking member Rep. Nick Rahall, D-W.Va., a supporter of the ISTEA formulas, said states backing STEP 21 and devolution "are not exactly stellar performers when it comes to dedicating their own state resources to their highway programs."

"While these states clamor for more federal funds, at the same time they are not willing to ante up their own resources. On the other hand, we find that many of the so-called donee states dedicate a

greater percentage of their own resources to their highway programs," said Rahall.

The donor state response has been that the "level of effort" evaluation has no relation to a state's actual highway funding needs and rewards states with a high gasoline tax regardless of whether they use the tax proceeds wisely.

Finally, donee states contend that the argument over transportation funding shouldn't be waged on regional terms in any case because a sound highway system benefits everyone.

"The basic reason for federalism is for Washington to use money and distribute money based on the needs of the people," asserts New York Transportation Commissioner John B. Daly.

"We are a United States, not 50 separate ones," Baucus declares, adding that "transportation ties us together as a nation and as a people."

Prospects for Compromise

What are the prospects for a compromise on the funding formula? House Transportation and Infrastructure Committee Chairman Shuster has argued strongly that without more money for ISTEA's successor — Shuster has called for as much as \$32 billion a year in highway funding compared to ISTEA's \$20 billion — there just isn't enough flexibility to make the kinds of tradeoffs that will win votes for a particular plan. Many observers agree, pointing out that the ability to trade dollars for percentage points helped ensure success for ISTEA's formula.

"Resources are a problem," says Baucus aide Kathy Ruffalo. "If you have more resources, you have more options."

But Mary Lynn Tischer, director of policy analysis, evaluation and inter-governmental relations of the Virginia Department of Transportation says, "Regardless of the money, some states have had a windfall for too long." Nonetheless, Tischer believes that the final bill will include more money than is currently on the table in any of the proposals and that donor state concerns will be addressed — at least to some extent.

One major interest group, the American Association of State High-

way and Transportation Officials (AASHTO), with the same mix of state and regional constituencies as Congress, has not taken a position on the funding formula issue. Bill Higgins, AASHTO's director of congressional relations, is pessimistic about the prospects for a compromise by the time ISTEA expires Oct. 1. "They're not necessarily on the same wavelength," Higgins says about the various sides on the funding issue.

As for staff members on the House and Senate committees involved with the legislation, they're generally unwilling to make any predictions at all, either on or off the record, about the outcome of the funding formula controversy or the shape of a successor to ISTEA.

The bottom line is that while the elements are in place for a funding formula compromise, the expiration of ISTEA may not be enough of an incentive to make such a deal a reality. That's why no one will be surprised if ISTEA's successor ends up with its own version of the 3:16 a.m. table.

Cynthia Burbank is chief of the Legislation and Strategic Planning Division of the Federal Highway Administration. From 1991 to 1994, she headed FHWA's Environmental Analysis Division with responsibility for implementing transportation provisions of the 1990 Clean Air Act Amendments. In her 22-year career in the U.S. Department of Transportation, Ms. Burbank has worked for the Federal Transit Administration, Federal Aviation Administration, Office of the Secretary, and FHWA. She received a bachelor's degree in economics from Georgetown University.

S. Lawrence Paulson is a partner in Hoffman Paulson Associates, a writing/editing and public relations firm in Hyattsville, Md. He has written and edited numerous studies for the Federal Highway Administration, Federal Transit Administration, and National Highway Traffic Safety Administration. He also spent seven years covering Congress as the Washington bureau chief of a national daily newspaper, The Oil Daily.

by Christine M. Johnson

"It is the policy of the United States to develop a National Intermodal Transportation System that is economically sound, provides the foundation for the nation to compete in the global economy, and will move people and goods in an energy efficient-manner. The National Intermodal Transportation System shall consist of all forms of transportation in a unified, interconnected manner, including the transportation systems of the future."
— Intermodal Surface Transportation Efficiency Act, Section 2

With the passage of the Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991, Congress established a new era for transportation, calling for more efficient and safe use of existing highway and transit infrastructure and emphasizing intermodalism — the seamless integration of multiple transportation modes. In this spirit, Title VI of ISTEA established the Intelligent Vehicle-Highway Systems Program — later renamed the Intelligent Transportation Systems (ITS) Program — prescribing the "widespread implementation of intelligent [transportation] systems to enhance the capacity, efficiency, and safety

of the federal-aid highway system and to serve as an alternative to additional physical capacity of the federal-aid highway system."

During the past five years, the National ITS Program, administered by the U.S. Department of Transportation (DOT), has advanced the state of the technology, demonstrated substantial public benefits, fostered new models of institutional cooperation, and begun to change how Americans travel. The program laid the foundation for an information and communications infrastructure that will enable the nation to realize the vision set forth in ISTEA: to manage the multiple transportation facilities and components as one unified system for greater customer service, efficiency, safety, and quality of life.

What's the Mission?

Surface transportation systems — the networks of highways, local streets, bus routes, and rail lines — are the ties that link communities and facilitate commerce, connecting residents to work, homes, schools, services, and each other.

During the past 20 years, however, transportation systems have struggled to keep pace with America's growing and changing travel needs. The General Accounting Office has projected that congestion in metropolitan areas could worsen by 300 percent to 400 percent over the next 15 years unless significant changes are made. Traffic accidents claim more than 41,000 lives each year. And many of the administrative systems supporting commercial freight and mass transit services are antiquated and cumbersome.

Intelligent transportation systems offer promising solutions that respond to these pressing challenges. These systems are diverse and versatile, combining telecommunications, computer, and sensing technologies to provide real-time information to both traffic managers and travelers on traffic, weather, navigation, and vehicle diagnostics — in much the same way the air traffic control system does for air traffic — to achieve

The National ITS Program

Where We've Been and Where We're Going

greater system efficiency, safety, and convenience. In the future, ITS will provide vehicles with crash-warning and collision-avoidance capabilities that will dramatically enhance our surface transportation system's safety.

Since 1991, the National ITS Program has pursued research, technology development, and field testing and has promoted deployment of first-generation ITS applications. In this work, it has become clear that the primary barriers to using this technology to achieve the ISTEA vision are not technical, but institutional. The program has, therefore, engaged in a host of institutional research efforts to encourage partnerships; resolve jurisdictional conflicts; protect personal and organizational privacy; and identify antitrust, procurement, insurance, and liability issues. The program also examines human behavior and response related to the safety and usability of ITS products and services.

The National ITS Program can be divided into six broad areas of interest:

- *Enabling research* focuses particularly on the comprehensive system architecture and associated standards. Research lays the foundation for national compatibility among all ITS components. This area of interest investigates human factors to ensure that ITS services are safe and user-friendly. In addition, research also attempts to improve the capabilities of technologies, such as communications and location-referencing systems, that enable ITS services to function effectively.
- *Advanced metropolitan travel management systems* include a great range of ITS services that address traffic management, traveler information, and transit management. Services include advanced traffic management systems (ATMS), advanced traveler information systems (ATIS), and advanced public transportation systems (APTS).
- *Advanced rural transportation systems* (ARTS) apply many of the



Advanced traffic and freeway management systems use monitoring, information-gathering, and control (automation) strategies to improve traffic flow. This variable message sign, for example, provides real-time information to drivers about incidents, alternative routes, and safety.

ITS services in other categories to address the specific safety and mobility problems of diverse rural communities.

- *Commercial vehicle operations* (CVO) can be enhanced through advanced technologies and information networks to increase productivity and efficiency for both fleet operators and state motor carrier regulators. The federal ITS/CVO program focuses particularly on ITS applications to safety, inspection, and other regulatory processes associated with commercial vehicles.
- *Advanced collision-avoidance and vehicle safety systems* aim to improve safety for drivers and pedestrians through human-centered vehicles equipped with technologies that can warn or help the driver to avoid impending crashes or can automatically signal for help immediately after a collision.
- *Automated highway systems* (AHS) will support the potential of vehicles equipped with crash-avoidance technology. DOT's research is centered on the potential benefits and feasibility of a smart vehicle that can communicate with a smart infrastructure. Because AHS will

share many subsystems with collision-avoidance systems, such as vehicle-based sensors, computational elements, and the driver interface, the two research programs are closely coordinated.

What Has Been Funded?

ISTEA authorized a net total of \$645 million for the program's funding from fiscal year (FY) 1992 to 1997. At the end of FY 1996, \$531.8 million of the ISTEA funds had been authorized for expenditure. This amount was supplemented by \$459.3 million in funds from the General Operating Expense budget (including \$20 million in FY 1991) for total funding of \$991.1 million through FY 1996. At the end of FY 1996, all but approximately \$12 million of the \$991.1 million had been obligated. Roughly 40 percent of total program funding has been directed by Congress.

DOT has worked diligently to build partnerships with state and local governments, academia, and the private sector in conducting three major activities of the program: basic and applied research, field testing, and deployment support.

Basic and Applied Research

The ITS Program has sought to adapt existing and emerging information and control technologies to meet basic, everyday transportation needs. Since 1991, about 30 percent of ITS Program funding has supported research and development efforts to improve the state of the art of enabling technologies, advanced metropolitan travel management systems, rural ITS applications, CVO, collision-avoidance systems, and AHS. Funding has specifically supported development of the National ITS Architecture and essential standards. In addition, DOT developed and enhanced analysis tools and methods, such as simulation models, to allow transportation professionals to more accurately monitor and control traffic, assess new technologies, and evaluate the impact of ITS services.

Operational Tests/ Priority Corridors

About 57 percent of obligated funds has supported field testing and demonstration projects as part of operational tests or the ITS Priority Corridors Program, and 73 percent of this amount was directed by Congress. These efforts provide a crucial bridge between the laboratory and large-scale deployment.

By 1996, DOT had launched 83 field operational tests across the nation. These tests are providing valuable information on the benefits of individual ITS services and on the means to overcome institutional barriers to deployment. In these tests, DOT is breaking new ground in developing public-private partnerships, and state and local agencies are forging new institutional arrangements. Both the technical tests and the issues involved with solving procurement and institutional problems have taught us much.

The ITS Priority Corridors Program, created by ISTEA, has been extremely effective in teaching us about the institutional arrangements necessary to advance intermodal approaches to regional and multi-state transportation needs. In March 1993, DOT designated four locations that met the ISTEA Section 6056(b) criteria as ITS priority corridors: the Northeast Corridor along Interstate 95, stretching through six

Advanced traveler information systems provide pre-trip and en route travel information through a variety of media, such as this kiosk. The users of this information include travelers, traffic managers, and transit operators.



states from Maryland to Connecticut; the Gary-Chicago-Milwaukee Corridor; the Houston metropolitan area; and the Southern California Corridor centered around Interstate 5 and Interstate 10 from Los Angeles to San Diego.

Deployment Support

State and local governments need assistance in overcoming the complex obstacles to adoption and deployment of advanced technology.

The ITS Program has spent roughly 13 percent of its funding to facilitate understanding, acceptance, and deployment of ITS services. These programs include technical workshops, forums that bring together elected officials and transportation professionals, and training programs to build the essential professional capacity to support advanced transportation systems.

In particular, the Early Deployment Planning Program has provided

funding and technical assistance to local and regional agencies to develop plans to apply ITS solutions to local problems. Ninety early deployment plans (EDPs) are serving as key mechanisms for incorporating ITS into the traditional transportation planning process. A survey of 13 areas found that at least 29 ITS projects, which are valued at more than \$210 million, have been initiated directly because of the EDPs.

What Have We Accomplished?

The ITS Program has made great progress in bringing a set of research concepts to the point of national deployment (for first-generation ITS services) and in making breakthrough developments in in-vehicle safety and information systems. The following paragraphs outline 11 significant achievements of the ITS Program.

Defined a Vision for the ITS Program and Charted a Course to Achieve It

In 1992, DOT and ITS America published complementary ITS visions and strategic plans. In March 1995, the two organizations jointly published the *National ITS Program Plan*, written cooperatively to guide the development and deployment of ITS services. The plan provided the foundation for DOT's efforts to develop "road maps," which began in mid-1995. These road maps mark milestones and critical paths for achieving key program objectives. Both the strategic and program plans are "living" documents that have been progressively refined through research and detailed sub-program strategic planning.

Launched an Aggressive Research and Technology Program

The National ITS Program has helped ITS evolve from relatively visionary concepts to viable and attractive solutions for transportation problems. To a large degree, general concerns about the technological limitations of ITS have either been refined to specific questions or resolved. Among its many achievements, the program has advanced the development of new concepts, such as real-time adaptive traffic

control; improved vehicle-tracking technologies used in public transportation, emergency response, and CVO; developed guidelines to help ensure that traffic management systems and in-vehicle navigation displays are user-friendly and safe; and promoted architecture and standards to ensure that ITS services are compatible and interoperable. The program's most significant accomplishment may be the breakthroughs it has made in showing the value and, in several cases, the technical feasibility of smart vehicles that can sense objects, avoid collisions, monitor driver alertness, and provide route-guidance information. DOT is now poised to launch a major series of operational tests and begin integrating these systems in a human-centered, in-vehicle configuration.

Tested and Proved the Viability of Numerous Technologies and Applications

DOT's 83 operational tests, 28 of which are completed, are demonstrating the viability of first-generation ITS technologies and services. These tests have identified and resolved technical issues; created new models of institutional cooperation; and shown how technologies can reduce congestion, improve emergency response time, increase transit system productivity and passenger convenience, and reduce the environmental impact of transportation. We are now seeing prod-

ucts and services refined by the operational test program — such as Boston SmarTraveler's real-time travel information service and Help Inc.'s Pre-Pass electronic clearance system for trucks — become self-sufficient and competitive in the marketplace.

Developed a National Architecture to Support ITS Services

In June 1996, the United States became the first country to develop a National ITS Architecture. This was the result of an unprecedented effort to provide a flexible and expandable framework for the development and deployment of ITS. Instead of a single design, the architecture provides an inclusive setting within which different designs can be implemented and yet can operate compatibly. The architecture identifies how existing infrastructure can accommodate ITS additions and technological evolution. It also provides a framework for the development of national standards to ensure interoperability of conforming products from competing vendors.

Began Development of Standards for Hardware and Software Compatibility

Standards allow communications, surveillance, monitoring, and computer processing systems to "speak" to each other; provide

Fleet management systems, which are used by public transit operators and commercial carriers, track the location of vehicles and also provide communication links between drivers and dispatchers. By exchanging real-time information, fleet managers are able to plan and schedule vehicle trips and routes better.



Guiding Principles of the ITS Program

The multifaceted ITS Program compelled the Department of Transportation to reexamine its traditional way of doing business. In May 1994, the department established the ITS Joint Program Office to manage the program. This action resulted in unprecedented interagency cooperation involving most of the department's modal administrations — the Federal Highway Administration, the National Highway Traffic Safety Administration, the Federal Transit Administration, the Federal Railroad Administration, and the Research and Special Programs Administration. The ITS Program is guided by four key principles:

- Support research and development of ITS technology to solve problems of surface transportation congestion, safety, efficiency, and mobility and to improve quality of life.
- Ensure that newly developed ITS technologies and services are safe and cost-effective.
- Promote and support the development of an interoperable and integrated system that reduces risks and costs to users, as well as to the public- and private-sector providers of ITS products and services.
- Identify and emphasize private-sector involvement in all aspects of the program.

design guidance to manufacturers; and reassure purchasers that their systems will be compatible with other ITS elements. In 1996, DOT signed cooperative agreements with five standards development organizations (SDOs) to accelerate the development and acceptance of standards in five critical areas: in-vehicle and traveler information systems, traffic management and transportation planning systems, electronics and communication message sets and protocols, roadside infrastructure, and unique short-range communication strategies. Other standards have also been identified and are being pursued by national and international standards organizations. Two of the program's early achievements are the National Transportation Communications ITS Protocol (NTCIP) that facilitates wireline communication between traffic management centers and roadside equipment and the "Smart Bus Bus" suite of standards that allows integration of electronic functions on transit buses. (The first "bus" in "Smart Bus Bus" refers to a transit vehicle, and the second "bus" refers to the device that enables electronic networking.)

Evaluated Societal Benefits of Independent and Integrated ITS

The DOT report *Review of ITS Benefits: Emerging Successes and other documents* — such as *Benefits Assessment of Advanced Public Transportation Systems* and *Assessment of Intelligent Transportation Systems/Commercial Vehicle Operations User Services: ITS/CVO Qualitative Benefit/Cost Analysis* and *Preliminary Assessment of Crash Avoidance Systems Benefits* — show how ITS technologies can positively affect transportation efficiency, productivity, safety, and user satisfaction. Research on the public benefits of ITS establishes a compelling national interest in launching the ITS infrastructure. The infrastructure will allow us to accomplish both the vision and mission of ISTEA and engender a wide new array of private-sector goods and services in much the same way as the Internet has.

Proposed Solutions to Remove Nontechnical Barriers to Implementing and Mainstreaming ITS

DOT initiated a major investigation into the institutional and legal issues associated with intergovernmental cooperation, public-private partnership, intellectual property rights, procurement, privacy, user acceptance, staffing and education, socioeconomic issues, and environmental issues. The results are documented in the 1994 report to Congress *Non-technical Constraints and Barriers to the Implementation of Intelligent Transportation Systems* and in the 1996 update of that report.

Created New Models of Public-Private Partnerships

Because successful development and deployment of ITS will rely on the efforts of both the public and private sectors, the department has tried to involve the private sector in all facets of the program from research to testing to deployment initiatives. For example, the National Highway Traffic Safety Administration (NHTSA) has nine cooperative agreements with industry to develop and test crash-avoidance systems. In addition, the goals and activities of the AHS program are being realized through a cost-shared cooperative agreement with the National AHS Consortium (NAHSC), which consists of close to 100 public and private stakeholders, including automobile manufacturers, suppliers, universities, and state governments.

Set National Goals to Encourage Widespread ITS Deployment

DOT has established a national goal to build the ITS infrastructure by 2005. Three specific "systems" of infrastructure have been defined to date: the metropolitan intelligent transportation infrastructure, Commercial Vehicles Information Systems and Networks (CVISN), and the infrastructure associated with rural applications. This national goal has helped create a positive environment within federal, state, and local governments and has inspired confidence among private-sector developers. The department is

monitoring progress on achieving this goal in 75 metropolitan areas and is making plans to monitor deployment of CVISN.

Launched a Model Deployment Initiative to Demonstrate the Benefits of ITS Infrastructure

In 1996, the department created the model deployment initiative to showcase the benefits and cost-effectiveness of ITS services integrated along the lines defined by the National ITS Architecture. By 1999, four sites — the New York City tri-state area, Phoenix, Seattle, and San Antonio — will showcase the benefits of the metropolitan ITS infrastructure. In the same time frame, eight states will demonstrate CVISN — California, Colorado, Connecticut, Kentucky, Michigan, Minnesota, and, in a joint project, Oregon and Washington.

Developed Plans to Meet Educational and Human Resource Needs

The transition to electronic management of surface transportation represents the same transition the Federal Aviation Administration (FAA) underwent as it moved from using a civil engineering staff to oversee the construction of airports to managing the air system more effectively, which required a very different set of technical skills. ITS applications use information, communication, and navigation technologies that are unfamiliar to surface transportation professionals. The ITS concept also emphasizes system management, operations, and performance measurement, instead of construction and maintenance and often requires unprecedented cooperation within and between the public and private sectors. The department's national strategic plan and five-year program for building professional capacity address the need to retool the skills of the nation's professionals in the transit, highway, and CVO fields.

What Have We Learned?

The program has demonstrated that the ITS concept, even at this early stage, is technically viable, highly cost-effective, and increasingly accepted as an essential component of a modern surface transportation system. To realize the full long-term

potential of ITS, however, an information and communication infrastructure is necessary to ensure that ITS services are integrated, intermodal, and interoperable. In addition, research performed by NHTSA and the Federal Highway Administration has demonstrated the potential for major breakthroughs in accident reduction and built the foundation for future human-centered smart vehicles. The major findings of the National ITS Program are documented in the 1996 report *Key Findings From the Intelligent Transportation Systems (ITS) Program: What Have We Learned?* The following paragraphs outline the major lessons learned thus far in the ITS Program.

ITS Delivers Significant Public Benefits

DOT's research and testing activities have demonstrated that ITS services can meet a wide range of community needs — enhancing capacity and improving efficiency, safety, and quality of life.

Enhancing Efficiency and Use of Existing Capacity

DOT estimates that deploying the intelligent transportation infrastructure in 50 of our largest metropolitan areas will reduce the need for new roads and save taxpayers 35 percent of required investment in urban highways. Better management of transportation systems is central to achieving the efficiency envisioned by ISTEA; however, managing any part of the system — transit, highways, or streets — more efficiently is nearly impossible unless system managers have access to information such as the locations of traffic incidents. And information does little good if there is no means to respond and make adjustments to the system or communicate with travelers. ITS field tests and deployments have shown that strategic application of information and control systems can significantly improve efficiency for system managers:

- ITS infrastructure in 75 of the largest metropolitan areas is estimated to have a benefit-cost ratio of 8.8 to 1.
- Freeway management systems allow existing physical infrastruc-

ture to handle 8-percent to 22-percent more traffic at 16-percent to 62-percent greater speeds compared to congested conditions.

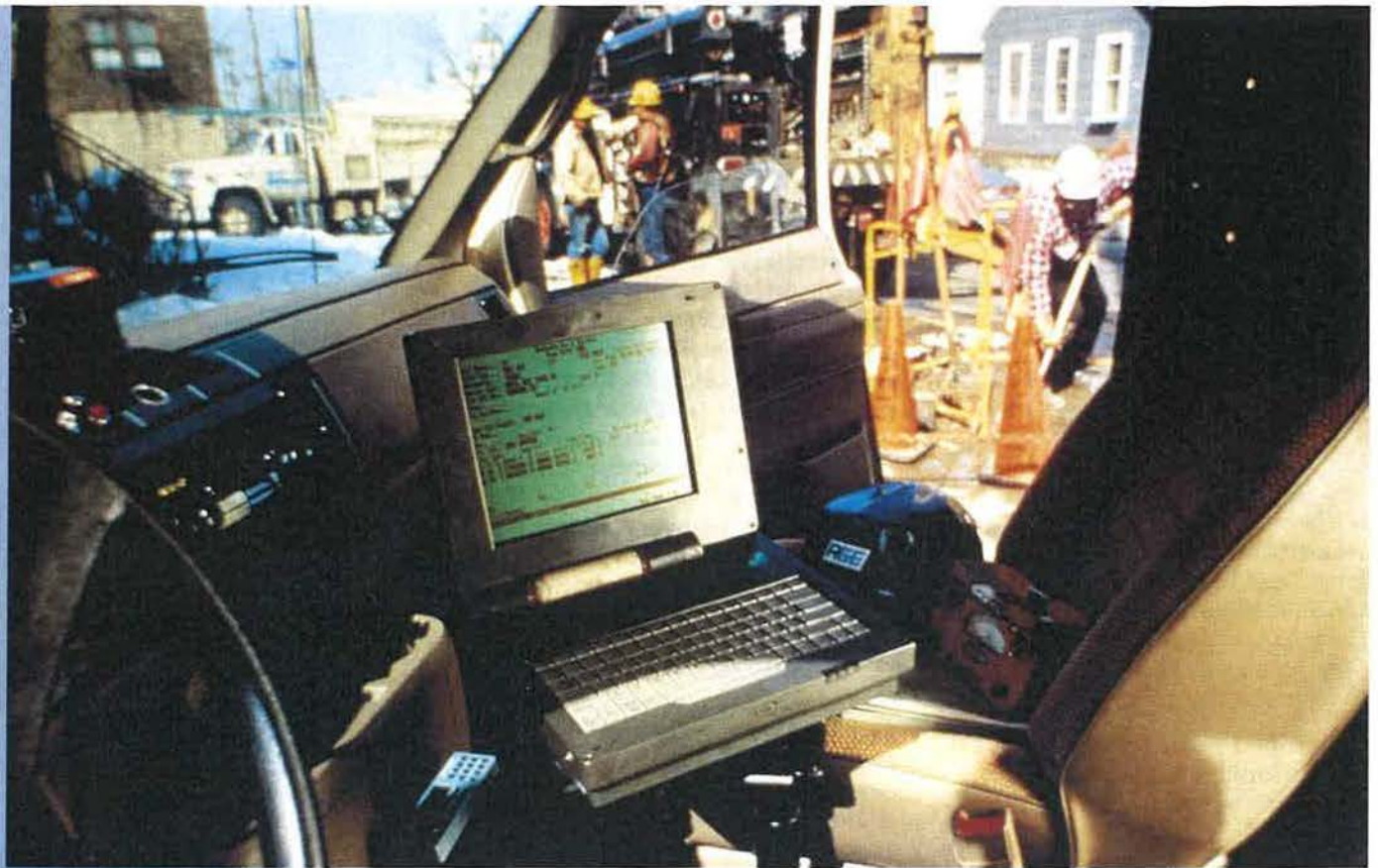
- Incident management programs have reduced incident-related congestion and delays by 50 percent to 60 percent.
- Electronic toll collection has increased throughput by 200 percent to 300 percent compared with traditional attended lanes.
- Automated traffic signal systems have shown the capability to decrease travel times by 14 percent, reduce delay by 37 percent, and increase travel speeds by 22 percent.

Preventing Accidents and Saving Lives

Today, ITS technologies are making it easier for emergency response teams to locate incidents and reach victims quickly, dramatically improving the chances of survival. Freeway management systems, such as ramp meters that help smooth traffic flow, have reduced accidents by 15 percent to 20 percent. New information technology for commercial vehicles is allowing more efficient and accurate safety inspections, increasing access to safety information for inspectors, and automating hazardous material incident response systems. NHTSA estimates that 1.2 million crashes — 17 percent of the annual nationwide total of 6.4 million — could be prevented if all vehicles were equipped with three ITS crash-avoidance countermeasures currently under development: rear-end crash warning systems, roadway-departure warning systems, and lane-change/merge crash-avoidance systems. This reduction in collisions corresponds to a \$26 billion annual savings in crash-related economic costs.

Reducing the Cost of Government Operations and Services

In an October 1995 report, *High-Tech Highways: Intelligent Transportation Systems and Policy*, the Congressional Budget Office states, "ITS research may enable highway and transit authorities to provide better service at lower cost, possibly reducing the need for public subsi-



ITS/CVO technologies will allow drivers to submit credentials electronically, reducing paperwork for both motor carriers and public agency regulators. Other technologies enable automated roadside safety inspections and electronic pre-clearance for safe and legal carriers.

dies." In an environment of limited budgets and cuts in public-sector subsidies, the components of ITS infrastructure can dramatically reduce the costs of transit management, toll collecting, and truck safety inspections:

- Advanced public transportation management systems in 265 actual or planned deployments are estimated to save transit operators from \$3.8 billion to \$7.4 billion in operating costs (in 1996 dollars) over the next decade, without diminishing quality of service.
- In Oklahoma, operating costs dropped from \$176,000 to \$16,000 per year per toll booth when booths were equipped with electronic debit systems — a cost reduction of 90 percent.
- Commercial vehicle administration programs have reduced compliance-related labor costs (obtaining licenses, permits, registrations, and credentials and reporting fuel-tax payments) by

9 percent to 18 percent through the use of advanced information technology.

Enhancing Quality of Life

Because ITS technology can enhance capacity using the existing physical infrastructure, it can lessen disruptions — caused by new construction — to wetlands, parks, open spaces, and neighborhoods. Also, ITS and its supporting infrastructure can increase mobility, giving people more information and greater control over their transportation choices. In greater Boston, for example, a majority of travelers change their routes, times of travel, or modes when they are given up-to-date information through advanced information services. National focus group research indicates high interest among all income groups in travel products that provide personal security and safety services, location assistance, advanced traffic notification, and alternative route advisories. Equally

important as the nation's baby boomers grow older, in-vehicle safety and information technology could enhance the capabilities of older drivers.

ITS Infrastructure Is Ready for Deployment

ITS products and services are not technologies of the future. They are already being applied to solve problems for state and local transportation managers, enforcement officials, and other transportation service providers; improve the efficiency of commercial shippers and carriers; and provide travelers with better information to improve the quality and safety of their trips.

Although market and user acceptance of individual components of intelligent transportation infrastructure are growing, local ITS deployment is narrowly focused and disconnected. For the most part, transportation officials and managers are reinforcing the fragmentation of today's transportation

systems and infrastructure instead of using the technology as a bridge to a new era of intermodalism as ISTEA intended. Although individual ITS products and services produce specific benefits, integrated ITS infrastructure is expected to deliver multiple and synergistic benefits and provide more options for both system managers and travelers. The risk of continuing the current pattern of local deployment is electronic "hardening" of the fragmentation that will take decades and billions of dollars to overcome.

To close the gap between the great potential of integrated ITS solutions and the current state of fragmented ITS deployment, DOT has developed a four-pronged strategy for encouraging the public sector to build integrated ITS infrastructure.

Showcasing the Benefits of ITS Infrastructure

The more exposure individuals have to useful products and services, the more likely they are to accept, purchase, and use them. The 1996 model deployment initiative, which will demonstrate intelligent transportation infrastructure at approximately 12 locations across the nation, aims to raise the awareness of the benefits of integrated ITS services and encourage public-sector officials to build supporting infrastructure.

Creating Funding Incentives

ITS deployment is gaining momentum under existing surface transportation programs, but not consistently, optimally, or systematically. Temporary funding incentives are necessary to intervene in the current deployment process to foster integration and national interoperability. The power of small incentives was shown dramatically in the model deployment initiative solicitation. The solicitation catalyzed institutional collaboration, even among sites that were not selected. Many of these sites are proceeding with their ITS deployment plans without direct DOT funding.

Establishing Standards

Public-sector officials are hesitant to buy new ITS products that might become obsolete under future standards. Private firms are reluctant to

invest in technology that may not meet future performance requirements. The relationship between standards and ITS infrastructure deployment is like the old riddle: Which came first — the chicken or the egg? We will have difficulty integrating ITS without standards, yet setting standards will be difficult without strong demand for integrated ITS services. The establishment of standards goes hand-in-hand with deployment incentives as priorities in DOT's ITS Program and must be supported by the reauthorization of ISTEA.

Building Professional Capacity

Just as the interstate construction program required new skills in road-building and civil engineering, ITS development requires skills in system integration, electronics, and communications. Because professionals with these skills currently do not exist in sufficient numbers to support the effective delivery of ITS, carrying out DOT's five-year program for building professional capacity is crucial to establishing the infrastructure to realize the ISTEA vision.

We Must Invest in the Next Generation of ITS — Particularly Smart Vehicles

The long-range potential of ITS cannot be fulfilled without smart vehicles — automobiles, buses, and commercial fleets — that combine collision-avoidance capability, route guidance, and other in-vehicle ITS services in a safe, human-centered, integrated system. This may involve stand-alone smart systems, as well as those that communicate with the infrastructure.

Research to develop and enhance this vehicle technology must be carried out in collaboration with the industry that will potentially manufacture it. The risk of not making this investment is threefold. First, the car of the future will largely be a "mobile computer." The economic block — Europe, Japan, or the United States — that develops the operating systems of this mobile computer will control the industry for a decade or longer. In addition, without accelerated developmental research, current evidence suggests that smart vehicles will be very late (perhaps decades) in arriving on the

market, if ever. This represents a potential loss of millions of lives and billions of dollars in accident-related costs. Finally, individually developed systems without proper human-centered integration could actually degrade safety.

Many of the fruits of today's ITS deployments are being harvested from research and development initiated in the 1970s. Continued research and development is needed to provide the technological foundation for the solutions to tomorrow's problems.

What's Next? A Reauthorization Agenda for ITS

ISTEA launched a National ITS Program that has amassed a formidable record of achievements. The reauthorization of ISTEA in the form of the National Economic Crossroads and Transportation Efficiency Act (NEXTEA) has the opportunity to realize the benefits of that research and extend the horizon of accomplishment. Although DOT envisions a reduced federal role, virtually all constituents agree that it must still provide critical research and technical assistance to state and local agencies, particularly in the area of ITS. The principal goals of the next phase of the ITS Program are to launch the deployment of an integrated ITS infrastructure, develop the standards and professional capacity to sustain it, and extend our research horizons, particularly in the area of integrated safety and navigational features of the intelligent vehicle.

Research and Technology

Continued funding is required to maintain the momentum of the ITS Program's near- and long-term research and technology agenda. As provided by the initial authorization, the department would continue to pursue both high-priority and high-risk initiatives, such as collision-avoidance systems, automated highway systems, advanced rural transportation concepts, the next generation of advanced travel management, and commercial vehicle operations. The research agenda would also support the development of standards and the execution of the five-year program for build-

ing professional capacity, as well as field operational tests and evaluations.

Incentives to Accelerate ITS Deployment

Based on numerous focus groups and "listening sessions," two options have emerged for accelerating the deployment of ITS infrastructure. One option would provide small incentive awards to metropolitan areas, primarily to support the cost of system integration, after the demonstration of institutional willingness to adopt and finance an integrated system. A second option would create a more traditional

ITS. The successor to ISTEA must make explicit the eligibility of ITS deployment for mainstream federal surface transportation funding. It should also pave the way for expansion of the capital planning process to include operational planning, as well as ITS operations and maintenance. NEXTEA should also reconcile disparities between highway and transit programs regarding the eligibility of ITS operating costs. The National Highway System Designation Act, for example, allowed most highway funds to be used for ITS operations, yet corresponding provisions are lacking in the transit programs. In addition,

works project. As in 1956, DOT is again serving as an agent to transform this nation's surface transportation system — this time with the intelligent transportation infrastructure, which will serve as the foundation for managing the many individual systems as one seamless system. DOT does not propose to do this alone, but instead to encourage public-sector agencies, with appropriate private-sector support, to build this new infrastructure for the 21st century. This new infrastructure will apply information technology to meet local needs within a framework that enables a national, interoperable system — a system that will open up business opportunities much as the interstate highway system did four decades ago.

A historic opportunity is at hand for Congress to dramatically improve the future of surface transportation. Although the full potential of ITS has yet to be realized, enough has been learned in the past five years to verify the wisdom of forging ahead, nurturing the National ITS Program and allowing it to fulfill ISTEA's promise of a safer, more efficient, and less costly intermodal transportation system.



Incident management and emergency management systems often work with freeway management systems to help transportation and law enforcement officials locate, respond to, manage, and clear highway incidents promptly, thereby decreasing congestion and preventing secondary accidents.

program that directly apportions ITS deployment funds to state and local agencies. These funds would support both hardware procurement and system integration. Funding eligibility under either option would be contingent on conformance with the National ITS Architecture and supporting standards and protocols.

Mainstream Deployment Provisions

Existing federal highway, transit, and motor carrier investment program policies and regulations have been refined over many decades, but they have not accounted for improved system management or

the next surface transportation authorization must sanction innovative procurement and financing approaches, including public-private partnerships.

Conclusion

"This telephone has too many shortcomings to be seriously considered as a means of communications. The device is inherently of no value to us." — Western Union internal memo, 1876

More than 40 years ago, the federal government conceived a plan to build the interstate highway system, the nation's most ambitious public

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The National ITS Architecture

A Framework for ITS Infrastructure

by Lee Simmons

Over the past decade, as information- and computer-based systems have become larger and more complex, the importance of and reliance on systems architectures have grown substantially. A systems architecture is the framework that guides and moderates the evolution of a complex system's many interrelated elements. It provides order and rules so that hardware, software, data, and communications can work together.

"Systems architectures have emerged as the centerpieces of system development programs," notes the General Accounting Office.

The centerpiece of intelligent transportation system (ITS) development is the National ITS Architecture — a systems architecture developed by a combined Lockheed Martin and Rockwell International team (representing the public sector, private sector, and academia) for the U.S. Department of Transportation (DOT). The architecture was completed in June 1996, after nearly three years of effort, including more than 50 stakeholder meetings, briefings, and workshops.

The architecture's development has been an important first step toward achieving the DOT's goal of encouraging states and localities to build an intelligent transportation infrastructure in metropolitan and rural areas, as well as interstate

corridors. Without a systems architecture, ITS deployment would be analogous to states, cities, and counties each building small parts of a limited-access freeway with little regard for its connections to segments in other jurisdictions. The National ITS Architecture shows how individual ITS services can be linked together to create intermodal and interoperable systems that better serve travelers and system managers in all areas. The architecture achieves three specific objectives:

- Provides a theoretical and practical framework in which 30 ITS services can operate together to provide various levels of service to travelers and system operators.
- Illustrates how ITS services can be incorporated within an existing infrastructure and can accommodate future technological advances.
- Supports "open" standards that enable multiple public- and private-sector organizations to independently deploy ITS components that work together, regardless of who designed or manufactured the particular hardware or software.

The architecture is quite extensive and contains more than 5,200 pages of documentation in 18 volumes. It is also the world's first systems architecture for ITS development and deployment.

A Framework for Building ITS Infrastructure

Any complex system that consists of many technical components and subelements carries the inherent risk of technological chaos — incompatibility, premature obsolescence, costly inefficiency. A system architecture provides a unifying framework to ensure that technologies can work together smoothly and effectively. The system architecture for a home entertainment system, for example, allows a television, videocassette recorder, audiotape deck, compact disc player, radio, headphones, speakers, and remote control, as well as future add-ons, to function as a unified system, even when individual components are designed and produced by different manufacturers.

In much the same way, the National ITS Architecture defines major ITS components and describes how system elements can interact compatibly. It provides a comprehensive technical and institutional framework that allows individual ITS services and technologies to work together and share information. More specifically, the architecture defines the following aspects of ITS infrastructure:

- Functions necessary to perform a given ITS service.
- Subsystems that enable ITS services to function (e.g., roadway or transit management center).

- Interfaces and information flows between subsystems.
- Wired or wireless communication modes available for transmitting ITS information.
- Requirements for developing standards to support national ITS interoperability.

The ITS architecture consists of a logical architecture and a physical architecture. The logical architecture defines eight major processes and associated information flows: (1) managing traffic, (2) managing commercial vehicles, (3) providing vehicle monitoring and control, (4) managing transit, (5) managing emergency services, (6) providing driver and traveler services, (7) providing electronic payment services, and (8) planning system deployment and implementation.

The physical architecture allocates the processes of the logical architecture to 19 major physical subsystems that are organized into four basic physical classes: transportation management centers, roadside equipment, vehicles, and travelers.

The physical architecture addresses three major layers of infrastructure: transportation, communications, and institutional. The transportation layer deals with the transportation infrastructure and operations of ITS. The communications layer identifies how existing and developing commercial or dedicated communications systems and open protocols can support ITS services. And the institutional layer outlines possible roles and relationships among public and private institutions — particularly how the federal government, state and local governments, vehicle manufacturers, and information and communications service providers could work together to implement ITS services.

The Architecture's Benefits: Tinker Toys vs. Lincoln Logs

The framework provided by the architecture is inclusive, flexible, and expandable. These characteristics promote production economies by allowing ITS products and services to be assembled in a variety of ways to address a range of needs and service levels and to

evolve in step with new technologies and requirements. In a sense, the architecture and the associated interface standards allow the elements of ITS infrastructure to be assembled with the flexibility and dexterity of Tinker Toys, whose standardized sprockets and uniform connectors can be easily linked together and rearranged in multiple combinations. In contrast, ITS deployment without an open architecture is analogous to building a cabin out of Lincoln Logs; the slightest change to the cabin's structure, such as putting in a new window, requires major reconstruction or, worse yet, starting over from scratch.

The architecture also allows ITS products from competing vendors to work together and ITS infrastructure implemented by one jurisdiction to work with systems in neighboring jurisdictions. As a result, "vendor lock-in," functional isolation, and obsolescence — all of which can be experienced with closed proprietary solutions — are less likely with the adherence to a national framework.

Communications Are Key

Communications networks are among the fundamental structural elements that make up an intelligent transportation infrastructure, because they serve as the paths ITS services use to access and share information. These networks link disparate ITS applications to each

other and to centralized management centers, allowing for the key functions of data gathering, synthesis, delivery, and broadcast to occur in real time. Because of their importance to ITS, the architecture advocates five types of communications links:

- Wide-area broadcast, such as that provided to an automobile's FM radio receiver.
- Wide-area two-way wireless, which allows more advanced, interactive services over, for example, a cellular phone link.
- Dedicated short-range communications (DSRC), such as wireless vehicle "tags" for toll collection.
- Vehicle-to-vehicle communications, which will someday endow



A worker tests the communications equipment that transmits traffic volume, average speeds, and video images of the traffic on Interstate 10 to the traffic operations center in Phoenix. Communications networks are among the fundamental structural elements that make up ITS infrastructure.

Photo courtesy of the Arizona DOT

vehicles with collision-warning and avoidance capabilities and will play a critical role in automated highway systems.

- Wireline communications, which include regular "phone line" devices, such as phone, fax, modem, video, and high-speed data networks.

The National ITS Architecture notes that ITS communications needs can be met through a combination of owned facilities, leased services, or both, including emerging digital communications developments associated with the national information infrastructure. For the most part, as noted by a member of the architecture development team, "The choice of which particular communications technology is used becomes a local design decision."

Establishing a Common Vocabulary With Standards

Although the National ITS Architecture defines how ITS components and subsystems can be linked together, the development of standards is essential in achieving national compatibility and interoperability. Standards and protocols establish a common vocabulary so that ITS elements can understand each other. Without them, systems conforming to the national architecture will have similar conceptual designs and, perhaps, functionality, but they may be incapable of seamless information exchange. For example, without standards for traffic controller interfaces, local authorities might have to choose proprietary solutions that are not easily upgraded or purchase expensive software customized for a particular equipment configuration. With appropriate standards, compatibility, interoperability, and expandability are much easier and more affordable.

The development of ITS standards is not a simple exercise. Four types of standards are required for many of the interfaces between ITS services and subsystems:

- Data standards provide uniform formats for data sharing across ITS applications.
- Message sets define message content and transmittal proce-

dures among various ITS elements and subsystems.

- Communications standards, many of which already exist as industry standards, can be modified to serve the communications needs of ITS applications more effectively.
- Performance standards include guidelines that could be the basis for safety standards or "human factors" guidelines that ensure that people use ITS services effectively.

Consensus has already been secured on many ITS standards, such as the National Transportation Communications ITS Protocol (NTCIP), which facilitates wireline communication between traffic management centers and field equipment. In 1996, DOT executed cooperative agreements with five standards development organizations to accelerate the nonproprietary development of standards for other key elements of ITS infrastructure.

The Architecture's Future

Long-term stewardship of the architecture is an important goal for DOT. As a result, the department has established the ITS Architecture Task Force to guide; promote; and facilitate effective, efficient, and rapid adoption of the national architecture. Key goals include:

- Increasing awareness of the architecture among highway and transit agencies.
- Mainstreaming the architecture into transportation planning and acquisition processes.
- Making sure the architecture remains current and relevant to transportation decision-makers.
- Developing preliminary guidance on what constitutes local system conformance with the architecture.

Preliminary guidance has already been produced on how to use the architecture to integrate the components of a metropolitan ITS infrastructure. A draft guide to architecture implementation for transit applications has been completed. Four similar guides covering other applications will be completed in 1997.

A critical next step is to validate the efficacy of the architecture

through field tests. The model deployments of metropolitan ITS infrastructure and commercial vehicle information systems and networks (CVISN), which were launched in 1996, will help DOT to refine or expand the architecture as a comprehensive guiding framework for building ITS infrastructure.

In addition, as proposed in the National Economic Crossroads Transportation Efficiency Act (NEXTEA), ITS projects in the future must adhere to the national architecture in order to receive federal funding. DOT is now preparing guidelines to help states and localities develop regional frameworks for ITS deployment that conform to the architecture. Even without federal guidance, some areas already see the architecture's value. For example, rather than starting from scratch, the Minnesota DOT used the national architecture as a basis from which to develop Minnesota's own architecture for ITS deployment.

Global Appeal

The National ITS Architecture is being examined and considered carefully by ITS advocates in the United States, Europe, Asia, and other parts of the world. DOT is particularly committed to achieving internationally consistent ITS architecture principles and standards, especially in North America, where implementation of compatible ITS services between the United States and its neighbors to the north and south can facilitate trade.

In the United States, the architecture is the framework that makes possible a national infrastructure of integrated, intermodal, and interoperable ITS. As such, its development is a cornerstone achievement of the national ITS program.

Lee Simmons is the systems engineering team leader in charge of the National ITS Architecture program for DOT. Previously, he worked as a civilian for 22 years on the development, production, and deployment of electronic systems to increase the Navy's aviation capabilities.

The Intelligent Vehicle Initiative

by Cheryl Little

In the wake of the computer and information revolutions, motor vehicles are undergoing the most dramatic changes in their capabilities and how they interact with drivers since the early years of the century.

In 1908, Henry Ford's Model T exemplified major breakthroughs in automotive design. Not only did its interchangeable parts inaugurate easy and economical mass production, but its "user-friendly" operation allowed almost anyone to drive.¹ Nearly 90 years later, the motor vehicle is resembling less and less Ford's simple machine and quickly becoming a complex "mobile computer," capable of acting as a navigator, a safeguard, and even, a second driver. These new capabilities will not only change how we drive; intelligent vehicles could also enhance transportation services, save lives, and bolster the competitiveness of U.S. industries.

However, intelligent vehicles aren't quite here. Instead, the components that make vehicles smarter — new information, safety, and automation technologies — are arriving on the market as piecemeal accessories, offered either as optional equipment by new vehicle manufacturers or as speciality components by after-market suppliers. These technologies are being developed and marketed to increase

driver safety, performance, and convenience. These individual technologies, however, have yet to be integrated to create a fully intelligent vehicle that works cooperatively with the driver.

In particular, the infusion of new and uncoordinated technologies in motor vehicles could potentially distract and overwhelm drivers. An individual could fill his or her vehicle with a smorgasbord of information, safety, and automation technologies (along with portable phone, computer, and fax machine) but suffer information indigestion as these uncoordinated technologies deliver excessive, competing, or contradictory messages and demands.

The automotive industry is already aware of and addressing potential problems associated with the uncoordinated influx of technology. But their progress is hampered by technical and economic obstacles, uncertain consumer interest, and insufficient standards and guidelines. Also, neither original vehicle manufacturers or government regulators (unless safety problems are clearly proven) have control over after-market products, especially their use in trucks and buses. However, without a "human-centered" design approach for the intelligent vehicle that attempts to integrate and coordinate various technologies, we may not only lose the opportunity to realize the benefits

offered by new in-vehicle technologies, but we could inadvertently degrade driving safety and performance.

The challenges involved in developing a "human-centered" intelligent vehicle are not unlike those faced by a tailor designing a coat out of many, varied pieces of cloth. The tailor must first understand the proportions and needs of the wearer, then meticulously sew the pieces together to fashion a coat that fits and is also useful and desirable. Similarly, the designer of an intelligent vehicle must integrate disparate technologies and systems to create a coherent machine that complements the human driver.

The Intelligent Vehicle Initiative

Recognizing the importance of smart vehicles and the potential for unintended consequences if human factors are not placed at the center of their design, DOT launched the Intelligent Vehicle Initiative (IVI) in 1997. This initiative aims to accelerate the development, availability, and use of integrated in-vehicle systems that help drivers of cars, trucks, and buses operate more safely and effectively.²

IVI rises to the challenge posed a year earlier by the National Science and Technology Council (NSTC), an executive office of the president, to develop "human-centered" transportation systems in the United States.

Advancing "Human- Centered" Smart Vehicles

In the spirit of this national effort, IVI advocates the creation of smart vehicles that fully consider the driver's requirements, capabilities, and limitations. Driver-centered design, however, will mean more than the ergonomics of "knobs and dials." It will also require that designers adopt what the Japanese call *kansei* — the infusion of human sensibility into the design process.³

IVI is a multiagency research and development (R&D) effort. DOT's Intelligent Transportation Systems (ITS) Joint Program Office provides a single budget for the ongoing vehicle-related ITS projects of the Federal Highway Administration (FHWA), the National Highway Traffic Safety Administration (NHTSA), and the Federal Transit Administration (FTA). These projects have collectively investigated the human factors, user acceptance, and technical development of individual driver information systems, advanced collision-avoidance and vehicle safety systems, and automated highway systems (AHS). By coordinating activities among DOT's agencies, IVI captures synergies in research and economizes its resources. IVI's role is to research and advance integrated concepts that have safety implications or benefits that will likely not be accounted for by the marketplace or are too far from commercialization to be of interest to most companies.

ITS research has already shown the benefits and feasibility of many of the technologies that will be contained within intelligent vehicles:

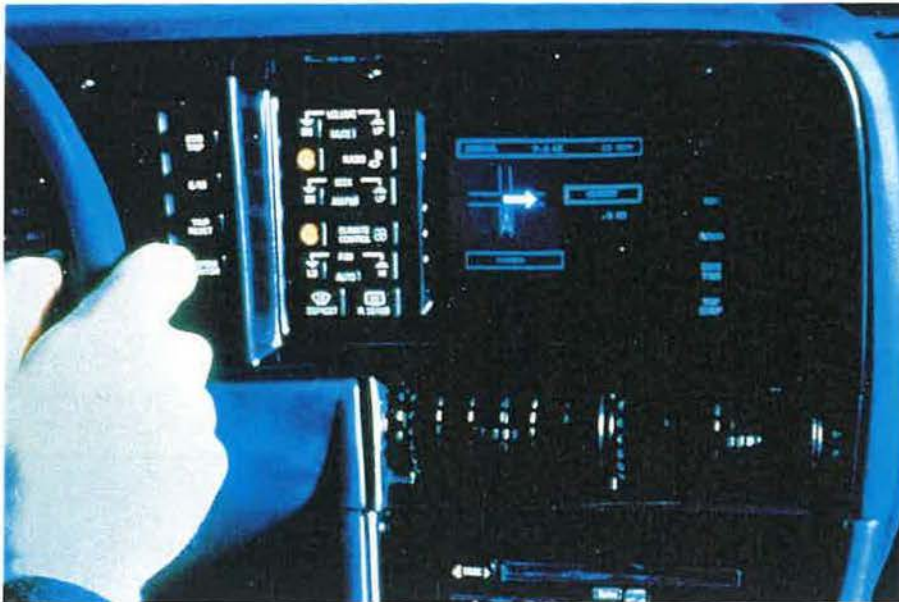
- Route guidance systems will help drivers better navigate unfamiliar streets or find the quickest route to their destinations. In the TravTek field test in Orlando, sponsored by DOT in 1992 and 1993, tourists driving vehicles equipped with route guidance systems made 30 percent fewer wrong turns and shortened their travel times by 20 percent compared to drivers who used paper maps.
- Collision-avoidance systems will expand the paradigm of traffic safety from protecting the occupant of the vehicle to preventing accidents altogether. According to one study, 60 percent of crashes at intersections and about 30 percent of head-on collisions could be avoided if drivers had an additional half-second to react.⁴ Nearly 75 percent of vehicular crashes are caused by inattentive drivers. NHTSA estimates that three types of collision-avoidance systems could prevent 1.1 million accidents in the United States each year — 17 percent of all traffic accidents. These same systems would save 17,500 lives (compared to the 10,500 lives saved by seatbelts and airbags) and \$26 billion in accident-

related costs.⁵ Other safety innovations that are now in testing include automatic collision notification systems, which will immediately signal for help if a vehicle's air bag deploys, and drowsy-driver warning systems that will keep drivers from falling asleep at the wheel.

- In-vehicle automation systems will temporarily take over driving during emergencies or allow autopiloting for prolonged durations. In 1996, NHTSA began field testing intelligent cruise-control systems, which will automatically adjust a vehicle's cruising speed to maintain a safe distance from vehicles ahead, to evaluate the safety impact of this technology. In a more dramatic step towards "hands-off, feet-off" driving, the National Automated Highway Systems Consortium (NAHSC), which is a partnership of DOT and nine other public and private organizations, demonstrated automated vehicle prototypes on a 12-kilometer test section of I-15 in San Diego this past summer. In the future, automated highway systems will allow traffic managers to double or even triple the effective capacity of highways by increasing speeds and shortening distances between vehicles.⁶ Automated highways could also potentially improve highway safety by eliminating accidents caused by human error.

Aside from delivering safety and efficiency benefits for the traveling public, the federal government expects that indigenous development of intelligent vehicles could promote America's economic competitiveness.

"The nation that develops and integrates an architecture that provides a seamless interface to the driver will dominate the automobile industry for many years to come," stated NSTC's Human-Centered Transportation Committee.⁷ With this perspective, IVI is endeavoring to forge alliances with the private sector, particularly auto manufacturers and suppliers. These alliances



Driver information and warning systems, such as this in-vehicle navigation system, will enhance the driver's knowledge of the surrounding environment.

are crucial since driver-centered intelligent vehicles cannot be produced and marketed without strong industry action and consumer interest.

The production of a safe, effective, and affordable intelligent vehicle, however, will be a long and difficult undertaking — an undertaking in which IVI must overcome many technical obstacles, better comprehend the complexities and idiosyncrasies of human behavior, and form cooperative relationships with industry to establish a vision for “human-centered” design of intelligent vehicles.

What is a “Human-Centered” Intelligent Vehicle?

The 1980s television series “Knight Rider” featured an intelligent vehicle that could leap moderately tall buildings, drive itself at seemingly supersonic speeds, spy on bad guys, and had the diction and personality of an English butler. The car was not only smart, but smart-alecky. Although intelligent vehicles in the real world will not be able to fly over standing traffic, they will have formidable capabilities. As envisioned by IVI, smart vehicles will be able to give route directions, sense objects, warn drivers of impending collisions, automatically signal for help in emergencies, keep

drivers alert, and may ultimately be able to take over driving.

The use of information- and computer-based technologies in motor vehicles, however, is not new. Widescale computerization of motor vehicles began in the 1980s with technologies designed to enhance vehicle operation and driver comfort. These technologies included electronic fuel injection to control engine performance, particularly to reduce vehicular emissions and improve fuel economy, antilock braking systems to help drivers retain control on slippery roads, and cruise control to relieve driver tedium during long stretches of driving. Whereas these technologies were primarily aimed at enhancing the capabilities of the vehicle, the most recent wave of in-vehicle technology, which is of most interest to IVI, are the intelligent transportation systems designed to enhance the capabilities of the driver. These systems include warning and information, driver assistance, and automation technologies.

Just as people possess different specialized abilities, in-vehicle ITS technologies endow vehicles with different types and levels of “intelligence” to complement the driver. Driver information systems expand the driver's knowledge of routes and locations. Warning systems,

such as collision-avoidance technologies, enhance the driver's ability to sense what's going on in the surrounding environment. And driver assistance and automation technologies simulate a driver's thinking and physical actions to operate a vehicle temporarily during emergencies or for prolonged periods.

But while a smart vehicle will extend the driver's capabilities, it will also potentially expand the driver's traditional role. In particular, in the midst of new in-vehicle technologies, the human role expands from that of sensory-motor skill, writes Thomas Sheridan, a professor who heads the Human-Machine Systems Laboratory at the Massachusetts Institute of Technology (MIT), “to that of planner, programmer, monitor of the automation, diagnostician ..., learner and manager.”⁸

Integration: The Key to Human-Centered Design

A key criteria of human-centered design is ensuring that a technology provides the intended benefits without engendering unintended adverse consequences. Driving is a potentially dangerous activity that requires attentive and alert drivers. Although technologies in the vehicle can enhance the driver's capabilities and comfort, they can also create potential distractions that transform even the best driver into a road hazard. The National Public Services Research Institute, for example, found that individuals with cellular phones in their cars had a 34-percent higher chance of having a collision.⁹

“The three tasks associated with cellular-phone use — placing calls, simple conversations, and complex conversations — all led to significant increases in the time to respond to highway traffic conditions and in the likelihood of failure to respond at all,” noted the institute.¹⁰ The uncoordinated infusion of new ITS technologies in motor vehicles could have similar negative impacts on safety and driving performance unless they are integrated to work cooperatively.

Just as the human brain coordinates memory, senses, thinking, and physical reaction during driving, a vehicle needs a coordinating system

to integrate the various capabilities of information, safety, and automation technologies. This coordinating system is the defining feature of a human-centered intelligent vehicle. Without it, the vehicle is simply a container for potentially overlapping or conflicting technologies.

Although DOT's ITS programs have developed preliminary human factors guidelines for individual systems, such as driver information,¹¹ collision avoidance,¹² and automated highway systems,¹³ these programs, through IVI, are beginning to explore fully how these systems should be integrated within a "driver-centered" framework. In particular, this framework must specifically address how information will be managed and displayed, how technologies can be improved to better serve drivers, and how drivers can learn to operate intelligent vehicles safely and effectively.

Setting Priorities

In an intelligent vehicle, drivers will have access to more information than they are traditionally accustomed. This includes information on road and weather conditions, route directions, vehicle diagnostics, anti-collision warnings, the driver's physiological status, etc. As a result, the vehicle itself must do some information filtering, a process called "data fusion." Data fusion, however, is a complicated task, which involves suppressing non-critical information — such as "the nearest fast food restaurant is two blocks to the left" — when a safety-critical message — such as "brake immediately" — is relayed to the driver.¹⁴ Data fusion must also consider how many messages a driver can receive within a given period without becoming overwhelmed or distracted.

Developing Effective and Affordable Technology

A key component of the intelligent vehicle, collision-avoidance technology, is not readily available to the buying public as standard or optional equipment. Many of the technologies used in crash-avoidance systems — radar detection, head-up displays, location referencing — have been used in the defense industry for decades; however, transferring these technologies from

military applications to the driving environment has been difficult. First, the driving environment is complex; varying patterns of driver and traffic behavior, uneven road conditions, changing weather, and other variables must all be considered and addressed. Second, the technologies must be re-engineered for mass production and made for much less cost. One of the challenges of manufacturers is to produce affordable technologies that are also highly effective and reliable.

Streamlining the Driver-Vehicle Interface

The design of the driver-vehicle interface — the place where the driver interacts physically and mentally with the vehicle — is critical. In an article entitled "Safety in Our Hands," published in *Traffic Technology International*, authors Susan Scott and Eugene Farber astutely remark, "The end result of successful ITS market deployment should not and cannot be a dashboard resembling that of a commercial aircraft."¹⁵

"An important safety benefit is achieved merely by making manufacturers' systems consistent — if the button for 'engage automated cruise control' is always on the same place on the dash and/or has the same icon on the button, it will be easier for customers to avoid dangerous mistakes (such as assuming the automated cruise control is engaged when it is not)," Scott and Farber go on to say.

DOT, as well as the Society of Automotive Engineers (SAE), have already begun to develop guidelines on the ergonomics of individual in-vehicle ITS technologies, particularly driver information and warning systems.

Presenting Information Effectively

A fundamental human factors research challenge is to determine how people best understand and process information. FHWA's human factors research has its roots in trying to design road signs that effectively communicate safety instructions and directions to drivers. These signs, however, can only present fixed information. As a re-

sult, a whole new area of language and symbols must be developed to communicate the dynamic information that can be provided by in-vehicle ITS technologies. For example, how should a driver information system communicate that traffic is stalled ahead because of construction? Microsoft and Apple, for example, employ "user-friendly" icons in their software that take advantage of the natural ways that people think about and manage information.

Designers of intelligent vehicles must also consider the media by which messages are conveyed to the driver, such as text via displays, speech via voice recognition systems, or aural "bells and whistles," such as the repeated "dinging" a car makes when keys are accidentally left in the ignition. The U.S. Air Force Systems Command, when developing instruments for pilots, found that 80 percent of human knowledge is acquired through visual input. But visual communication is not always best in all situations. For example, NHTSA found in its studies of human reactions to collision warnings that drivers responded best to a voice warning of short discrete words.

Helping Drivers Understand the Technology

Drivers must also understand how to use technology, particularly automation technologies that may be invisible to them. For example, a survey by the AAA Foundation for Traffic Safety revealed that 49 percent of drivers misused or didn't know how to use antilock braking systems (ABS). ABS requires the driver to press the brake pedal firmly and hold it down without letting up; this runs counter to the traditional method of pumping brakes. Perhaps as a result, early research has shown no clear improvement in the number or severity of collisions of passenger vehicles equipped with ABS, and in some cases, ABS-equipped vehicles were more likely to be involved in certain types of accidents.¹⁶

For intelligent vehicles, these concerns can be addressed by careful design, such as allowing certain features to be engaged only when the car is parked or hands-free activation of in-vehicle services via voice recognition systems. However,



many ITS technologies will likely require increased driver education and training.

When Might We See a Human-Centered Intelligent Vehicle?

The timing of "human-centered" intelligent vehicles' arrival on the market will depend on the evolution of technology, particularly the resolution of technical and cost constraints for some advanced concepts, such as collision-avoidance and automated systems, manufacturers' interest and production lead-times, and consumer demand. The federal role, as manifested by IVI, is to protect safety and enhance transportation services by helping both manufacturers and users recognize the importance of the integration of in-vehicle systems as well as the concept of "human-centeredness" in intelligent vehicle design.

How Might Intelligent Vehicles Evolve?

Over time, IVI expects that intelligent vehicles will advance in three primary ways: in the capabilities of in-vehicle systems, in the sophistication of the driver-vehicle interface, and in the ability of vehicles to communicate with each other and a smart infrastructure.

Capabilities of Individual In-Vehicle Systems Will Improve

Rudimentary information and warning systems are already appearing on the market, while driver assistance and automation technologies are positioned farther out on the horizon. The key technical challenge in developing driver information systems is to reduce production costs while providing dynamic route guidance abilities. Most current systems, for example, provide routes based on "static" maps irrespective of traffic considerations. Dynamic route guidance systems could determine optimum routes based on prevailing "real-time" conditions on the roadway, such as the location of bottlenecks caused by accidents or construction.

The primary technical challenge in collision-avoidance system development is to reduce costs while also enhancing sensing capabilities to improve accuracy and reliability.

Automated vehicles will share many of the sensing elements of collision-avoidance systems and must also possess an intelligence that can continuously assess the changing contexts and circumstances of the driving environment.

Driver-Vehicle Interface Will Become Increasingly Sophisticated

The integration of individual in-vehicle technologies will be reflected in coordinated and streamlined information displays and controls. Over time, the vehicle will become increasingly sophisticated in how it communicates information to and accepts commands from the driver. This sophistication will stem from the use of voice recognition, head-up displays, and vision-enhancement technologies that can relay information and commands and can also allow the driver to keep both hands on the steering wheel. Voice recognition software is already becoming increasingly common in Japanese in-vehicle navigation systems although it is still quite expensive for the average consumer.

Intelligent Vehicles Will Communicate With Other Vehicles and With a Smart Infrastructure

For intelligent vehicles to reach their maximum potential, they must be able to communicate with an intelligent transportation infrastructure and with other intelligent vehicles. For example, communication with a smart infrastructure would allow an intelligent vehicle to learn of incidents and then proactively suggest alternative routes in real time. Smart vehicles could also act as probes that could send information about travel conditions back to the infrastructure to create a richer base of knowledge about travel conditions on roads and highways. In addition, fully automated vehicles will likely rely to some extent on the guidance provided by an intelligent infrastructure and on communication with other smart vehicles. For example, in the recent AHS demonstration in San Diego, automated vehicles with magnetic sensors under their bumpers were guided by magnets implanted at

1.2-meter intervals just below the road surface.

Based on a review of the best publicly available information on technology development and potential cost and technical breakthroughs in these three areas, IVI foresees three "generations" of intelligent vehicles arriving on the market over the next 20 years.

Over the next five to 10 years, we should see the first generation with advances in the capabilities of individual driver information and warning systems. These systems will become increasingly integrated with information coordinated through displays. Drivers will still maintain full control over their vehicles although collision-warning systems will provide limited automated assistance. In addition, vehicles would have a greater intelligence about road conditions in real time due to rudimentary communications with an intelligent infrastructure.

In about 10 to 15 years, the application of improvements in individual ITS systems will bring on a second generation with more and better intelligence in the vehicle. Although drivers will still maintain full control over their vehicles, collision-avoidance systems could take control temporarily during emergencies. In addition, more sophisticated voice recognition systems will be incorporated within the driver-vehicle interface. Vehicles will be able to communicate with each other to improve collision-avoidance capabilities. And communications with an intelligent infrastructure will be more interactive.

In about 20 years, in the third generation, we could see fully automated highway systems, cooperative systems of vehicles and infrastructure, and advances in the driver-vehicle interface, such as use of vision enhancements and head-up displays.

What Is the Industry's Interest in Intelligent Vehicles?

Intelligent vehicles hold major potential for industry.

"A breakthrough in navigation and autopiloting could revitalize the consumer's desire to spend discretionary income on motor vehicles, even in the most saturated markets,"

concludes a study by MIT on the future of the automobile industry.¹⁷

The trucking industry could also benefit from technologies that could keep commercial drivers safe and help them navigate the nation's interstate corridors more efficiently.

The critical issues for manufacturers are reducing the production costs of in-vehicle ITS technologies and systems integration, eliminating liability concerns, and better gauging consumers' potential demand for autonomous and integrated systems. Recognizing the importance of human factors in making their systems more attractive to consumers, the industry is already involved in domestic and international standards development efforts.

In addition, the private sector is becoming increasingly intrigued by the prospect of integrating in-vehicle technologies. As an initial step toward integration, the Society of Automotive Engineers' ITS Data Bus Committee is trying to develop open platforms to integrate navigation and in-vehicle communications equipment.¹⁸ Others are taking additional steps.

In early 1996, Delco Electronics unveiled a concept car, the SSC, which featured about two dozen safety, security, and communication technologies, some of them linked.¹⁹ For example, the vehicle's navigation, phone, and air-bag systems were all linked so that emergency services would be automatically notified if the air bag deployed during a crash.

"Through integration, we wanted to show that it really is possible to enhance quality and to make the car safer, more secure, and a true communications device," said Gary W. Dickinson, chief executive officer of Delco Electronics in an article profiling the SSC.²⁰

In 1997, Intel and Microsoft began promoting similar personal computer software platforms for

integrating in-vehicle technologies. The platforms are called Connected Car-PC and Auto PC, respectively. Both platforms would run on Microsoft's new open operating system, Windows CE. As reported by *The Hansen Report on Automotive Electronics*, this PC architecture would be able to coordinate multiple in-vehicle technologies and to "connect the driver to the Internet, e-mail, cell phone, fax/pager, as

research suggests that consumers are interested in advanced traveler information systems that provide accurate and timely information; are reliable, affordable, and easy to use; and improve personal safety and security.²² But the driving public is notoriously picky about what goes in their vehicles. In the 1980s, consumers in the United States almost universally rejected voice-alert systems in the vehicle, including those



Perhaps the ultimate in vehicle IQ will be a vehicle's ability to drive itself. In August 1997, the National AHS Consortium demonstrated automated vehicle prototypes.

well as weather and traffic information." The computer would also be able to run entertainment and security systems or contact emergency services. Furthermore, the PC could allow electronic features to be operated by voice commands. Neither Microsoft nor Intel intend to produce a vehicle PC themselves, but they are instead trying to interest automotive suppliers and consumer electronics companies to take on vehicle PC development.²¹

Will Consumers Accept Intelligent Vehicles?

User acceptance will play a critical role in how intelligent vehicles will look and perform. Preliminary DOT

reminding passengers to buckle their seat belts.²³ But consumers are also growing more accustomed to interacting with machines, which have become an intractable feature of everyday life in banking, communications, and entertainment.

From a market perspective, customization is an attractive feature, as exemplified by the thriving vehicle accessories market, which allows consumers to individualize "one size fits all" vehicles. Given the wide variety of information and technologies that could be placed in vehicles, it is not too improbable that in the future, drivers would be able to personalize the types of information provided by their ve-

hicle. The ability to personalize would mean that the vehicle would know the driver's routine, recommend routes, and remember the context of those trips, such as ongoing construction on a much traveled exit ramp. In another fashion, an intelligent vehicle could allow the driver to customize how information is presented, in much the way that Microsoft or Apple allows a user to customize how he or she maneuvers through programs or the way an individual can touch a button in high-end luxury cars to position the seat, mirrors, and steering wheel for a particular driver. Paralleling the current discussions on air bags, however, are questions such as whether drivers would be able to disengage systems, particularly safety systems, they didn't like or found personally distracting.

Although DOT, as part of the national ITS program, has identified or will soon investigate user acceptance of individual in-vehicle systems, a challenge to the manufacturers and to IVI is to more precisely identify how public consumers would value the integration of these systems within an intelligent vehicle.

What is the Federal Role?

The federal role in the development of the human-centered intelligent vehicle is to cooperate with industry to develop technology, identify societal costs and benefits, build public confidence, promote standards and guidelines, encourage industry research and development, and promote U.S. industry.

The IVI research and development effort will include system definition and then development of intelligent vehicle concepts, evaluation of benefits and user acceptance, field operational testing, and demonstration and showcasing. IVI is structured to ensure that useable products are available for operational tests and demonstrations within three to four years.

The availability of the smart vehicle, however, will largely depend on industry and consumer interest. As a result, IVI will aggressively seek out and incorporate public and private stakeholder views to refine its vision of human-centered intelli-

gent vehicles and to assess how its research and development efforts can assure that intelligent vehicles are technically, socially, institutionally, and economically beneficial.

Conclusion

Looking back on a century inundated by technology, the motor vehicle stands out as a singularly dynamic invention. In the next century, this dynamism will be driven by advances in information and computer technology. Our challenge is to ensure that new information, safety, and automation technologies are integrated to create human-centered intelligent vehicles that can advance safety, surface transportation efficiency, and economic competitiveness.

Technological change, however, is constant. Even as we envision one set of technologies, the envelope of possibilities expands. The latest innovations in information and computer technology, for example, are focusing on the development of neural links that will allow commands to be given with muscle impulses, eye movements, and brain waves, creating an almost symbiotic relationship between humans and machines.²⁴ The vision of a human-centered intelligent vehicle, therefore, is not fixed but will continuously evolve in the wake of continuing technological breakthroughs. For DOT, however, putting people at the center of technology, as witnessed by the efforts of IVI, will remain paramount.

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ITS

Is Already Paying Dividends

by Maria Koklanaris

It's Memorial Day weekend, 1997. A sea of cars streams out of New York City and heads south on the always-congested I-95 corridor. In state after state, traffic slams to a dead halt as drivers approach tollbooths. Sometimes the wait to get through the tollbooth can be a half-hour long. Sometimes it's longer.

It doesn't have to be this way.

For some fortunate commuters around the nation, inconveniences such as long toll lines are becoming a thing of the past. These drivers live and work in areas served by intelligent transportation systems (ITS), a series of projects designed to make getting from point A to point B as easy, safe, and cost-effective as possible.

The pre-paid toll pass is an example. In many cities around the nation, drivers may purchase cards that allow them to get through tollbooths without stopping. They need only slow down while a monitor reads the pass, which is usually placed in their car windshield. Then they can get back on their way. The result is less aggravation and more time saved for drivers. And more cars per hour move through the tollbooth.

On New York's Tappan Zee Bridge over the Hudson River, for example, 350 to 400 vehicles per

hour get through the lanes where tolls are collected manually. But up to 1,000 vehicles per hour move through the electronic toll lanes, according to the Spring 1997 issue of *ITS Quarterly*.

"We have an ability to make better use of the infrastructure that we have," said Christine Johnson, director of the ITS Joint Program Office at the Federal Highway Administration headquarters in Washington, D.C.

Electronic toll collection is an ITS program the average driver can easily spot and understand. But it's only one small part of the huge system that makes up ITS. This network includes:

- Traffic and transit management and control.
- Vehicle tracking, including improved emergency response to drivers in distress.
- Government transactions, such as toll collection and truck regulation.
- Vehicle operations, including crash avoidance and information for travelers.

And while driver convenience and efficiency of infrastructure are key benefits, they are perhaps not the most important benefits of ITS, Johnson said. The most important benefits are safety and reduced cost.

"ITS saves lives," she said.

In fact, the National Highway Traffic Safety Administration estimates that if all vehicles were equipped with just three of the primary ITS crash-avoidance mechanisms, there would be a 17-percent reduction in annual crashes. That would mean 1.2 million fewer acci-



Oklahoma City saved \$160,000 per year per toll booth when booths were equipped with electronic debit systems. Drivers with prepaid electronic toll transponders affixed to their cars also save time by not having to stop at toll booths.

dents, more than 4,900 lives saved, and \$26 billion saved.

Johnson also maintains that with ITS, while "we still have to build (more roads), we don't have to build as much." One study estimated that for the same level of new capacity, an ITS strategy coupled with modest new building would save 35 percent over a traditional build approach. Another national study found an 8-to-1 benefit cost ratio for ITS in the 75 largest metropolitan areas.

Savings in transit systems over the next decade would also be in the tens of billions of dollars, according to an estimate by the ITS joint program office. With ITS, future transit systems could provide enhanced and more reliable service to riders, using fewer vehicles and operators. Over 10 years, savings in transit costs would total between \$3.8 billion and \$7.4 billion, while savings in road construction costs would total about \$15 billion.

"We're not talking about taking money away from roads and putting it into ITS," said Mel Cheslow, senior ITS engineer for D.C.-based Mitretek, which is under contract to the Federal Highway Administration. "We would argue that the most efficient way to use money is putting in highways and putting in ITS on top of them."

How would all this happen? Johnson and Joe Peters, who oversees benefits studies and evaluations for the ITS joint program office, said these large-scale benefits can be achieved when ITS is in place — with the different types of ITS integrated — across the country in both rural and urban areas. Some form of ITS is now in place in each of the 75 most populous metropolitan areas in the nation, but services must be much more widespread and integrated to see the fullest large-scale benefits, they said.

"There's very little rocket science involved in ITS," Peters said. "Getting the state of the practice at the same level as the state of the art" is what still must be done, he said.

Still, benefits have been realized on a smaller scale in many areas of the country. Freeway management system projects, for example, have improved conditions in areas such as Seattle, Detroit, and Minneapolis.

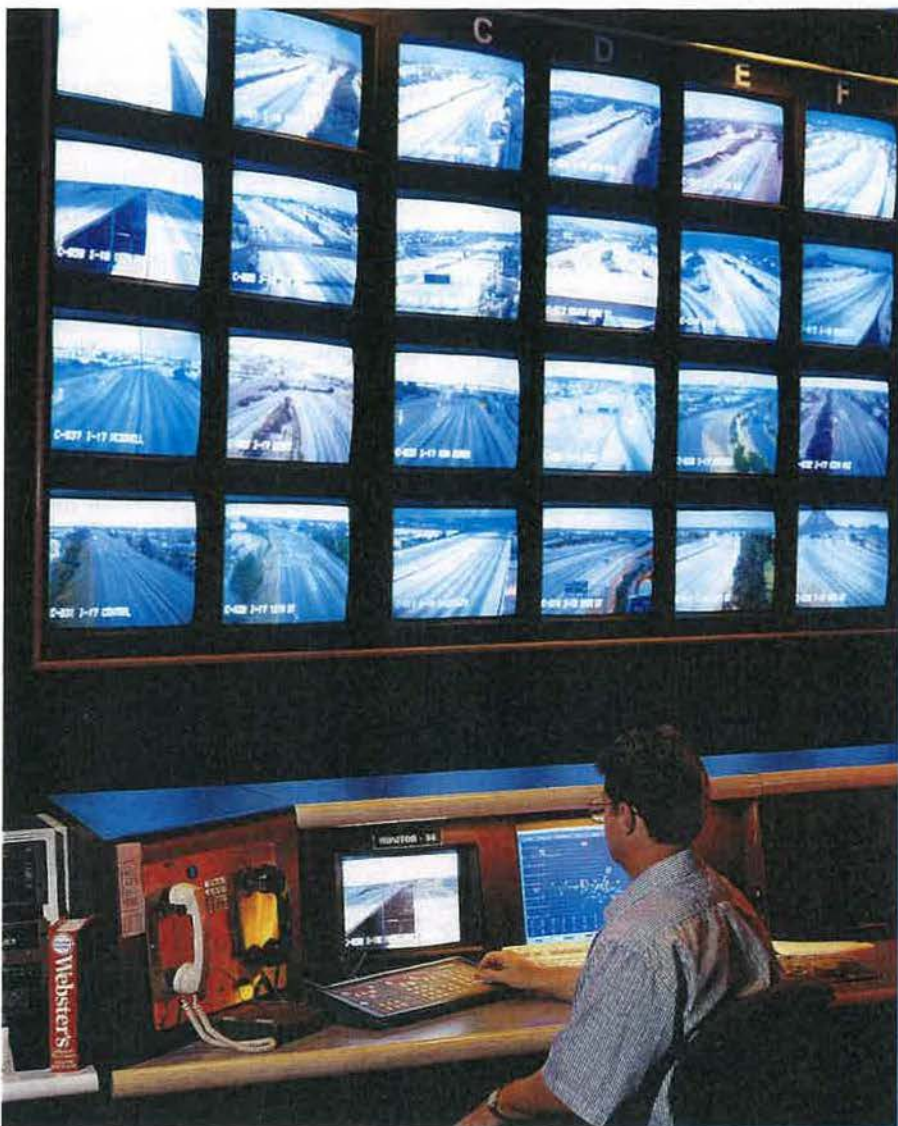


Photo courtesy of the Arizona Department of Transportation

High-speed communication equipment, traffic sensors, and video cameras help an operator monitor freeway conditions at the traffic operations center in Phoenix.

In all three areas, studies have shown that while traffic was consistently increasing, implementation of a freeway management system allowed speeds to remain steady or increase. Meanwhile, accident rates fell.

ITS has also had a positive effect on the environment. Because delays and travel time were decreased, car emissions also went down.

It may not have been called ITS in 1966, but the city of Wichita Falls, Texas, was using a computerized traffic signal system that certainly qualifies as an ITS. In those early years, the city reported a 16-percent reduction in stops, a 31-percent reduction in vehicle delay, an 8.5-percent reduction in accidents,

and a 50-percent increase in speed.

Years later, Toronto in Canada reported similar success with its traffic signal system, called SCOOT. The 1995 study reported an 8-percent decrease in travel time, a 22-percent decrease in vehicle stops, a 17-percent decrease in vehicle delay, a 6-percent decrease in fuel consumption, a 5-percent decrease in carbon monoxide, and a 4-percent decrease in hydrocarbons.

Many cities have had success with traveler information programs. These range from information kiosks where motorists can pick up maps and schedules to call-in projects where they can find out about accidents and delays and to Internet sites where they can access

real-time maps showing congestion on major arteries. Studies show that commuters use this information. Up to 40 percent of travelers changed their plans upon learning of problems on their regular routes, according to 1993 surveys in Boston and Seattle.

ITS has also produced tangible benefits for transit systems. Systems that allow authorities to pinpoint the location of buses on computerized maps have created more efficient fleets. In Baltimore, for example, a November 1995 study reported a 23-percent improvement in on-time buses equipped with the form of ITS known as automatic vehicle location.

A more efficient fleet may also create a need for fewer buses. A 1995 study reported that automatic vehicle location systems made the Kansas City, Mo., fleet efficient enough that seven fewer buses were needed. The city's transit authority saved \$500,000.

Successes such as these have led the ITS joint program office to focus more strongly on integrating ITS to realize maximum benefits.

"Many ITS elements are complementary," said Don Roberts, ITS Project Team manager for Mitretek. "The challenge for the future is to focus on integrated ITS benefits."

In 1996, the joint program office selected four locations around the country to serve as models of ITS application and integration. The four models are San Antonio, Phoenix, Seattle, and metropolitan New York City.

"All four sites were picked because of (their prior) significant investment in ITS," Roberts said. "They had already done things. We expect significant additional benefits from integration."

San Antonio is operating an advanced traffic management system called TransGuide. The first phase of TransGuide — 42 kilometers of highway in a proposed system of 307 kilometers — went online two years ago at a cost of about \$33 million. TransGuide, considered the most sophisticated traffic management system in the country, uses a digital communications network to warn drivers about conditions ahead of them and to transmit information about accidents and other incidents

to police and rescue workers as quickly as possible. The network includes changeable message signs, lane-control signals, loop detectors, and surveillance cameras.

Last year, the Texas Transportation Institute and the Texas Department of Transportation teamed up to evaluate the accident rate and response time before TransGuide and after TransGuide. The transportation officials compared the time periods from Aug. 1 to Dec. 31 in 1992, 1993, and 1994 — when TransGuide was not online — with the time period from Aug. 1 to Dec. 31, 1995, the first five months of TransGuide deployment. They found that accidents decreased 15 percent, and the response time for major and minor traffic incidents decreased by an average of 20 percent, according to *ITS Quarterly*, Spring 1997. *ITS Quarterly* further reports that the savings associated with these reductions amounts to \$4.95 million and would total \$67 million over 20 years.

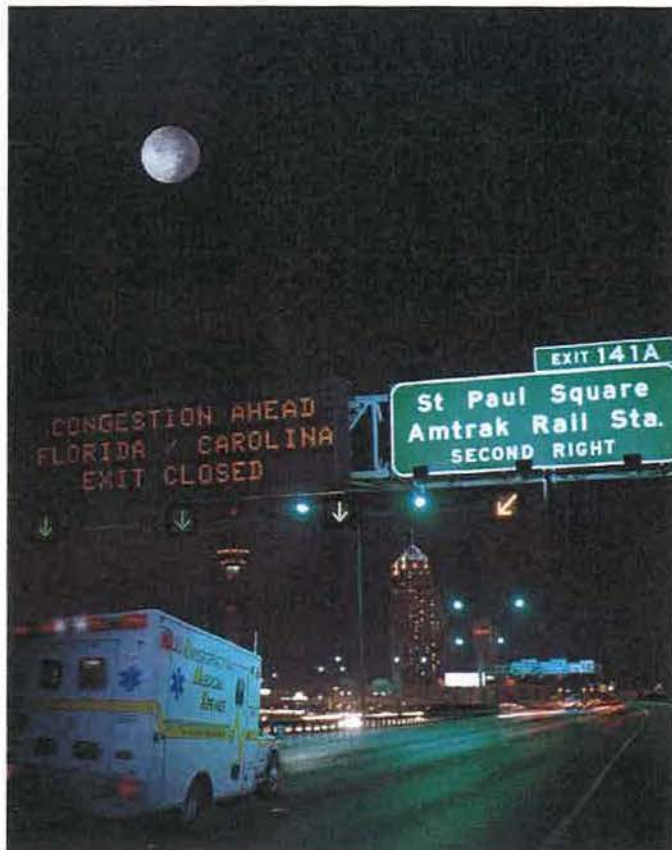
The transportation officials studying the effectiveness of TransGuide also surveyed drivers and found that most motorists felt more confident on the road, believed they had

saved time, and found traffic signs easier to understand since TransGuide went online, according to *ITS Quarterly*.

Peters said future plans for TransGuide include providing emergency vehicles with surveillance cameras showing actual incidents. This can save rescue workers valuable time because "they will be able to see what they are coming to" and to evaluate the scene before arrival.

In Phoenix, ITS is reducing the wait for passengers to board buses with a "smart farebox." "You take your MasterCard and swipe it to get on a bus," Peters said. The farebox also accepts Visa and a special card called the BusCard Plus, which is available to bus-riding employees through their companies. The farebox automatically adjusts for rate increases and fare changes, and it tells commuters if their card has become invalid.

Peters said a next step for ITS in the Phoenix area will be multi-jurisdictional coordination of traffic signals. This would mean that traffic signals across the metropolitan area would be timed to change together, making it possible for many commuters to leave the city and reach



Doctors at hospitals are able to view patients inside EMS units via video teleconferencing as part of the TransGuide LifeLink program in San Antonio.

their homes in the suburbs without hitting a red light.

Seattle and the Puget Sound area, another ITS model site, are testing devices that let travelers who run into trouble on the road send for help immediately. Peters said these devices, called MAYDAY, are particularly needed in rural areas where drivers may be many kilometers from the nearest telephone.

The MAYDAY devices — a pager and a cellular phone — each have buttons a motorist can push to declare an emergency, ask for medical or mechanical assistance, or ask for directions. In the case of motorists who don't know where they are, the devices also transmit 9-1-1 signals to a dispatch center where the location of the motorist is shown on an electronic map.

Peters said Seattle users of the World Wide Web can plan their routes to work before they leave home, saving valuable time. Users can pull up a real-time display showing which freeways are most congested.

The city is also developing for the future an "ideal in-vehicle navigation system," Peters said. This system, installed in a motorist's vehicle, "knows where the congestion is and can route you around it."

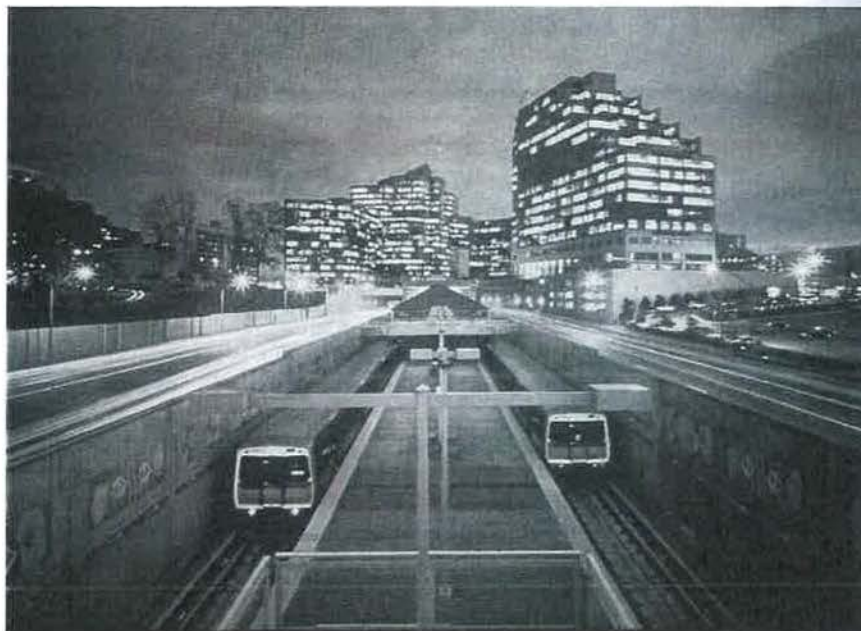
Metropolitan New York City is the fourth model ITS site. The metro area includes parts of three states: New York, New Jersey, and Connecticut.

The three states have formed an agency called TransCom, which provides communications about highway incidents. Before TransCom, Peters said, commuters from one state might have information about accidents or roadwork near their homes but could be in for unpleasant surprises as soon as they

crossed into a new jurisdiction. Now, he said, "They have surveillance of the freeways across state lines."

U.S. athletes were not the only shining stars at the 1996 Olympic Games, as far as transportation experts are concerned. The Traveler Information Showcase in Atlanta during the Olympics won a gold medal of its own.

The Department of Transportation worked with the state of Georgia, the city of Atlanta, the city's transit authority and its airport, the Olympic Games committee, five nearby counties, and nearly two dozen private companies to integrate five ITS projects. During the



Transit customers can benefit from their local operators' success in using advanced public transportation services to save money and implement safer and more efficient services.

Olympics, 17.8 million spectators were transported by bus and rail, and 10,700 athletes were transported on 2,000 buses.

The Atlanta program tracked and coordinated freeway, side street, and transit operations; implemented high-occupancy vehicle lanes; offered travelers information on cable television, in rented cars and hotels, and on the Internet; and set up 130 information kiosks giving visitors data on everything from real-time traffic conditions to rideshare information and the weather.

A high level of integrated ITS continues in Atlanta. The city oper-

ates a \$140 million facility, known as the Atlanta Regional Transportation Management Center, which provides surveillance and communications through sensors, video, and fiber-optic lines on all interstate highways within the perimeter of I-285. The center shares and receives information from six surrounding counties, the city's transit authority, a public cellular phone-in line, and a number of airborne and ground-based traffic spotters.

"The Olympics offered the chance to really show what can be achieved with ITS," said Johnson. "The Olympics simulated what every major city is going to face in the next 10 to 20 years — on a daily

basis. Our experience in Atlanta showed what could be accomplished by using ITS and with minimal changes to the infrastructure. More importantly, it demonstrated that an integrated intelligent transportation infrastructure is the enabling infrastructure for the management of operations on an intermodal basis."

ITS enhances the ability to move people and vehicles in less time, with less aggravation, and for less money. Integration of ITS is expected

to significantly compound the benefits of ITS, the most important of which are safety and reduced cost to the taxpayers.

Maria Koklanaris is a freelance writer. She has been a working journalist since her graduation from The Pennsylvania State University in 1986. She has been employed by *The Hamptons Magazine* on Long Island, N.Y.; The Connection Newspaper Group in Fairfax County, Va.; The Washington Post; the Associated Press wire service; and The Washington Times.

BUILDING SMART INFRASTRUCTURE

to Serve Travelers and System Managers

by Jeff Lindley

No single technology "fix" can meet America's growing demand for and changing patterns of travel. Although each intelligent transportation systems (ITS) product mobility or services has its unique merits, it is important that they are seamlessly united to support multimodalism and intermodalism in metropolitan and rural areas and on interstate corridors. A critical goal of the U.S. Department of Transportation (DOT), therefore, is to develop an intelligent transportation infrastructure — a communication and information backbone — that will enable ITS products and services to work not only as strong individual players, but as a powerful and effective team to save time and lives and improve quality of life.

Many different agencies build and operate highways, surface streets, and transit. Others are responsible for emergency response, law enforcement, and other functions. Each is responsible for managing some limited slice of our surface transportation system. But for travelers, these jurisdictional boundaries are invisible; to them it is all one system.

In addition, public sector interest in ITS is growing. Municipal public

works agencies are periodically upgrading their computerized traffic signals. Transit properties are gradually upgrading their bus and rail communications systems. States are investing in freeway management and incident response systems. And regulatory agencies are creating new technologies and information databases to track the safety and movement of trucks. But like traditional transportation investments, most ITS investment decisions are "stovepiped" — separate sections added to extend the existing system. Departments within a public jurisdiction and jurisdictions within a region often do not see the value of or have the resources for integrating their systems. We see this as one of our greatest challenges in linking together ITS services — changing transportation system planning, implementation, and management processes.

To meet this challenge, the National ITS Program is pursuing several activities to help states and localities make smart investments in smart infrastructure. These efforts include the development of a deployment strategy to build ITS infrastructure in metropolitan areas, sponsorship of model deployments, the identification of criteria to help localities and regions adopt the national architecture and supporting

standards, the development of programs to train and educate new ITS professionals, and continued research and development to advance state-of-the-art ITS.

What is Intelligent Transportation Infrastructure?

The term "ITS infrastructure" refers to the integrated electronics, communications, and hardware and software elements that can support ITS services and products. ITS infrastructure is not just a collection of components; it is a unified system that will allow components to communicate with each other and work together. The infrastructure will function much as the local- and wide-area networks used in most work places do. These networks allow electronic file sharing, mail, and other information exchanges within a single building or between geographically dispersed sites, even though individuals in the workplace may have different brands of computers and software of varying capabilities. Workers increase their productivity and utility, and so does the workplace as a whole.

ITS infrastructure can be configured to address the needs of three specific types of users — metropolitan residents, commercial carriers, and rural residents.

- *The metropolitan intelligent transportation infrastructure* will integrate the various components of advanced traffic management, traveler information, and public transportation systems. In January 1996, then Transportation Secretary Peña announced Operation TimeSaver, a national goal aimed at deploying ITS infrastructure in 75 of the nation's largest metropolitan areas within the next decade, with an eye toward cutting travel times for all modes by 15 percent.
- *Commercial Vehicle Information Systems and Networks (CVISN)* will integrate ITS and commercial vehicle operations (CVO) user services and already existing information databases to promote safe and efficient freight operations and enable electronic business transactions. The department's goal is to encourage the public and private sectors to build CVISN in all interested states by the year 2005.
- *The rural initiative* has identified seven clusters of technologies to upgrade transportation systems in 450 rural communities and small towns, on rural roads, and in the national highway system, as warranted. Eventually, an ITS infrastructure will link rural areas with adjacent metropolitan areas and with commercial operations.



Figure 1 — Elements of a metropolitan ITS infrastructure.

Vision: Safe and Efficient Shipping Operations

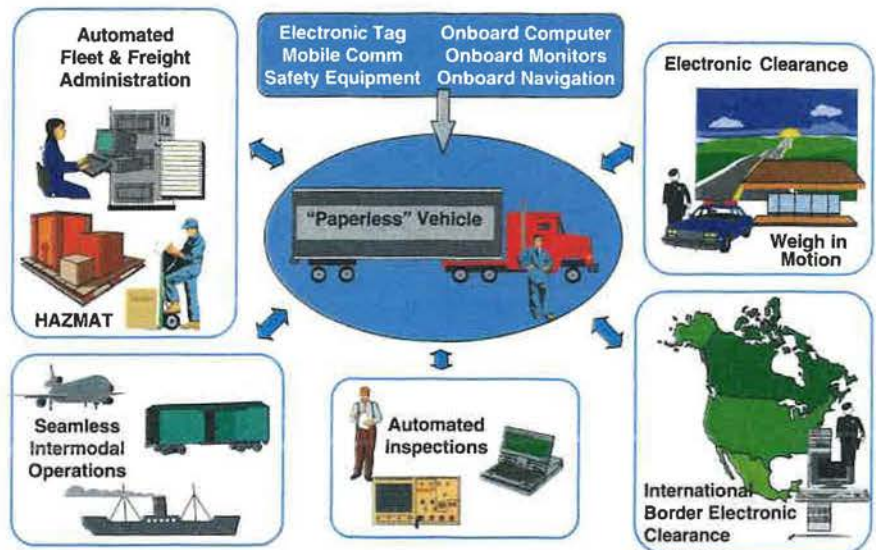


Figure 2 — User services provided by Commercial Vehicle Information Systems and Networks (CVISN).

How ITS Infrastructure Can Benefit System Managers and Travelers

Although individual ITS products and services produce specific benefits, integrated ITS infrastructure is expected to deliver multiple and synergistic benefits and provide more options for both system managers and travelers.

Enhancing the Use of Existing Capacity

ITS infrastructure can enhance the effective capacity (the throughput) of existing transportation facilities. The department estimates that by deploying ITS infrastructure over the next 10 years, taxpayers would save 35 percent of required invest-

Vision: Electronic Business Transactions

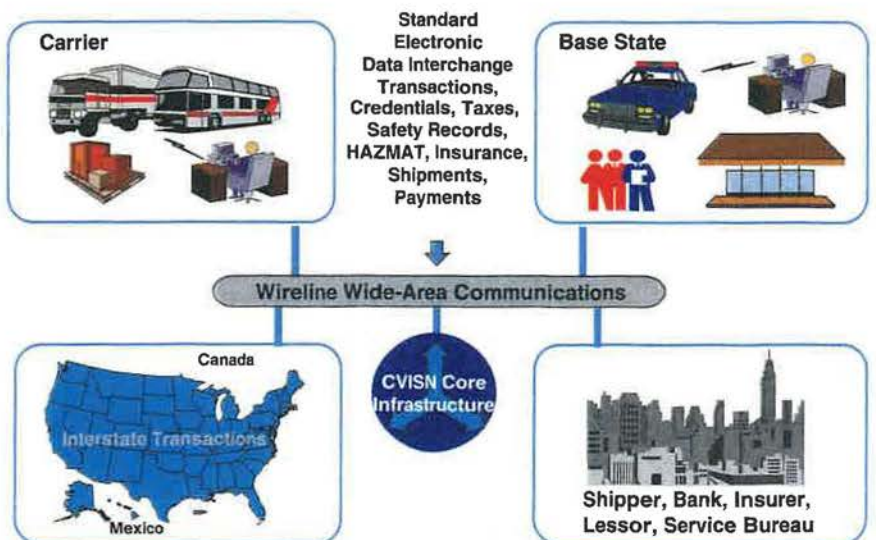


Figure 3 — Electronic business transactions possible through CVISN.

ment in urban highways in 50 major urban areas.

As a dramatic example, when two sections of the Santa Monica Freeway collapsed during the 1994 earthquake, the Smart Corridor field test was put to an early trial. Using video surveillance, changeable message signs, and adjustment of traffic lights, the system diverted the equivalent of 20 lanes of additional traffic through the parallel surface-street network with no resulting gridlock. In addition, smart interactive kiosks were deployed to inform travelers of highway conditions and to help them plan transit trips. Originally, two kiosks were scheduled to be deployed as part of a test of this technology. After the earthquake, 78 kiosks were installed at major gathering places.

Promoting Data-Sharing for Better System Management

ITS is mostly about information — its collection, analysis, and distribution to allow transportation managers to operate their systems in real time. The intelligent transportation infrastructure allows data from a variety of sources to be shared and compiled, so that the combined database is richer and more cost-effective to update. This richer database allows jurisdictions to better implement congestion management systems and other types of information management programs.

For example, at the core of the ITS effort for the 1996 Olympics was the Atlanta Regional Transportation Management Center, which provided surveillance and communications on all interstate highways through the use of road sensors, video, and fiber-optic lines. Other information on the network was provided by six transportation management and control centers in the counties surrounding Atlanta; these centers integrated local traffic signal systems with freeway operations for those counties. In addition, the Metropolitan Area Rapid Transit Agency

(MARTA) gathered information on road conditions from MARTA's bus fleet; 239 buses were equipped with tracking and communications equipment that relayed data to the agency's transportation information center. Information also came in from airborne and ground-based traffic "spotters," a public cellular phone-in line, and a variety of other sources.

The major transportation agencies in the Atlanta area shared this information through a central clearinghouse, using a client-server architecture. The architecture allowed jurisdictions to operate their transportation facilities independently while having access to data from other jurisdictions in a format that was uniform, consistent, and current to all systems. The central system, which handled all compatibility issues, can also expand to accommodate additional types of data.

In addition, DOT is working with the U.S. Customs Service to develop the North American Trade Automation Prototype (NATAP), which is expected to be launched in September

1997. This system will enable data on goods, carriers, and drivers to be entered electronically only once but will allow for multiple use among 53 U.S. agencies and their counterparts in Mexico and Canada.

Creating "Virtual" Management Teams

A myriad of agencies are responsible for operating; maintaining; and planning transportation systems, facilities, and support services — state DOTs, transit agencies, municipal and county public works, metropolitan planning organizations (MPOs), law enforcement agencies, toll authorities, and emergency response services. These agencies, however, have different responsibilities and motivations, which make it difficult to create truly intermodal surface transportation systems.

Because intelligent transportation infrastructure will provide cost savings by allowing agencies to share infrastructure, it will also encourage these diverse jurisdictions to share ideas, tasks, and responsibilities. In Atlanta, for example, the ITS effort created de facto management teams



Photo courtesy of Kemp Davis Photography of San Antonio

Transportation management centers collect, analyze, and distribute real-time information to control highway operations and provide rapid incident detection and response. Operators Marcelino Romero and Christine Jauregui respond to an incident from inside the TransGuide Operations Room in San Antonio.



Smart kiosks at transit stations, shopping centers, and other public places can provide travelers with up-to-the-minute information on transit schedules, road conditions, and alternative routes, giving a measure of sanity, control, and predictability to the transportation system.

that included several federal, state, and local traffic and transit agencies.

For commercial vehicle operations, no agency corresponds to the MPO — an agency that oversees transportation planning and provides a forum for diverse stakeholders — although such coordination is needed to guide planning for interstate corridors and to bring together state DOTs, the U.S. Treasury, law enforcement, and other relevant agencies. The development of CVISN, which will integrate several motor carrier information systems, is already bringing together these agencies in 10 states across the country, and it will eventually expand to other interested states.

Fostering Intermodalism

Intermodalism is accomplished by increasing transportation options, providing seamless connections between modes, and coordinating the activities of public agencies. Intelligent transportation infrastructure accomplishes all three tasks by addressing the three interrelated elements of metropolitan transportation systems — roads and highways, travelers, and transit — and by providing better information on travel options and by coordinating the activities of multiple travel modes.

During the Olympic Games in Atlanta, for example, transportation agencies collectively used information to better manage traffic signals,

and the estimated departure times of bus, rail, and van services; weather and tourism information; and regional driving conditions.

Increasing Customer Access to Information and Control of Options

Individual travelers need up-to-date information about how they can reach their destinations safely and quickly. Regional multimodal traveler information systems provide the foundation in delivering transportation services. These systems can transfer data gathered by other ITS technologies — information regarding traffic flows, incidents, and road and weather conditions — into information programs on alternative routes, travel times, route guidance, and the comparable performance of other modes for the same trip. This information can be transmitted via a variety of media. In Atlanta, cable television, cellular phones, handheld personal computer devices, and public kiosks were deployed throughout the city to help visitors and residents navigate the transportation system during the Olympics.

Reducing the Cost of Government Operations and Services

A 1997 national investment and market analysis prepared for ITS America and DOT by Apogee Research predicts that it will cost

\$24 billion over the next 20 years to build ITS infrastructure in the largest 75 metropolitan areas; however, the benefits will reach \$212 billion, resulting in an 8.8-to-1 benefit-cost ratio.

In an environment of limited budgets and cuts in public-sector subsidies, the components of ITS infrastructure can also dramatically reduce the costs of transit management, toll collection, and truck safety inspections. For example, CVISN will greatly reduce the time and paperwork associated with issuing credentials and conducting other transactions with motor carriers. In other venues, deployment of ITS technologies for electronic toll collection and transit fare payment will reduce the costs of handling cash transactions. Sharing a common infrastructure also saves duplicative spending.

Advancing a New Generation of Products and Services

Building intelligent infrastructure will engender a new generation of products and services, much as the interstate system "created" the trucking industry and numerous other businesses and as the Internet is creating new products, business opportunities, and services today.

"The absence of a public core infrastructure represents a barrier to market growth. The infrastructure is extremely important for providing real-time traffic information," noted a representative of Motorola. The presence of an ITS infrastructure inspires confidence that products will be able to "plug" into an established system and provide intended services to consumers.

A vice president at Siemens believes that a basic ITS infrastructure is a crucial step toward further development of traveler information services. By building a core intelligent transportation infrastructure, the public sector will establish a rational sequence of ITS deploy-

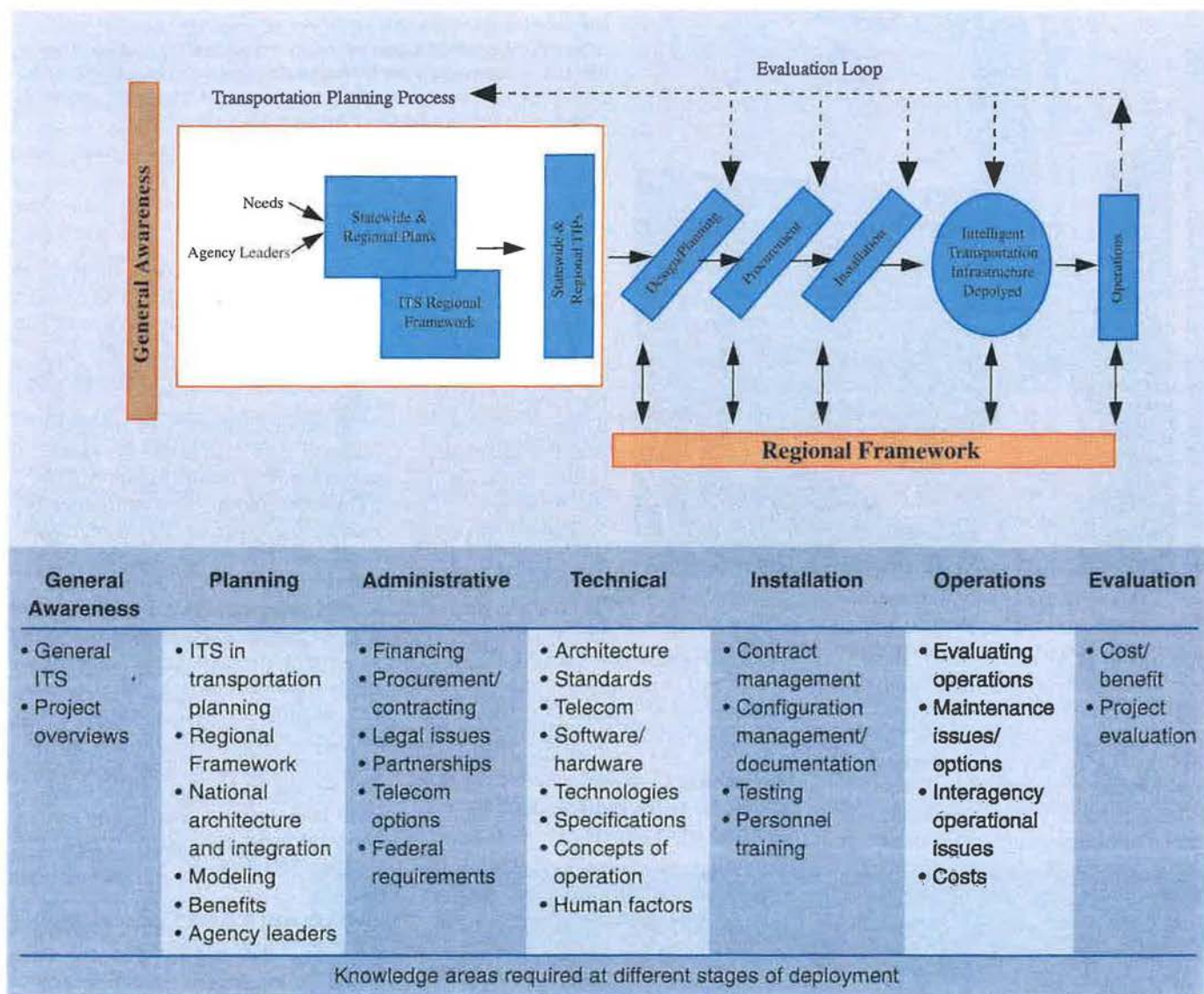


Figure 4 — ITS infrastructure deployment process for metropolitan areas.

ment to support commercially viable ITS products and services.

DOT's Continuing Steps

The whole of the ITS infrastructure is greater than the sum of the parts. But to what degree are states, regions, and municipalities building the whole (an integrated ITS infrastructure) as opposed to randomly purchasing and deploying the parts (individual ITS products and services)? Although system managers and travelers across the country are using ITS products and services, no area has all the components of intelligent transportation infrastructure in place, and with very few exceptions, none has integrated the components into a regional communication and information platform. As a

result, DOT is pursuing several activities to support the deployment of ITS infrastructure across the nation.

Developing Deployment Strategies for ITS Infrastructure

The National ITS Program has developed an Intelligent Transportation Infrastructure Deployment Strategy to meet our goal to help build ITS infrastructure in the 75 largest metropolitan areas over the next 10 years. This strategy outlines a process that includes the promotion of general awareness of ITS infrastructure and its benefits; mainstreaming of ITS projects within the transportation planning process; the development of regional frameworks that are rooted in the National ITS Architecture; installation;

and, finally, operations. The strategy also identifies the essential knowledge and skills that are required for each stage of deployment. This past summer, DOT also began finalizing the Intelligent Transportation Infrastructure Business Plan that provides a detailed work plan to meet the objectives established by the deployment strategy.

Showcasing the Benefits of ITS Infrastructure

The mission of the 1996 Model Deployment Initiative (MDI) is to exhibit ITS infrastructure in metropolitan areas and commercial operations (as well as to showcase successful jurisdictional and organizational working relationships) for public- and private-sector

decision-makers. The four metropolitan sites — Seattle, Phoenix, San Antonio, and the New York City tristate region — will demonstrate the benefits of integrated advanced travel management services that feature a strong regional, multimodal traveler information component.

"We're not interested in buying a few devices and putting them out; we're interested in the infrastructure to support these devices," said the principal administrator for the Phoenix MDI.

The seven CVISN projects — in California, Colorado, Connecticut, Kentucky, Michigan, Minnesota, and Washington/Oregon — will demonstrate the benefits of exchanging CVO safety and regulatory information and conducting compliance transactions electronically.

The MDI projects are expected to conclude by the end of fiscal year 1999. The federal role includes shepherding ITS infrastructure deployment, evaluating the effects and benefits of deployment, and providing technical assistance. The National ITS Architecture is serving as a framework for building ITS infrastructure at these sites.

Creating Funding Incentives

A major gulf exists between traditional transportation planning processes and ITS. The National ITS Program believes that special incentive funding will likely be warranted on a transitional basis for ITS infrastructure to successfully compete for mainstream funding. A March 1997 report by the General Accounting Office entitled *Surface Transportation: Prospects for Innovation Through Research, Intelligent Transportation Systems, State Infrastructure Banks, and Design-Build Contracting* surveyed the perspectives of transportation officials in the nation's 10 largest cities. Officials in six of these cities supported dedicated federal ITS funding. Without this commitment, a transportation planner in New York, as an example, feared that ITS investments would not be able to compete for scarce dollars with higher priority road and bridge rehabilitation projects. The nature and extent of federal funding incentives will be resolved by the National Economic

Crossroads Transportation Efficiency Act (NEXTEA).

Establishing Conformity Criteria for Architecture and Standards

The National ITS Architecture and technical standards, which define ITS elements and how they can work together, are prerequisites to integrated deployments of ITS. As a result, NEXTEA will require "architecture consistency" and the adoption of national standards for all ITS projects that use federal funds. The architecture was completed in July 1996, and the National ITS Program is pursuing an aggressive five-year effort to develop standards. A key effort now is to identify criteria so that localities can ensure that their regional frameworks for ITS infrastructure conform to the national architecture and agreed-upon standards. This conformance will ensure that ITS services in different cities and regions are interoperable.

Building Professional Capacity

The next generation of transportation planners, engineers, and managers at the federal, state, and local levels must be trained to design and build future intelligent transportation systems from a system-integration perspective, as effectively as the civil engineers designed and built the interstate highway system. Elected officials and the general public need to understand how ITS infrastructure can enhance "capacity" through better operations management. Planners need better tools to evaluate the effectiveness of ITS solutions compared with traditional build-or-buy alternatives. And new transportation professionals need to be developed in our universities and colleges. Because professionals with these skills currently do not exist in sufficient numbers to support the effective delivery of ITS, carrying out DOT's five-year Professional Capacity Building Plan is crucial to establishing ITS infrastructure. In Spring 1997, DOT developed implementation and business plans to guide this effort.

Pursuing Research and Development

Ongoing research and development is essential for advancing the real-time and dynamic capabilities of the

components of ITS infrastructure. In addition, in 1997, DOT launched the Intelligent Vehicle Initiative (IVI) to accelerate the development, availability, and use of integrated in-vehicle systems that help drivers of cars, trucks, and buses receive information, make decisions, and operate more safely and effectively. IVI is coordinated by the ITS Joint Program Office, which will provide a single budget for ongoing vehicle-related ITS projects within the Federal Highway Administration, the National Highway Traffic Safety Administration, the Federal Transit Administration, and the Federal Railroad Administration. A key research question will be resolving how smart vehicles can work cooperatively with a smart infrastructure.

Summary

DOT intends to lead, not mandate, the development of the ITS infrastructure — to encourage deployment through incentives instead of imposing rigid spending requirements. We do not propose to work alone, but instead encourage public-sector agencies, with appropriate private-sector support, to build this new infrastructure for the next century. We envision an infrastructure that applies information technologies to meet local needs within a framework that establishes a national, interoperable surface transportation system. We believe this infrastructure will strengthen multiple modes of transportation and link those modes to advance intermodalism. The infrastructure will enable smart sequencing of ITS deployment. Most importantly, we expect that the benefits of ITS infrastructure will transform surface transportation infrastructure, making it more efficient, safe, and cost-effective for travelers and system managers.

Jeff Lindley is the deputy director of DOT's ITS Joint Program Office. Since 1985, he has also held positions in the Federal Highway Administration's Office of Research, Development, and Technology; the Office of Traffic Management and ITS Applications; and Region 9 in San Francisco.

The ITS Professional Capacity Building Program

by Thomas F. Humphrey

"President Clinton has made education his number one priority. In transportation, we have always understood the need to master new skills. Today, we need to learn and relearn. We are moving toward an integrated transportation system. We need to understand all modes of transportation and work side-by-side with all members of the DOT family." — Rodney Slater, Secretary of Transportation

Throughout its history, the U.S. Department of Transportation (DOT) has recognized the need to elevate the knowledge, skills, and abilities of surface transportation professionals to advance new technologies and programs. In the 1950s, the Interstate Highway System required transportation agencies to acquire and develop new road-building and civil engineering skills. In the same decade, the Federal Aviation Administration retrained its staff to master new electronics and advanced information systems that improved air traffic safety and efficiency.

Today, DOT is again rising to the challenge to build professional capacity. This time, DOT is devising innovative training, education, and

outreach programs to advance the deployment of intelligent transportation systems (ITS) infrastructure across the nation.

The introduction of ITS systems and technologies will expand the "business" focus of many public-sector surface transportation agencies from the building and expansion of physical infrastructure to include more intensive operation and management of existing infrastructure. This expansion of focus will fundamentally change the functions and routines of transportation professionals whose daily job is to support the flow of passengers and cargo across the nation.

In particular, ITS deployment will require skills that go beyond the borders of the traditional civil engineering knowledge of many of today's surface transportation professionals. ITS deployment rests upon a foundation of multidisciplinary knowledge, skills, and abilities. It requires expertise in information, communications, electronics, and automation technologies and systems integration. ITS deployment will also require unprecedented cooperation among public-sector agencies and between the public and private sectors, necessitating new skills in partnering, contracting, and negotiations.

Goals of the Professional Capacity Building Program

In March 1996, DOT and the Intelligent Transportation Society of America (ITS America) launched a five-year Professional Capacity Building (PCB) Program to support the national goal to deploy ITS infrastructure in the 75 largest metropolitan areas by 2005. The PCB Program has four primary objectives:

- Ensure that sufficient numbers of trained public transit, highway agency, and motor vehicle regulatory professionals are available to build, operate, and maintain an integrated, interoperable, and intermodal ITS infrastructure, particularly multimodal transportation management and traveler information services.
- Cultivate the next generation of transportation professionals to staff ongoing and future ITS deployments and operations, particularly by instilling interdisciplinary knowledge and skills.
- Increase the awareness of ITS benefits and deployment options among public-sector decision-makers and industry, particularly regarding interjurisdictional cooperation, public-private partnerships, and funding.
- Raise public awareness about ITS benefits and services to create informed transportation users.

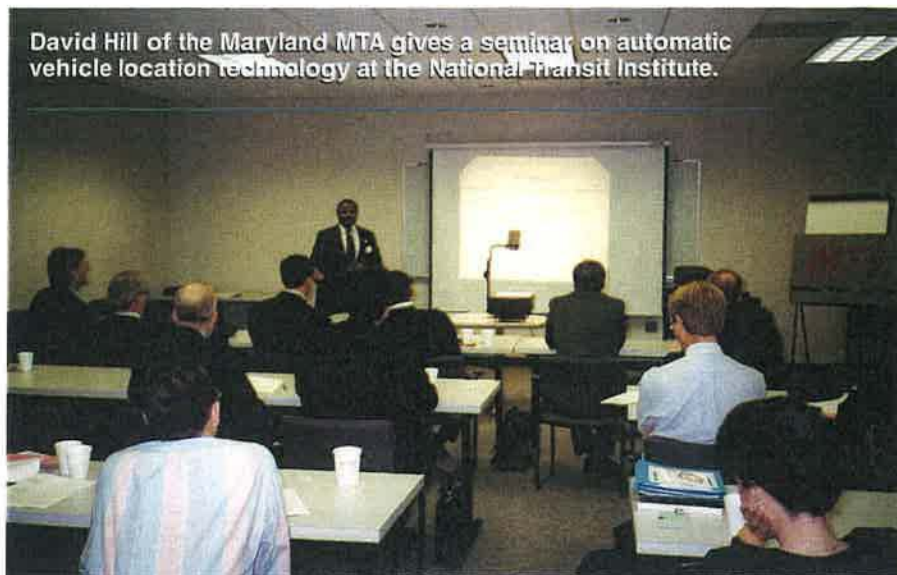
DOT and ITS America guide the PCB Program in cooperation with a steering committee of prominent transportation professionals from government agencies, academic institutions, and the private sector; the commissioner of the Georgia DOT, Wayne Shackelford, serves as the chair.

The Need for ITS Professional Capacity

Since 1992, a series of studies, reports, conferences, and workshops have identified the need to develop a new "breed" of transportation professional to deploy ITS. This early research revealed four fundamental facts.

First, ITS deployment will require skills unfamiliar to today's cadre of

David Hill of the Maryland MTA gives a seminar on automatic vehicle location technology at the National Transit Institute.



transportation professionals. According to a survey conducted by the Institute of Traffic Engineers (ITE), 44 percent of the respondents working within local agencies judged their ability to operate and maintain advanced traffic management systems as fair or poor, and 35 percent of those same respondents stated that the lack of qualified technical and maintenance personnel was a severe or major problem. For state agencies, 50 percent of the respondents rated their ability to operate advanced systems as fair or poor, and 66 percent rated their ability to maintain such systems as fair or poor. Of these respondents, 71 percent felt that improved training would increase their ability to operate their systems, and 100 percent said improved training would increase their ability to maintain such systems.¹

Second, trained ITS professionals do not currently exist in sufficient numbers to effectively support widespread ITS infrastructure deployment. ITS deployment will require more transportation professionals now and in the future. For example, according to ITE, about 550 new entrants to the professional ranks of public-sector traffic operations are needed annually to meet current requirements. An additional 300 to 500 annual entrants are also necessary to meet emerging needs such as ITS. The current curricula at many universities and colleges may be unable to provide these entrants with the requisite knowledge and

skills. Notably, one report found that the "[Civil Engineering] baccalaureate candidate has been exposed to an average of 4.6 credit hours in all transportation subjects. His/her exposure to traffic operations principles and applications can be, literally, zero!"²

Third, we need a deeper and more technical understanding of the requisite knowledge, skills, and abilities needed for ITS deployment. ITS deployment encompasses a broad range of activities, including promoting general awareness of ITS infrastructure and its benefits; mainstreaming ITS projects within the transportation planning process; developing regional frameworks that are rooted in the national ITS architecture; and installing, operating, and maintaining ITS infrastructure.³ We need a comprehensive and systematic method for understanding what unique knowledge, skills, and abilities are required for each stage of ITS deployment and by which particular agencies. We must then develop appropriate education, training, and outreach programs to build professional capacity.

Fourth, we must determine and understand the best methods to deliver ITS training, education, and outreach programs. There are already existing ITS courses, which have been developed by federal agencies and associated training institutes such as the National Highway Institute and the National Transit Institute, state agencies, universities and colleges, and professional

organizations. The PCB Program is determining how these courses could more keenly serve ITS deployment needs. In addition, course development and delivery of both new and existing courses must surmount practical obstacles to learning. An ITE report, for example, identified five critical reasons why transportation staff do not receive adequate training: heavy workload, unavailable funding, long duration of courses, inconvenient place of training, and inconvenient scheduling of courses. Thus, new delivery media such as distance learning, interactive CD-ROM, and other innovative technology-based programs must be pursued.

"Tracking" Professional Capacity

The PCB Program proposes to address professional capacity building needs within a framework that places targeted audiences into three tracks that focus the development and delivery of ITS training, education, and outreach programs.

As shown in the accompanying table, Track 1 targets existing transportation professionals and trained professionals from other fields — including academic faculty and consultants working with public agencies — whose expertise supports ITS. Track 2 advances the development of future transportation professionals and leaders, including students at universities, colleges, and technical and vocational schools. Track 3 builds the awareness of elected and appointed officials who have influence over transportation policies, especially concerning funding, land use, environmental protection, and quality of life. This track also raises the awareness of the traveling public, which benefits from ITS deployment. In little more than a year, the program has made considerable progress in each track.

In Track 1, which addresses the current training needs within the federal ranks, as of the end of May 1997, DOT:

- Presented a one-day ITS Awareness Seminar in 11 DOT regional and in 21 Federal Highway Administration (FHWA) divisional locations. Approximately 800 individuals participated in these seminars. The number of partici-

pants will reach 1,500 by the end of fiscal year 1997.

- Prepared and piloted a four-day course titled "Integrating Intelligent Transportation Systems" in Washington, D.C., in June 1997. This course will be presented to about 400 state, regional, and local professionals by the end of the fiscal year.
- Developed a series of nine one-day technical guidance seminars and workshops targeting federal, state and local ITS professionals. In cooperation with universities and professional associations, the PCB Program will deliver 20 seminars to approximately 500 individuals in 1997. Two workshops on telecommunications have already been presented and are now available to interested states and localities.

In Track 2, which promotes the development of future transportation professionals, we:

- Coordinated with the National Transit Institute (NTI) to develop ITS technology training for the transit industry.
- Launched programs with universities to assess educational needs and design model courses and curricula.

In Track 3, which aims to increase the awareness of public decision-makers, we:

- Developed and delivered Executive Scanning Tours and Reviews, which allowed high-level public-sector officials, legislators, and industry senior executives to view ITS deployments first-hand.
- Developed an Intelligent Transportation Infrastructure "Toolbox" for FHWA and Federal Transit Administration field offices.

Going Forward

Building the professional capacity needed to support deployment of ITS infrastructure is and will continue to be a priority for DOT.⁴ Going forward, the PCB Program will be needs-driven — continuously assessing training, education, and outreach needs. It will develop and offer training and educational programs to meet current and future demands. And it will infuse ITS into the mainstream thinking of government, industry, and academia. Also

PCB PROJECTS FOR TARGETED AUDIENCES			
	Track 1 Current Professionals	Track 2 Future Leaders	Track 3 Deployment Decision-Makers
Program	Training and/or retraining of existing professionals	Facilitating the education of future transportation professionals	Public outreach
Objective	Continuing education and expansion of the trained pool of ITS practitioners	Facilitate the development of next generation of ITS leaders	Informed decision making for transportation and ITS
Substance	Seminars, workshops, short courses	Courses, programs, curricula	Public information
Audience	Federal, state, regional, local	Undergraduates, graduates, faculty	Public decision-makers, elected and appointed officials, pre-college students (K-12)
Media	Classroom, distance learning, CD-ROM, non-traditional forms, WWW	Various new media, traditional classrooms	WWW, PBS/television, literature, video
Delivery Organizations	DOT headquarters, National Highway Institute, National Transit Institute, Local Technical Assistance Program, DOT regions, divisions, technical/vocational schools, universities, private sector, professional associations	Universities, colleges, community colleges, technical schools	Professional associations, public technology companies, ITS America

in the future, the PCB Program will expand to address the professional capacity needed to support rural ITS infrastructure and commercial vehicle information systems and networks (CVISN).

As it has done in the past, DOT will ensure that transportation professionals, decision-makers, and travelers can support and effectively use the technologies and systems — in this case, the new ITS infrastructure — that will advance the safety, efficiency, and quality of the nation's surface transportation systems.

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Thomas F. Humphrey has been the full-time coordinator for the ITS Professional Capacity Building Program since September 1996. He has more than 35 years of professional transportation experience in academia, at the federal and state levels of government, and in the private sector. Before coming to DOT, he was a senior research associate at the Massachusetts Institute of Technology's Center for Transportation Studies.



NHI Charts NEW Course For the Future

by Jacqueline M.
Richardson

"Reinventing government" has become the norm in the 1990s. Without a doubt, public agencies have had to change the way they operate.

In the transport sector, this change has stemmed not only from fiscal considerations, but also from the desire of the public agencies to work closely with private organizations and academic institutions to advance the application of new technologies. This collaboration is vital, for example, to introduce new technologies, such as Intelligent Transportation Systems (ITS) and Superpave, into the mainstream practice of current and future transportation professionals.

Public agencies, such as federal, state, and local transportation departments, have also expressed the desire to exchange information with foreign transportation organiza-

tions — both public and private. For the United States to compete effectively in international markets, its organizations will need to learn about transportation systems abroad and to seek ways to integrate those with U.S. systems.

expanding its reach to other customer groups. For example, NHI is strengthening its ties to universities throughout the United States and providing them with course materials that can be incorporated into their curricula.



Secretary of Transportation Rodney Slater presents Julio Cesar Caballero, director of the Argentinian Portland Cement Institute (*Instituto de Cemento Portland Argentino*), with a plaque, making his organization a permanent Certified Technology Transfer Center of the Pan American Institute of Highways on Sept. 5, 1995.

The collaboration of public transportation agencies with the various groups has clearly heightened the need to share information and to "transfer technology" through high-quality, diverse training and education.

The National Highway Institute (NHI) sees its role as facilitating this transfer of technology through workshops, seminars, training courses, fellowships, and professional exchanges. NHI is already the leading source within the Federal Highway Administration (FHWA) of comprehensive technical training and education programs for transportation professionals. However, NHI is



Dr. Ilene Payne, director of the Universities and Grants Program of NHI, discusses the presentation schedule with fellowship recipients at the 76th Annual Meeting of the Transportation Research Board in January 1997. Recipients of Dwight D. Eisenhower fellowships present their research projects at the TRB meeting every year.

Course Design, Delivery, and Medium

NHI is working with its experts to design courses that are focused on learner results. Based on the theory of Instructional Systems Design (ISD), the approach is to design courses based on what the participants need to learn, how they will use the knowledge they gain, and how they can best retain what they have learned. NHI is making its courses more interactive by building more interaction between the instructor and the class and among class members. Moreover, NHI is including multimedia presentations, group and individual exercises, and tests in its training courses.

NHI is also developing a certification program for instructors. Instructors, many of whom are industry experts, will enhance their presentation skills by applying adult education principles that will improve the effectiveness of the newly designed training courses.

To better reach its customers, NHI is using state-of-the-art technology, such as distance learning (e.g.,



Forty-two participants from 22 countries participate in the "Pavement Distress Identification and Techniques for Rehabilitation and Design" training course at the University of Nevada, Reno, from April 28 to May 8, 1997.

teleconferencing, satellite broadcasts) and computer-based training (e.g., CD-ROM), as well as instructor-led classes. For example, in March and April 1995, NHI's distance-learning course "Load and Resistance Factor Design for Highway Bridge Substructures" was transmitted via satellite simultaneously to 22 state departments of transportation, two technology transfer centers, one city government, and one university. The course was so well received that it was taught in a classroom setting 18 times through the spring of 1996. Likewise, in April and July 1996,

NHI presented the "Seismic Bridge Design Applications" course via satellite to 20 state departments of transportation. An estimated 534 transportation professionals participated in this course.

Personnel

Meeting the needs of its international customers is another challenge that NHI is meeting head on. To better communicate with its non-English-speaking customers, NHI recruited multilingual professionals who speak Spanish, Portuguese, Russian, Czech, German, Finnish,

and Vietnamese. Already, NHI staff and instructors travel to other countries to give technical assistance, hold technology transfer seminars, and deliver training courses in the native language of the country.

NHI also has a new organizational structure in which each staff member is part of a team. Five disciplinary teams represent the areas of concentration — program development, infrastructure and civil engineering, transportation engineering, international training, and universities. Four cross-cutting teams — marketing, process improvement, delivery and fiscal



Participants from FHWA's Washington State Division and from the countries of Zimbabwe and Colombia attend a hands-on demonstration on measuring aggregate properties at the Superpave Regional Lab Center of the University of Nevada, Reno. The demonstration was part of the conference entitled "Pavement Distress Identification and Techniques for Rehabilitation and Design" that was held from April 28 to May 8, 1997.

management, and curriculum delivery and media selection — work to improve the customer outreach, effectiveness, and quality of NHI services in each area of concentration.

"This organizational structure reflects our team approach to developing and delivering innovative training and education programs," said NHI director Moges Ayele.

Lastly, NHI is increasing the number of instructors from within the FHWA to enhance the technical competency of the staff. The FHWA staff is the agency's greatest resource, and NHI can provide opportunities to augment and sustain their expertise.

Customer Service Focus

Responsiveness is a key ingredient to delivering excellent customer service. Recognizing that, NHI is developing tools to solicit and measure customer feedback to its workshops, seminars, courses, fellowships, and professional exchanges. NHI has already reduced its response time in implementing customer requests. NHI can now develop a course in a matter of months; previously, the process could take years.

NHI is also tailoring course materials to the needs of specific groups. It is developing courses that present the same material in a different light, depending on whether the audience includes technicians who actually use transportation technologies, managers who choose to adopt the technologies, or policy-



Greg Speier (left), director of the Pan American Institute of Highways (PIH), leads a work group discussion on national highway maintenance strategies at the PROVIAL seminar in Chile. About 180 transportation professionals from throughout the Americas attended the seminar held Nov. 11 to 15, 1996. NHI serves as the headquarters for PIH.

makers who plan to use the technologies and include them in their budgets.

The 1994 Transportation Research Board Special Report entitled *Highway Research: Current Programs and Future Directions* recognized education and training as being "as important as research in improving highway transportation." The report added that "more must be done because the value of R&D products can be jeopardized by the inability of highway engineers and technicians to adopt and use them properly." The National Highway Institute shares this belief in the importance of training and educa-

tion and stands prepared for challenges ahead.

For more information about NHI or to subscribe electronically to the NHI monthly newsletter, please consult the web page at www.nhi.fhwa.dot.gov.

Jacqueline M. Richardson is the marketing specialist for the National Highway Institute. She manages media relations, writes articles, and designs advertisements promoting NHI products and services. She designed the new NHI web page, which has launched the NHI Public Awareness Campaign.

ROAD SAFETY AUDITS

Scanning for "Gold" Down Under

For more than 100 years, the Federal Highway Administration (FHWA) and its predecessors have recognized that the United States is not the source of every good idea — that there is much to be learned from observing the way other countries solve their highway-related problems.

Therefore, throughout its history, FHWA has been actively involved in technology and information exchange

by sharing American "know-how" and by going to observe, or "scan," how other nations do things. FHWA knows that no matter who first discovers the "gold mine," there are real advantages to sharing the "wealth."

So, for two weeks in late October 1996, a scanning team visited Australia and New Zealand to review the road safety audit process in those countries. The scanning team, sponsored by FHWA, included



A safety audit can be done during the detailed design phase of project development. If a problem is identified, it is easier for a designer working on a computer to erase a line than to move concrete during or after construction is completed.

state, local, FHWA, and academic representatives.

The road safety audit is a process in which a team of experts attempts to identify potentially dangerous features of the highway operating environment. The process is also applicable to existing highway facilities.

The team's conclusion was that road safety audits hold promise for maximizing the safety of roadway design and operations and should, as a minimum, be piloted in the United States.

Road Safety Audits in Australia and New Zealand

The *Road Safety Audit* manual of Austroads — Australia and New Zealand's equivalent of the American Association of State Highway and Transportation Officials (AASHTO) — defines a roadway safety audit as "a formal examination of an existing or future road or traffic project, or any project which interacts with road users, in which an independent, qualified examiner reports on the project's accident potential and safety performance."

The first roadway safety audits were part of a comprehensive accident reduction program. The aim was, and still is, to proactively identify potential safety problems to prevent the occurrence of crashes or to lessen crash severity should a crash occur.



A safety audit includes a review of project design records.



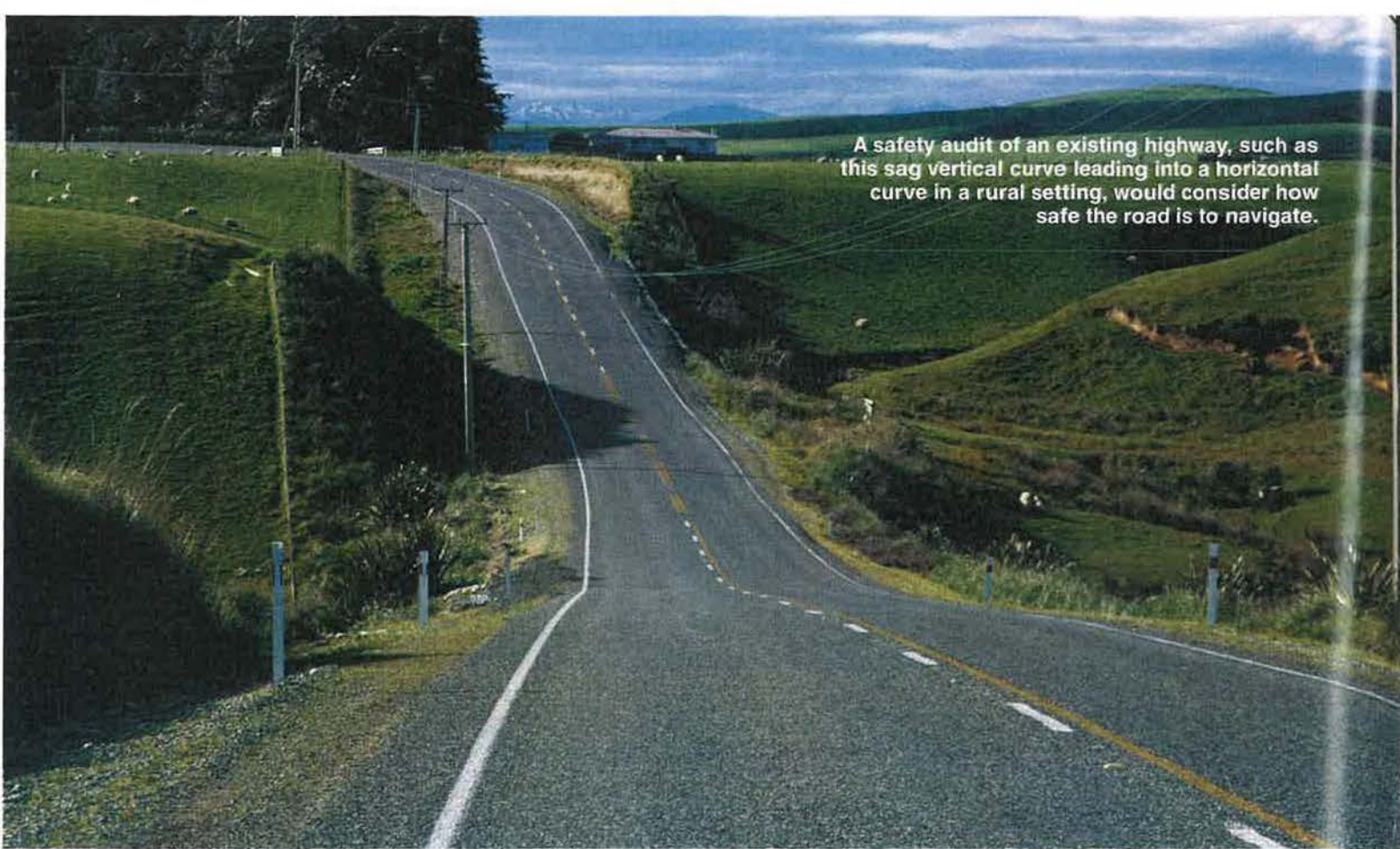
This designer is making a presentation using a plan layout. Safety audits are not just done during the detailed design phase but also during the preliminary (or conceptual) phases.

Road Safety Audit Action Plan

The Office of Highway Safety is promoting a new quality initiative called "road safety audit." Currently used in the United Kingdom, Australia, and New Zealand, the road safety audit provides an independent check on quality in terms of safety during the design and/or operation of roadways.

A number of states will pilot the road safety audit to determine its usefulness and applicability. An action plan has been developed as follows:

- Identify partners interested in promoting or piloting road safety audits — summer/fall 1997.
- Evaluate and revise, as appropriate, road safety audit guidelines for use in the United States — by fall 1997.
- Conduct a workshop with pilot states, partners, and FHWA to work out the final details for conducting the pilots — late 1997 or early 1998.
- Provide training to auditors if necessary — prior to audits.
- Pilot road safety audit in 10 to 12 states — 1998.
- Evaluate the pilots for applicability in the United States. Complete final report post-audits.



A safety audit of an existing highway, such as this sag vertical curve leading into a horizontal curve in a rural setting, would consider how safe the road is to navigate.

Audits are an essential component of an overall safety culture and management system in Australia and New Zealand that commits each person — planner, designer, constructor, and operator — to assume responsibility for his actions.

The scanning team repeatedly heard much about the relationship of roadway safety audits and quality improvement initiatives. In fact, audits were viewed as an integral part of the quality program. Audits were used both as a measure of the integration of safety during the various project stages and as a means for building safety into road projects by eliminating unsafe conditions.

Road safety audits are concerned with the safety of all road users — motorists, pedestrians, and bicyclists — and are sometimes performed during all stages of a project, regardless of size or type. The audit stages are feasibility, draft design, detailed design, pre-opening, and post-opening/existing roadway.

The importance of conducting audits in the feasibility and early design stages was a recurring theme heard by the group.

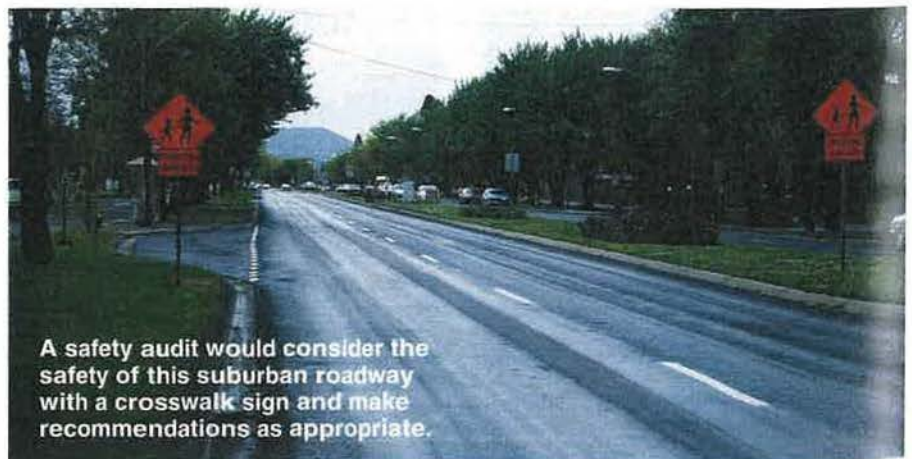
"It is easier, quicker, and cheaper to change a pencil line on a draw-

ing than to move concrete and asphalt after the job is built," the Austroads manual so aptly explains.

In both Australia and New Zealand, the cost of performing the audit was seen as an extremely minimal expense in comparison to the benefits received. For small projects, such as an analysis of an intersection, it costs only a few thousand dollars to review the background information, make a site visit, and produce a report. For large projects, the increases in cost to the overall project to conduct the

recommended reviews at the feasibility, draft design, final design, and pre-opening stages are small, and sometimes the reviews result in changes that actually reduce project costs. Although Australia and New Zealand — and the United Kingdom also — are still quantifying the benefits of audits, the total long-term benefit in reduced crashes was deemed to be many times the cost.

As a matter of fact, the mindset of officials in Australia and New Zealand is that safety audits are essential parts of a good design



A safety audit would consider the safety of this suburban roadway with a crosswalk sign and make recommendations as appropriate.



A safety audit team reviewed the operation of this congested urban intersection and recommended improvements in a brief written report.

process. Thus, safety audits are a necessary cost, not an additional expense.

The Scanning Team Evaluation

The scanning team's report on the trip will be published within the next several months. It will discuss a broad range of issues related to roadway safety audits, including the critical success factors:

- Management's commitment to the audit process as part of an agency's strategic business plan and safety management system plan.
- Multidisciplinary and independent reviews by a qualified individual and/or team.
- Timely and concise documentation of findings by the auditor or audit team.
- Program/project manager's systematic assessment (risk

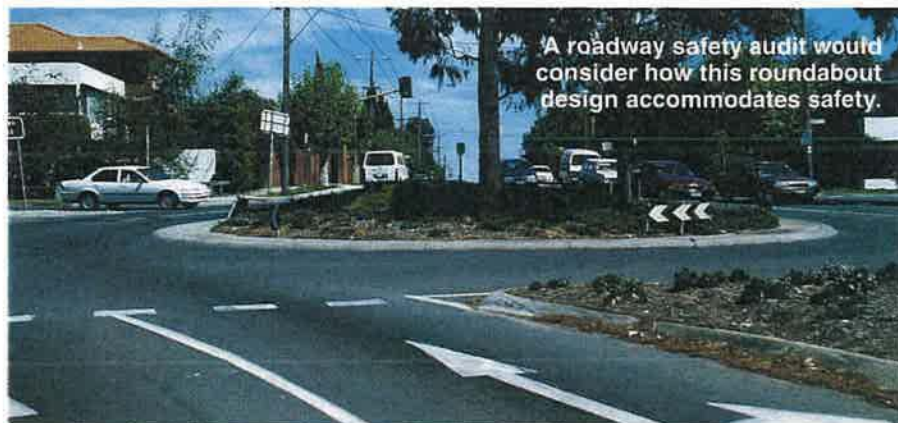
management) to determine if the added benefits exceed the costs and if the findings should be accommodated.

To some on the team, the term "audit" has negative implications because it may seem to indicate that the aim is to catch someone making an error. To others, the term conveys the independence of the activ-

ity. The team decided that the title of the process is really not the significant issue. What is important is the desire and resolve of all parties to implement all the elements of the process to prevent the construction of a roadway that compromises safety.

Very few highways are built to optimal safety design; resources, land, community disturbance, and other constraints do not allow it. However, the safety audit requires the full consideration of safety issues just as the environmental impact statement requires a full review of environmental factors.

FHWA's Office of Highway Safety will solicit states this year to pilot the road safety audit program in 1998. A workshop will be held in late 1997 or early 1998 for participating states and industry partners. The training of auditors will be provided, if necessary, prior to the pilots. The operational implementa-



A roadway safety audit would consider how this roundabout design accommodates safety.



The members of the scanning team (from left) are James Shanafelt, Martin Lipinski, Michael Trentacoste, Patti Boekamp, Eugene Wilson, David Manning, Leanna Depue, Greg Schertz, and Thomas Werner.

The group of nine from the United States was multidisciplinary and comprised of all levels of government and academia:

- Patti Boekamp, Engineering and Capital Projects Department, city of San Diego.
- Leanna Depue, Missouri Safety Center, Central Missouri State University.
- Martin Lipinski, Department of Civil Engineering, University of Memphis.
- David Manning, Director, Transportation Safety Office, Wisconsin Department of Transportation.
- Greg Schertz, FHWA Regional Safety Engineer, Lakewood, Colo.
- James Shanafelt, Washington State Department of Transportation.
- Michael F. Trentacoste, Director of Highway Safety, Office of the Associate Administrator for Safety and Systems Applications, FHWA.
- Thomas Werner, Director, Traffic Engineering and Safety Division, New York State Department of Transportation.
- Eugene M. Wilson, Department of Civil Engineering, University of Wyoming.

Also accompanying the group was Bruce Corben, Senior Research Fellow, Monash University, Clayton, Victoria, Australia.

Implementing Road Safety Audits in the United States

The Institute of Transportation Engineers (ITE) has a Transportation Safety Council committee called Implementing Road Safety Audits in the United States. The committee is chaired by Weston S. Pringle Jr.

The goal of the committee is to use the recommendations in the FHWA road safety audit scanning report and the experience of the committee to develop an informational report on the need, value, and procedure to apply road safety audits in the United States. This informational report will serve to

build consensus with governors, state traffic engineering administrators, and practitioners.

The committee conducted its first meeting in January 1997 and is currently reviewing the draft report from the FHWA road safety audit scanning review. A draft outline of the informational report is being prepared.

Committee members include Weston S. Pringle Jr., Weston Pringle & Associates; Ian Appleton, Transfund New Zealand; Joseph M. Fiocco, Pennsylvania Department of Transportation;

Beatrice Isaacs, University of Hartford; James C. Jeffrey, Engineering Consulting Services; Paul K. Harker, Federal Highway Administration; Phillip W. Jordan, Vic Roads Corp; Eugene R. Russell, Kansas State University; and Martin A. Wallen, Wallen Associates.

For more information about this committee, please contact Louisa M. Ward, technical program manager for traffic engineering and safety, ITE, 525 School St., SW., Suite 410, Washington, DC 20024-2797.

tion of the road safety audits by the pilot states will be assessed. The Office of Highway Safety will sponsor the evaluation in coordination with the other partners.

In the United States over the next decade, hundreds of billions of dollars will be spent by cities, states, and the federal government to rebuild our infrastructure. Safety is always identified as a top priority in programming, designing, and constructing highway projects. The road safety audit process has significant potential to ensure that quality design and safe operations are the top priorities in all stages of those projects.

Michael F. Trentacoste is the director of FHWA's Office of Highway Safety. Previously, he held several top positions with the Office of Motor Carriers, including director of planning and customer liaison, director of field operations, and director of motor carrier standards. He has also worked in the Federal Railroad Administration and the Office of the Secretary of Transportation. He has a bachelor's degree in civil engineering from Manhattan College and a master's degree in transportation from Northwestern University. He is a member of the American Society of Civil Engineers and a registered professional engineer in the state of New York.



Three members of the U.S. scanning team — from left, Mike Trentacoste, David Manning, and James Shanafelt — participate in an actual field review.



Two safety auditors review the project layout in the field. Field review is a part of the roadway safety audit process.

Interactive Highway Safety Design Model: Design Consistency Module

by Raymond A. Krammes

Introduction

The Federal Highway Administration (FHWA) has a high-priority research program to develop and implement the Interactive Highway Safety Design Model (IHSDM). IHSDM is an integrated system of modules that highway planners and designers can use to evaluate the safety of highway geometric design alternatives within a computer-aided design (CAD) environment.

This article focuses on design consistency, one of five modules that comprise IHSDM. Before turning to design consistency, however, it is important to understand the overall structure of IHSDM. Then, the concept and measures of design consistency and its evaluation within IHSDM will be discussed. To conclude, an example is given to illustrate the prototype Design Consistency Module.

IHSDM

In its current form, available information on the safety effects of highway planning and design decisions is not readily usable to evaluate and compare design alternatives. The lack of convenient evaluation tools limits a designer's ability to detect potential safety problems in design, to select safety cost-effective design parameters, and "to compare the



A typical two-lane rural highway.

safety of various alternatives or to optimize the safety of a particular design."¹ From a broader perspective, it is difficult to assess tradeoffs between safety versus social, environmental, and economic impacts. As a result, differences in safety performance may not be given due consideration in deciding among design alternatives.

IHSDM is envisioned as a computer-based tool that facilitates evaluation of the safety implications of design alternatives throughout the planning, design, and review phases of typical highway construction or reconstruction. For ease of use, it is being developed in a CAD environment, in which most design work is currently performed. The initial development efforts are re-

stricted to two-lane rural highways, such as the one pictured above. Two-lane rural highways are the largest single class of highways, representing approximately two-thirds of all federal-aid highways. Because of their age, condition, and crash experience, they are common targets for improvement projects. As such, they are also a logical initial focus for IHSDM. A second phase of IHSDM development will add the capability to evaluate multilane design alternatives.

As illustrated in figure 1, IHSDM is structured in five modules:

- *Accident Analysis Module* will consist of three models: one that estimates the number and severity of crashes on specified

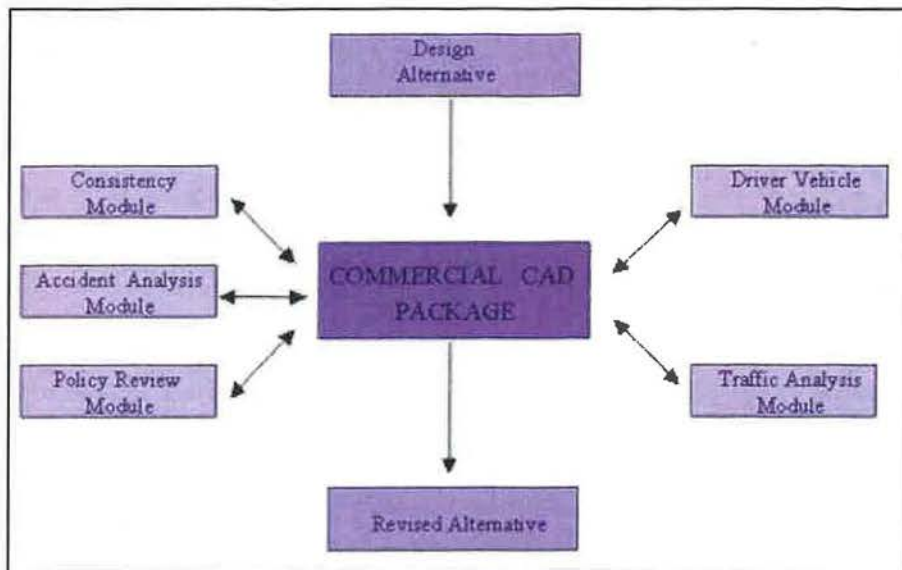


Figure 1 — Structure of IHSDM.

highway segments; a second that performs safety benefit-versus-cost analyses of alternative roadside designs; and a third that uses an expert systems approach to evaluate intersection designs, identify geometric deficiencies that may impact safety, and suggest improvements that correct these deficiencies.

- *Design Consistency Module*, as described in more detail in this article, will evaluate the consistency of a design relative to drivers' speed expectations.
- *Driver/Vehicle Module* will consist of a Driver Performance Model linked to a Vehicle Dynamics Model, which will permit the designer to evaluate how various drivers would operate a given vehicle (e.g., passenger car or tractor-trailer) through a design and identify whether conditions exist that could result in loss of vehicle control (e.g., skidding or rollover).
- *Traffic Analysis Module* will use existing microscopic traffic simulation models to estimate likely operating conditions on a design under current and projected traffic volumes.
- *Policy Review Module* will evaluate design elements for conformance with established design policies (AASHTO, state, or local), identify elements that deviate from those policies, and aid the designer in documenting

the safety implications of those deviations.

IHSDM provides an integrated collection of evaluation tools that estimate safety-related measures of effectiveness, identify areas for improvement, and compare design alternatives. A users group representing state departments of transportation and FHWA field offices provides periodic input to ensure that these tools are responsive to

the needs of the user community. FHWA is also working with civil design software vendors through cooperative research and development agreements so that IHSDM can be integrated into those software packages for delivery to highway planners and designers.

This article is the third in a series on IHSDM in *Public Roads*.^{2,3} Future articles will describe other modules.

Design Consistency

Drivers are inclined to interpret and react to roadway features or situations as if those situations were similar to what they have experienced previously, whether or not they actually are similar. As a result, drivers are more likely to become confused and, possibly, commit errors at features that violate their inclination — or, in human factors terminology, driver expectancy — than at features that are consistent with their inclinations. Therefore, design consistency, which refers to a roadway design's conformance with driver expectancy, is an important roadway characteristic from a safety perspective.

Driver errors related to inconsistent geometric features typically occur in guidance (i.e., speed and path) decisions. Current design policy specifies that a design speed should be selected and applied

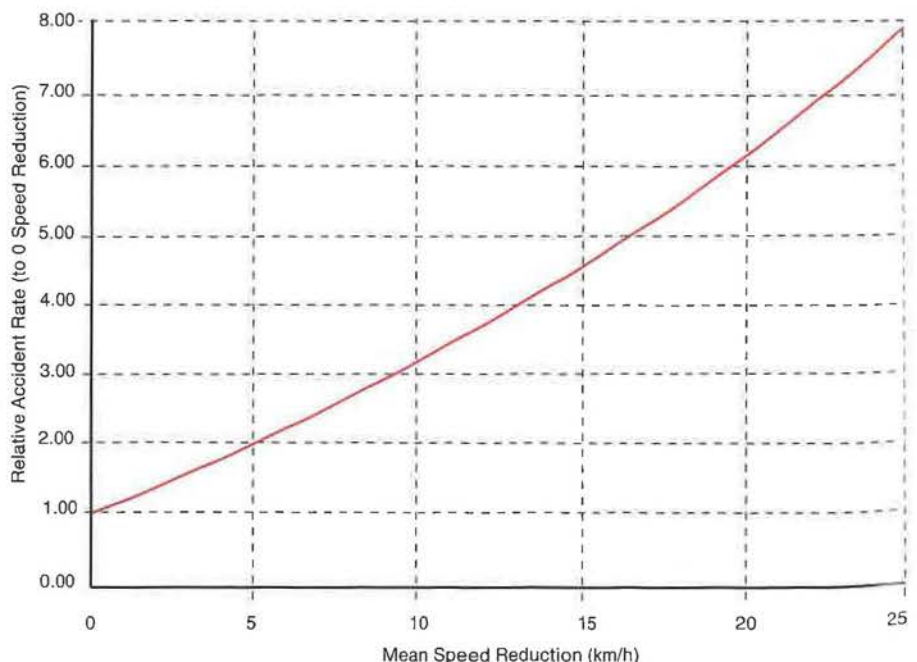


Figure 2 — Relative crash rate versus speed reduction on horizontal curves.

along a roadway in order to avoid geometric features that require unexpected and, therefore, error-prone adjustments in speed.

It has become apparent, however, that the design-speed concept, as currently applied, is not sufficient to ensure design consistency measured in terms of the uniformity of operating speeds along a roadway.⁴ A roadway's design speed is the maximum speed at which a driver can operate uniformly through all geometric features of the roadway without deviating from assumed design criteria. Thus, a single design element (e.g., a sharp curve) may result in a relatively low design speed when, in fact, drivers may be able to operate at speeds higher than the design speed on the rest of the roadway without exceeding any design criteria. Since most drivers travel as fast as they feel comfortable and slow down only where necessary, rural highways with lower design speeds exhibit uneven operating speed profiles. That is, drivers accelerate to their desired speed on tangents and gentle curves and decelerate only on sharper curves.

Crash studies have shown that the larger the speed reduction required from the preceding tangent to the subsequent curve, the higher the crash rate on the curve — i.e., the higher the required speed reduction, the more likely it is that some drivers will not reduce their speed as much as required. Figure 2 summarizes relative crash rates on curves that require speed reductions compared to curves that do not require speed reductions.⁵ For example, the expected crash rate on curves that require a 10-km/h speed reduction is three times the rate on curves that require no speed reduction.

Therefore, the primary measure of design consistency for two-lane rural highways is the expected reduction in 85th percentile speed between the approach tangent and the middle of a curve. Expected speed reductions are derived from a speed-profile model that estimates speeds at each point along a roadway as a function of the geometry of the roadway. The model combines estimated 85th percentile speeds on curves and desired speeds on long tangents with esti-



Figure 3 — Plan view of a proposed two-lane rural highway.

mated deceleration and acceleration rates entering and departing curves to produce the speed profile.

A model has been calibrated for passenger vehicles in level and rolling terrain (i.e., vertical grades less than 5 percent) as a function of horizontal alignment geometry.⁴ The calibration was based on more than 20,000 passenger vehicle speed measurements at 138 curves and 78 tangents on 29 two-lane rural highways in five states. Research is underway to expand the model to consider a wider range of horizontal and vertical alignment conditions and to calibrate it for other vehicle types (i.e., trucks and recreational vehicles).⁶

Prototype Design Consistency Module

FHWA's Geometric Design Laboratory at the Turner-Fairbank Highway Research Center has developed a prototype of the Design Consistency Module. To illustrate the use of the module, it was applied to the two-lane rural highway shown in figure 3. This plan view shows

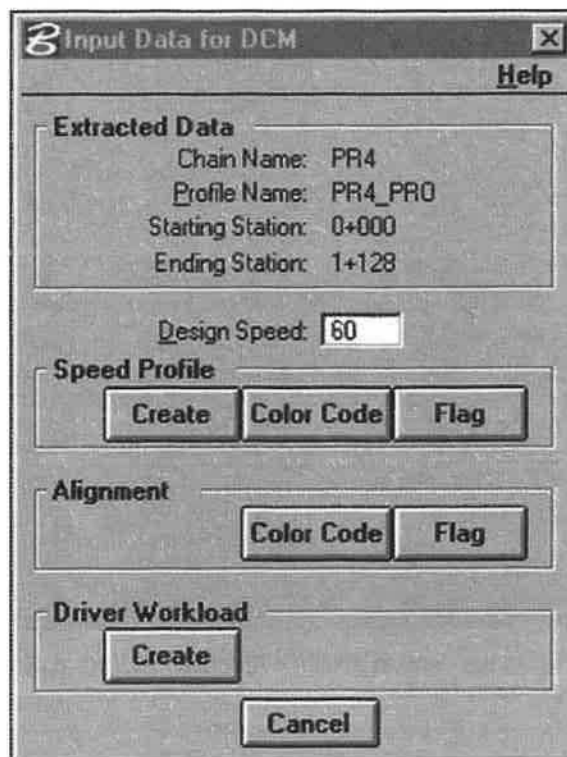


Figure 4 — Dialog box for design consistency module.

the 1.1-km highway's horizontal alignment, which consists of four tangent segments and three circular curves. The alignment has a 60-km/h design speed.

The Design Consistency Module is executed through a dialog box within the CAD environment, as illustrated in figure 4. The first step

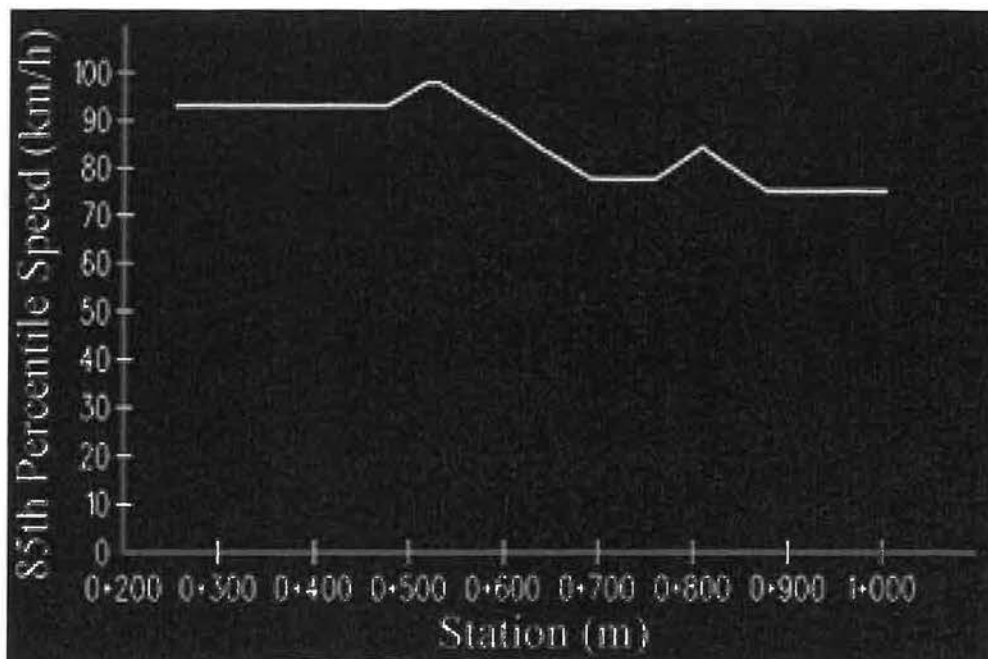


Figure 5 — Estimated 85th percentile speed profile for proposed highway.

than 10 km/h, yellow indicates a difference between 10 and 20 km/h, and red indicates a difference of more than 20 km/h. Figure 6 illustrates that the design of the roadway should be expected to elicit 85th percentile speeds that exceed the design speed by more than 20 km/h over much of its length.

In figure 7, the colored flags indicate the magnitude of differences in 85th percentile speeds from each tangent to the succeeding curve. Green flags indicate speed changes no more than 10 km/h, yellow indicates a change between 10 and 20 km/h, and red indicates a change greater than 20 km/h. According to figure 2, the expected crash rate on the curve with the red flag is more than six times the rate of a curve requiring no speed reduction.

The information provided in figures 6 and 7 allows planners and designers to double-check their design-speed assumption. Figure 6 alerts designers that 85th percentile speeds are likely to be significantly higher than the assumed design speed, and figure 7 identifies with a red flag the curve where resulting safety impacts would probably be greatest.

Since speed influences many alignment and cross-section design decisions, a large discrepancy between design and 85th percentile speeds would prompt the designer to consider design modifications that increase the design speed and/or decrease likely 85th percentile speeds. If the assumed design speed is, in fact, the appropriate target speed considering the roadway's function, then the designer would seek design modifications that would influence drivers to operate more uniformly at that target

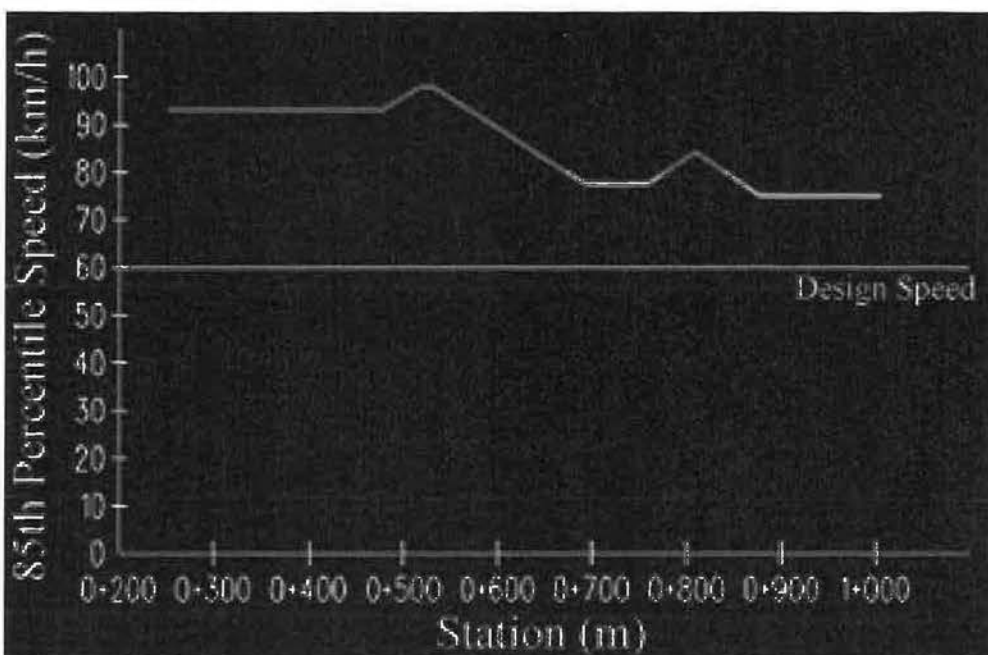


Figure 6 — Speed profile with color-coding of differences between design and operating speeds.

in evaluating design consistency is to "create" the speed profile by "clicking" that button.

Figure 5 shows the resulting, estimated 85th percentile speed profile. It has the characteristic sawtooth shape of operating speeds along a highway whose design speed is less than most drivers' desired speed. The profile includes three curves — represented by horizontal lines that indicate the speed on each curve based upon its sharpness — and two intervening tan-

gents — represented by the spikes between the curves that indicate acceleration out of one curve and deceleration into the next curve.

To facilitate interpretation of these results, the user may request options in the dialog box to "color-code" or "flag" the speed profile. In figure 6, the color-coding of the speed profile indicates how much 85th percentile speeds deviate from the design speed. Green represents 85th percentile speeds that differ from the design speed by no more

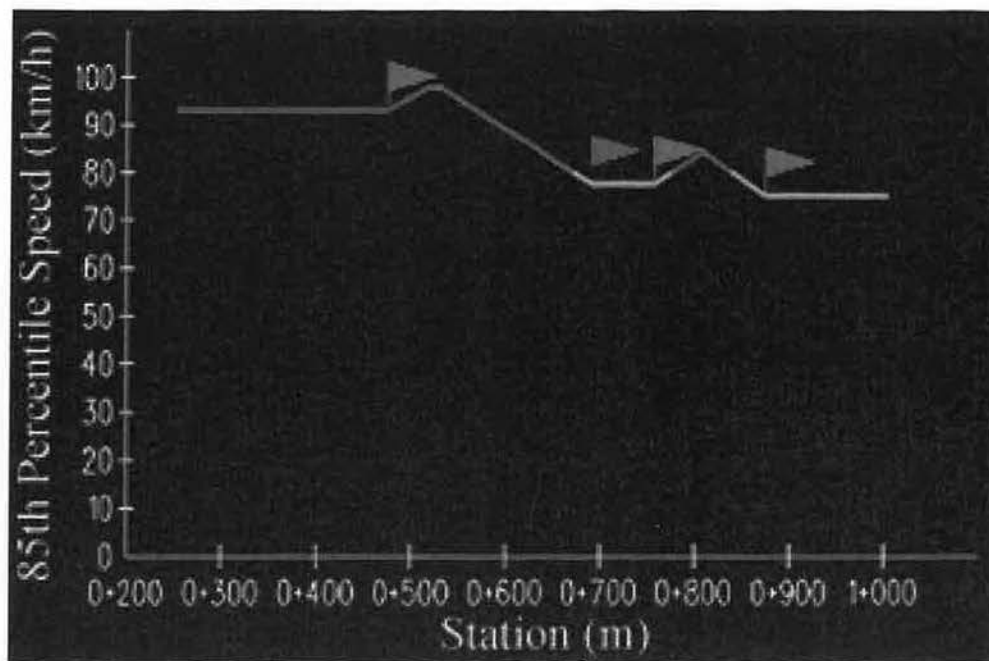


Figure 7 — Speed profile with flags for required speed reduction.

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Raymond A. Krammes is a senior highway research engineer in FHWA's Office of Safety and Traffic Operations Research and Development, Safety Design Division. Before joining FHWA in 1997, he spent 11 years conducting research at the Texas Transportation Institute and teaching transportation engineering in the Civil Engineering Department at Texas A&M University. He received bachelor's, master's, and doctoral degrees in civil engineering from Pennsylvania State University. He is registered as a professional engineer in the state of Texas.

speed — for example, sharpening the flatter curves and/or shortening tangent lengths. If a higher design speed is desirable, then the designer would need to consider another set of modifications to accommodate a higher speed — for example, flattening sharper curves, increasing sight distance, widening the clear zone, and flattening roadside slopes. Whereas these modifications may be feasible for a new roadway, they would be impractical on many existing roadways. If social, economic, environmental, or other constraints preclude these modifications, then the designer should consider other actions to mitigate potential safety impacts. Possible actions include widening or paving shoulders on sharper curves, removing or relocating roadside obstacles, relocating or increasing sight-distance triangles at intersecting roadways on curves, and providing supplementary signing and pavement marking treatments.

Summary

The Design Consistency Module provides highway planners and designers with feedback about the reasonableness of their design-speed assumption. The color-coding and flagging alert designers to design elements that require extra attention. Designers could respond to this feedback by changing the

design speed, adjusting the design to smooth out the speed profile, and/or taking other actions to improve safety. In contrast, current design procedures provide no feedback that highlights potential safety problems; as a result, designers may not realize opportunities to make feasible refinements that would improve safety.

A prototype of the Design Consistency Module is currently available. Ongoing research, scheduled for completion in 1999, will validate the module and expand its scope to consider a wider range of horizontal and vertical alignment conditions and to provide speed estimates for trucks and recreational vehicles. The expanded module will be beta-tested by members of the IHSDM users group, refined as necessary, and made available for stand-alone use and for incorporation into commercial civil design software packages.

Future *Public Roads* articles will review the Accident Analysis, Driver/Vehicle, Policy Review, and Traffic Analysis Modules of IHSDM, which provide additional measures of safety effectiveness. Development efforts are in progress for each module, and versions will be released as individual modules are completed. The scheduled release date for the full IHSDM, consisting of all five modules, is 2002.

The Search for the Optimal Asphalt

by Dr. Brian Chollar and Dr. Mohammed Memon

The Office of Engineering Research and Development of the Federal Highway Administration (FHWA) is constantly looking for new materials and methods to improve the quality of our nation's highway system. At the Turner-Fairbank Highway Research Center (TFHRC), research on chemically modified asphalts is an ongoing project that has already resulted in furfural-modified asphalt, compatibilized crumb rubber asphalt (CCRA), and chemically modified crumb rubber asphalt (CMCRA), all of which were developed by the authors of this article. But at FHWA, the search for the optimal asphalt continues, and this time, it has simply taken a different route.

Chemically modified crumb rubber (CMCR) has been used successfully to improve both high- and low-temperature performance grade specifications in many types of asphalts, including those with low asphaltene levels. Data shows that the performance grade of an asphalt with an asphaltene content of only 0.3 percent can be improved significantly. Test results show the expansion of its performance grading from 46-16 to 76-32, which expands its useful temperature range from 62°C to 108°C. CMCRA is also more homogenous and has a lower separation range after heated stor-

age than conventional crumb rubber-modified asphalts (CRMA). Such a low separation range is an exciting result because it is expected to deter pavement raveling, leading to longer life for these pavements.

So far, CMCRA has only been tested in small laboratory quantities. However, the results indicate that it may possibly be one of the most cost-efficient modified asphalts in the industry. As the National Asphalt Pavement Association's vice president Dale Decker stated, "This new crumb rubber technology may produce high-performance pavements, but the costs and mix performance must be tested in full-scale production before it can be considered a viable product for replacing other modified asphalts." Consequently, scaled-up production is soon to be held, where different quantities of CMCRA will be tested to determine whether the binder's reactivity, separation, and rheological properties are consistent at each stage of production with those recorded at TFHRC's laboratories.

After seeing that a chemical modification to crumb rubber significantly upgraded the performance of neat or virgin asphalts, researchers at TFHRC pursued a similar procedure with polymer-

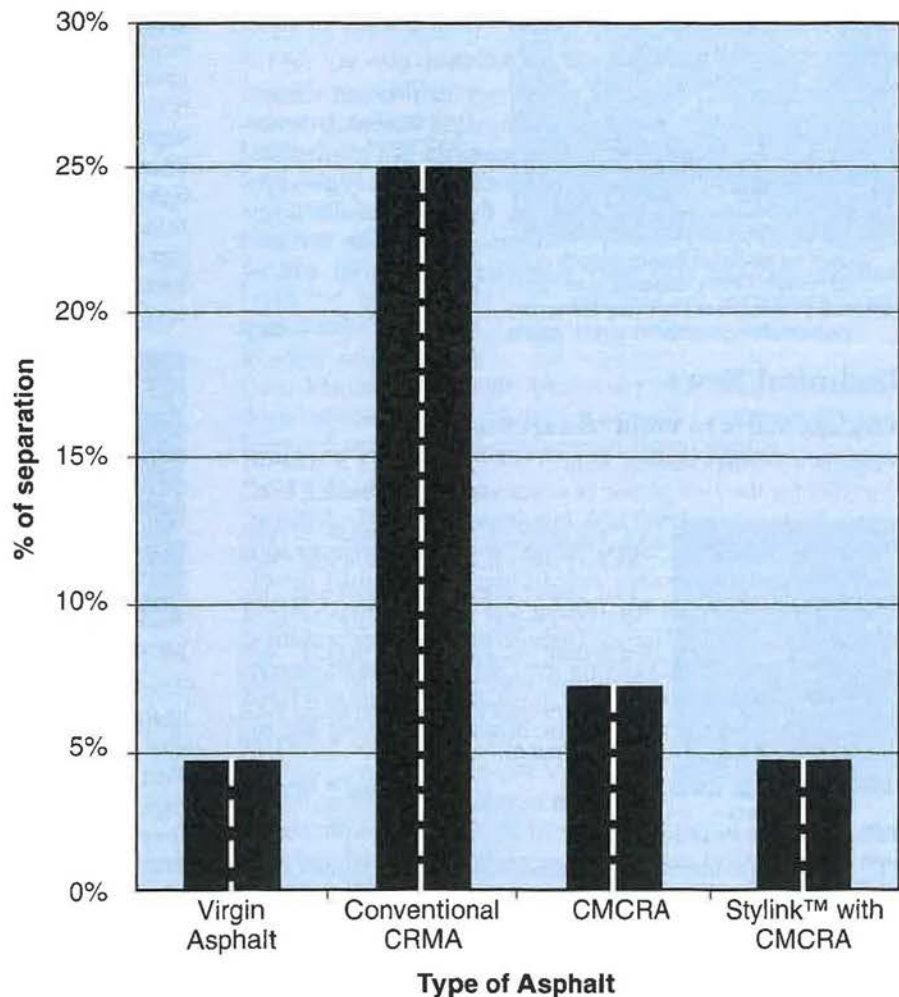
modified asphalts. Unlike conventional polymer-modified asphalt, CMCRA enhanced the interaction of polymer functional groups within polymer-modified asphalt system, containing both normal and low asphaltene contents. This new development led to an improvement in the rheological properties of the chemically modified binder by one performance grade for both high and low temperatures, as well as in its homogeneity. For example, Stylink™, a trade name for a particular polymer in asphalt, has exhibited separation features very similar to those of virgin asphalt after being combined with chemically modified crumb rubber. That is, the difference in stiffness between the top and bottom third of a chemically modified Stylink™ binder after 24 hours of heated storage was found to be only between 2 percent and 4 percent. Figure 1 compares the propensity of four types of asphalt to separate or settle during heated storage.

American Association of State Highway and Transportation Officials (AASHTO) binder performance data also showed that the predicted fatigue performance of three Stylink™ binders is improved by one performance grade (brought down from 19°C to 16°C) when

combined with CMCR. Although further research is needed on combining CMCR and polymer-modified asphalts, the procedure has been disclosed for patenting purposes, and interest is gaining momentum across the asphalt industry.

Dr. Brian Chollar is a research chemist in the Office of Engineering Research and Development at the Turner-Fairbank Highway Research Center in McLean, Va. Dr. Chollar has worked for FHWA for 23 years. His areas of expertise are asphalt chemistry and snow and ice chemicals for winter maintenance. He received his bachelor's degree in chemistry from Purdue University and his doctorate in organic chemistry from the University of Minnesota.

Dr. Mohammed Memon is also a research chemist working in the Office of Engineering Research and Development at TFHRC. He has worked for FHWA as a contractor for six years. His areas of expertise are asphalt and polymer chemistry. He received his doctorate from the University of Sindh in Pakistan.



Asphalt's propensity to separate after 24 hours of heated storage.

"Along the Road" is the place to look for information about current and upcoming activities, developments, trends, and items of general interest to the highway community. This information comes from Federal Highway Administration (FHWA) sources unless otherwise indicated. Your suggestions and input are welcome. Let's meet along the road.

Policy and Legislation

Secretary Slater Commends the D.C. Seat Belt Law

U.S. Secretary of Transportation Rodney E. Slater commended the District of Columbia for enacting a primary enforcement seat belt law that will serve as a model for the nation. The new law, enacted on April 9, 1997, becomes effective Oct. 1, 1997. The primary enforcement law allows law enforcement officers to stop vehicles and issue citations for no other reason than not using seat belts. Forty-nine states have laws requiring motorists to use seat belts, but only 11 have primary seat belt laws. The goal of the law is to increase seat belt use by 12 to 15 percentage points within a year. The district now has a seat belt use rate of 58 percent, 10 percentage points lower than the national average.

Management and Administration

HITEC Signs MOU With ITS America

The Highway Innovative Technology Evaluation Center (HITEC), a center of the Civil Engineering Research Foundation (CERF), has signed a Memorandum of Understanding (MOU) with ITS America to work to move highway-related innovations into practice through technology evaluations. HITEC and ITS America will offer complementary services and work together to promote educational events for the industry.

— CERF

Technical News

Virginia Starts to Build "Smart Road"

Virginia's Transportation Board awarded a \$17.3 million contract for the first phase of construction on the 9.5-kilometer highway that will link Interstate 81 and Blacksburg, Va. The nation's first "Smart Road" will offer a direct route for motorists and provide researchers and product developers a research lab for testing the latest transportation technologies. The Virginia Department of Transportation (DOT), Virginia Tech's Center for Transportation Research, and FHWA will build the road in phases and hope to have more than one kilometer of the Smart Road ready for research purposes by summer 1998.

— Smart Travel™ Virginia

ITS America Petitions FCC

ITS America petitioned the Federal Communications Commission (FCC) to add Intelligent Transportation Services as a mobile service with co-primary status in the 5.850 to 5.925 GHz band. Currently, FCC's Location and Monitoring Service, a part of the FCC's Transportation and Infrastructure Radio Services, covers the 902- to 928- MHz bandwidth. This 902- to 928- MHz bandwidth, which is used by ITS interests for toll and commercial vehicle op-

erations, is too small and too congested to support current and future dedicated short-range communications applications, according to the petition. The petition must undergo a lengthy review process, which will probably take nearly two years to complete.

— ITS America

Public Information and Information Exchange

DOT Provides \$100,000 for "Smooth Operator" Program

Secretary Slater announced that the U.S. DOT will provide a \$100,000 grant to "Smooth Operator," a regional public awareness and enforcement program targeting aggressive drivers in the Washington, D.C., metropolitan area. The program involves conducting aggressive driver traffic enforcement on the Capital Beltway.

D.C. Mayor Tests Traffic Signal Control System

During ITS America's Seventh Annual Meeting and Exposition in Washington, D.C., in June, Mayor Marion Barry Jr. rode with an ambulance crew through intersections equipped with a 3M™ Opticom™ Priority Control System. The system, created to make proceeding through traffic stopped at a red light safer, helps to prevent dangerous predicaments by allowing the ambulance to change the traffic signal. To operate the system, an ambulance is equipped with an emitter and sends a beam to a detector attached to a traffic signal, which will then change a red light to green. This demonstration was the first step in testing the priority control system and was made possible through a partnership between the D.C. Department of Public Works and the Federal Highway Administration.

— ITS America

ITS America Honors Traveler Information Systems

ITS America announced top achievement awards last month at the society's Seventh Annual Meeting and Exposition. The winners included TravInfo, an up-to-the-minute traffic information service for San Francisco travelers; Houston TranStar, a traffic and emergency management service; and the Atlanta Traveler Information Showcase, a real-time traveler information disseminator.

— ITS America

NCAC Presents 1997 Collection to Smithsonian

The FHWA/NHTSA National Crash Analysis Center (NCAC) at the Virginia campus of The George Washington University submitted material to the Smithsonian Institution's Permanent Research Collection of Information Technology Innovation at the National Museum of American History in Washington, D.C. Each year, the Computerworld Smithsonian Chairmen's Committee nominates individuals who are using information technology to improve society. Under the Transportation category, FHWA/NHTSA submitted information on computer crash simulation software that lowers the cost of testing automobile structures and provides more complete data for researchers and regulators.

— Computerworld Smithsonian Awards

Evaluation Service for Innovative Building Technologies Is Created

The Civil Engineering Research Foundation (CERF) and the National Evaluation Service (NES) have formed an evaluation service designed to expedite the introduction of innovative technology into the building marketplace. The service has come about after two years of planning through the Partnership for Building Innovation and will be administered by the NES. Through the expert panel process, the service will evaluate all types of building technologies, including products, designs, and construction processes.

— CERF

Personnel

Jane Garvey Named FAA Administrator

Jane Garvey, former deputy administrator of the Federal Highway Administration, was confirmed as the administrator of the Federal Aviation Administration by voice vote in the Senate on July 31.



Jane Garvey

ASCE Honors Sen. Warner and Rep. Oberstar



John Warner

The American Society of Civil Engineers elected Sen. John W. Warner (R-Va.) and Rep. James L. Oberstar (DFL-Minn.) as Honorary Fellows. Warner chairs the Subcommittee on Transportation and Infrastructure, and Oberstar is the ranking Democrat on the House Committee on Transportation and Infrastructure. The committee is responsible for reauthorization of the Intermodal Surface Transportation Efficiency Act (ISTEA). The Honorary Fellow is the society's highest honor for non-members.

— ASCE



James Oberstar

Gloria Jeff Is Acting Federal Highway Administrator

Gloria Jeff, FHWA associate administrator for policy, will serve as acting federal highway administrator. Transportation Secretary Slater made the announcement Aug. 4.

Curtis Shufflebarger, Jr. Died Aug. 4

Curtis L. Shufflebarger, retired chief of the Interstate and Program Support Branch of the Office of Engineering, died Aug. 4. Shufflebarger, who had a 30-year career with the FHWA, primarily in the Office of Interstate and Program Support, Federal Aid and Design Division, Office of Engineering, retired five years ago. He was a graduate of

Virginia Military Institute. He is survived by his wife, Virginia, his two children, and four grandchildren.

Anthony Kane Is Acting Deputy Federal Highway Administrator

On Aug. 4, Secretary Slater appointed Anthony Kane, FHWA executive director, to serve as acting deputy federal highway administrator.



Valentin Riva

ACPA Appoints New President

Valentin J. Riva has been named president of the American Concrete Pavement Association (ACPA). Riva is ACPA's third president since the association was founded in 1964. He succeeds M.J. Knutson, who will be retiring later this year.

— American Concrete Pavement Association

Thomas Pasko Retires

Tom J. Pasko retired Aug. 1, 1997, after 36 years of service with FHWA. He was director of the Office of Advanced Research from 1992 to 1995 and was most recently in charge of intergovernmental programs. He received both his bachelor's and master's degrees in civil engineering from Pennsylvania State University and completed additional graduate-level courses at Cornell University. He is a licensed professional engineer in Pennsylvania.



Tom Pasko (right) receives an award from Bob Betsold, FHWA associate administrator for research and development, at his retirement celebration.

Carl Izzard Died July 8

Carl F. Izzard, a former director in the Office of Research and Development from 1968-1970, died July 8 at the age of 92. Izzard, called the "Father of FHWA Hydraulics" because of his extensive research and contributions to the industry, earned a degree in civil engineering from Stanford University and attained a master's degree in hydraulics engineering from the University of Iowa. During his 43-year career with FHWA, he established a hydraulic research branch in the Office of Research, created an integrated research program for the entire Office of Research and Development, and was a founding member of the Urban Hydrology Research Council of the American Society of Civil Engineers. He is survived by his wife, Mary, and his two daughters, five grandchildren, and one great-grandchild.



Carl Izzard

by Kristin Iden

"Internet Watch" tracks new and interesting developments in transportation resources on the Internet.

Academia and Transportation on the Web

Intermodal transportation, paratransit, horseshoe induced damage on roadways, evaluation of moisture-sensitivity tests for hot-mix asphalt, geographic information systems (GIS) for transit are just a small sampling of the topics available on academic web sites. From software downloads to research reports, the academic sponsored sites are full of current, ongoing, and past research. Any bibliographic search should include a stop at a few of these sites:

To begin, stop by the Texas Transportation Institute (<http://tti.tamu.edu>) for a glance at the incredible amount of information stored on their site. TTI has a huge site; the research and development area spans the following categories: economics and planning, materials and pavements, safety, structural systems, systems planning, traffic operations, and transportation systems. This site is a wonderful resource for someone starting a research project or to find current information.

Another site from Texas comes from the Center for Transportation Research at the University of Texas at Austin (<http://www.utexas.edu/depts/ctr/index1.html>). The center is the research component of the Bureau of Engineering Research at the university. Current research information includes topics in the following areas: pavement materials, design and management; traffic science and traffic engineering; and transportation engineering.

The Pennsylvania Transportation Institute (PTI) is an interdisciplinary research unit within Penn State's Intercollege Research Programs, a collection of the university's research facilities under the direction of the senior vice president for research and dean of the Graduate School. This site (<http://www.pti.psu.edu/welcome.htm>) covers research in the areas of pavements, materials and construction, transportation operations, transportation structures, and vehicle systems and safety.

Chartered by the North Carolina General Assembly in 1977, the Institute for Transportation Research Education (ITRE) at the University of North Carolina (<http://itre.ncsu.edu/>) conducts research, education, and technical assistance projects on a wide variety of transportation issues for local, regional, and national agencies. As a non-profit, systemwide university transportation center, ITRE draws from the professional and technological resources of the 16-campus University of North Carolina system, Duke University, and other universities throughout the Southeast.

The University of California at Davis's Institute of Transportation Studies (<http://www.engr.ucdavis.edu/~its/>) was formally established in 1991 to organize and promote multidisciplinary research of complex transportation problems. Among the research summaries available online are abstracts about energy and environmental analysis, transportation economic evaluation, travel behavior analysis, hybrid and electric-drive vehicles, and transit and paratransit.

The School of Civil and Environmental Engineering at Georgia Tech (<http://www.ce.gatech.edu/Centers/TREC/trec.html>) sponsors the Transportation Research and Education Center (TREC). More than 80 faculty and research staff are associated with TREC, making it one of the largest centers in the United States. The advanced transportation research topics online include radar propagation studies, traffic monitoring accuracy, signal timing improvement, automated highway system, traffic data integration, and adaptive signal control system.

The Center for Urban Transportation Research (CUTR) at the University of Florida (<http://www.cutr.eng.usf.edu/index.html>) has an emphasis on developing innovative, implementable solutions to transportation problems. Among the areas of research are public transportation, intelligent transportation systems, transportation demand management, transportation for the disabled and elderly, transportation economics, geographic information systems, access management, alternative fuels, and transportation safety.

The University of Wisconsin-Milwaukee Center for Urban Transportation Studies (<http://www.uwm.edu:80/Dept/CUTS/>) provides full text research. In addition, the site lists ongoing training and development for transportation industry professionals.

Each of these sites contains links to many other web-based research sites. For a listing of these and other online resources, see the Useful Links page (<http://www-.tfhrc.gov/site/linkpage.htm>) on the Turner-Fairbank Highway Research Center site (<http://www.tfhrc.gov>). If you have any links you would like to suggest, please e-mail them to the web master at TFHRC.

The next "Internet Watch" will be a review of the Federal Highway Administration web sites and other related DOT sites. Happy surfing!

Kristin Iden is the webmaster/electronic publishing specialist for the Federal Highway Administration's Turner-Fairbank Highway Research Center in McLean, Va. She is employed by Avalon Integrated Services Corp. of Arlington, Va.

RECENT PUBLICATIONS

The following are brief descriptions of selected reports recently published by the Federal Highway Administration's (FHWA) Office of Research and Development. All publications are available from the National Technical Information Service (NTIS). In some cases, limited copies of publications are available from the R&T Report Center.

When ordering from NTIS, include the NTIS PB number (or publication number) and the publication title. For customers outside the United States, Canada, and Mexico, the cost is double the listed price. Address requests to:

**National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
Telephone: (703) 487-4650**

Requests for items available from the R&T Report Center should be addressed to:

**Federal Highway Administration
R&T Report Center, HRD-11
9701 Philadelphia Court, Unit Q
Lanham, MD 20706
Telephone: (301) 577-0818**

Long-Term Pavement Performance Information Management System Data Users Reference Manual

Publication No. FHWA-RD-97-001

The publication presents an overview of the Long-Term Pavement Performance Information Management System (LTPP IMS) program and the data available to researchers. The NTIS number is PB97-164073; the cost is \$21.50 for a paper copy or \$10 for the report on microfiche.

Preliminary Vehicle Impact Simulation Technology Advancement (Pre-VISTA)

Publication No. FHWA-RD-96-059

This report evaluates the current finite element technology capability applied to roadside hardware design and vehicle crashworthiness research using the non-linear structural code DYNA3D. The NTIS number is PB97-135818; the cost is \$31 for a paper copy or \$14 for the report on microfiche.

Detection Technology for IVHS, Volume II: Final Report Addendum

Publication No. FHWA-RD-96-109

This addendum contains the results of analyses for an addition 39 runs of the experiment. The Detection Technology for IVHS project identified traffic parameters and their required accuracies for characterizing traffic flow. The NTIS number is PB97-126353; the cost is \$28 for a paper copy or \$14 for the report on microfiche.

Opportunities for Advanced Vehicle Control Systems in Commercial Vehicle Operations and Public Transportation Systems

Publication No. FHWA-RD-96-139

Public transportation and freight movement systems provide an ideal application for Advanced Vehicle Control Systems (AVCS). This paper explores present research relevant to automatic control for trucks and buses. The NTIS number is PB97-126445; the cost is \$21.50 for a paper copy or \$10 for the report on microfiche.

Impedance Spectroscopy for the Evaluation of Corrosion Inhibitors in Highway Deicers

Publication No. FHWA-RD-96-178

Electrochemical impedance spectroscopy (EIS) measurements were carried out on steel bars that were exposed to solutions, some containing corrosion inhibitors. This report evaluates the effectiveness of the inhibitors over an 11-month period. The NTIS number is PB97-142764; the cost is \$25 for a paper copy or \$10 for the report on microfiche.

Determination of Pile Driveability and Capacity from Penetration Tests, Volume I: Final Report

Publication No. FHWA-RD-96-179

This report highlights research conducted on the potential improvement of dynamic wave equation analysis methodology using in situ soil-testing techniques. The NTIS number is PB97-163935; the cost is \$44 for a paper copy or \$19.50 for the report on microfiche.

LTPP Data Analysis, Phase I: Validation of Guidelines for k-Value Selection and Concrete Pavement Performance Prediction

Publication No. FHWA-RD-96-198

This publication examines the effect of slab support on concrete pavement performance. The NTIS number is PB97-136725. The cost is \$35 for a paper copy and \$14 for the report on microfiche.

Pavement Treatment Effectiveness, 1995 SPS-3 and SPS-4 Site Evaluations, National Report

Publication No. FHWA-RD-96-208

This publication evaluates the performance of SHRP SPS-3 and SPS-4 experiment sites based on field reviews after five years of performance. The NTIS number is PB97-156897; the cost is \$25 for a paper copy or \$10 for the report on microfiche.

FHWA Vehicle Crash Analysis Conference Proceedings

Publication No. FHWA-RD-96-212

The Turner-Fairbank Highway Research Center sponsored university research on finite element (FE) modeling of vehicle impact with a variety of safety structures. This report is a compilation of seven university research papers commissioned for the study. The NTIS number is PB97-152763; the cost is \$35 for a paper copy or \$14 for the report on microfiche.

Conferences/Special Events Calendar

Dates	Conference Theme	Sponsor	Location	Contact
Sep 13-18 1997	International Public Works Congress and Exhibition	American Public Works Assn.	Minneapolis, Minn.	APWA (816) 472-6100
Sep 16-19 1997	South African Transport Conference and Transport Expo '97	The Chartered Institute of Transport in South Africa	Johannesburg, South Africa	Cilla Taylor (confplan@iafrica.com) (012) 63-1681 Fax: (012) 63-1680
Sep 17-19 1997	European DIVINE Concluding Conference	Organisation for Economic Co-operation and Development	Rotterdam, The Netherlands	Boudewijn Hoogvelt (hoogvelt@wt.tno.nl) +31 15 269 64 11 Fax: +31 15 269 73 14
Sep 22-23 1997	New Hampshire High-Performance Concrete Showcase	N.H. Dept. of Transportation, Univ. of N.H., Federal Highway Administration	Waterville Valley, N.H.	K. DesRoches (kathy.desroches@unh.edu) (603) 862-2826 Fax: (603) 862-2364
Sep 25-27 1997	City Trans Asia Conference '97	City Trans Asia Management Pte Ltd.	Singapore	Conf. Secr. (mpconven@singnet.com.sg) +65 297 2822 Fax: +65 292 7577
Oct 2-4 1997	ACEC 1997 Fall Conference	American Consulting Engineers Council	Salt Lake City, Utah	Jen Lobner (www.acec.org) (202) 347-7474 Fax: (202) 898-0068
Oct 5-8 1997	Workshop on Composite Materials: Processing and Mechanics	N.M. Inst. of Mining and Technology, Institute for Mechanics and Materials	Mescalero, N.M.	Marilyn Samms (immevent@imm.ucsd.edu) (619) 534-0710 Fax: (619) 534-8908
Oct 6-8 1997	1997 Western Bridge Engineers' Seminar	FHWA and DOTs of Alaska, Arizona, Calif., Idaho, Nevada, Oregon, & Wash.	Coeur d'Alene, Idaho	Jean Canfield (360) 943-7732
Oct 11-15 1997	IBTTA 65th Annual Meeting	International Bridge, Tunnel and Tumpike Association	Denver, Colo.	IBTTA (202) 659-4620 Fax: (202) 659-0500
Oct 19-22 1997	ATA Management Conference and Exhibition	American Trucking Associations	Las Vegas, Nev.	Gail Wright (703) 838-1755
Oct 20-22 1997	International Symposium on High-Performance Concrete (in conjunction with 43rd PCI Annual Convention and Exhibition)	FHWA, Precast/Prestressed Concrete Institute	New Orleans, La.	PCI (info@pci.org) (312) 786-0300 Fax: (312) 786-0353
Oct 20-24 1997	ASNT Fall Conference and Quality Testing Show	The American Society for Non-Destructive Testing Inc.	Pittsburgh, Pa. (614) 274-6003	ASNT (www.asnt.org) Fax: (614) 274-6899
Oct 21-24 1997	4th Annual World Congress on Intelligent Transport Systems	Intelligent Trans. Society of America, VERTIS, ERTICO	Berlin, Germany	Sandra Fitzgerald (www.itsa.org) (202) 484-2902
Oct 29-31 1997	Fifth Annual U.S. Hot Mix Asphalt Conference and Superpave Workshop	National Asphalt Pavement Assn., State Asphalt Pavement Assns., Asphalt Institute	Phoenix, Ariz.	NAPA (888) 468-6499 Fax: (301) 731-4621
Nov 5-7 1997	Asia-Pacific DIVINE Concluding Conference	Organisation for Economic Co-operation and Development, ARRB Transport Research	Melbourne, Australia	Sue Hailes (sueh@arrb.org.au) +61 3 9881 1578 Fax: +61 3 9887 8104
Nov 9-12 1997	IEEE Conference on Intelligent Transportation System	Institute of Electrical and Electronics Engineers	Boston, Mass.	IEEE Boston Section (617) 890-5290 Fax: (617) 890-5294
Nov 9-14 1997	ACI Fall Convention (Theme: Durability)	American Concrete Institute	Atlanta, Ga.	ACI (810) 848-3795 Fax: (810) 848-3796
Nov 14-18 1997	AASHTO Annual Meeting	American Assn. of State Highway and Transportation Officials	Salt Lake City, Utah	Hannah Whitney (202) 624-5800

Dates	Conference Theme	Sponsor	Location	Contact
Dec 2-5 1997	ACI Annual International Conference on High-Performance Concrete: Design and Materials and Recent Advances in Concrete Technology	ACI, Amer. Soc. of Civil Engineers, NIST, CANMET, et al.	Kuala Lumpur, Malaysia	ACI Member Services Dept. (248) 848-3700 Fax: (248) 848-3701
Jan 11-15 1998	TRB 77th Annual Meeting	Transportation Research Board	Washington, D.C.	Angie Arrington (202) 334-2362
Feb 18-20 1998	Colorado High-Performance Concrete Showcase	Colo. DOT, FHWA, Univ. of Colo.	Denver, Colo.	Mark Leonard (Mark.A.Leonard@dot.state.co.us) (303) 757-9486 Ext. 486 Fax: (303) 757-9197
Mar 10-13 1998	Latin American ITS Regional Conference (Theme: Deploying ITS in Latin America)	ITS America, International Road Federation	Buenos Aires, Argentina	Kip Stacy-Protts, ITSA (202) 484-4542
Mar 23-27 1998	9th Asia-Pacific Conference on NDT (in conjunction with ASNT Spring Conference and 7th Annual Research Symposium)	The American Society for Non-Destructive Testing Inc.	Anaheim, Calif.	ASNT (www.asnt.org) (614) 274-6003 Fax: (614) 274-6899
Mar 29-Apr 3 1998	ACI Spring Convention (Theme: Structural Design)	American Concrete Institute	Houston, Texas	ACI (810) 848-3795 Fax: (810) 848-3796
May 3-7 1998	9th REAAA Conference: Strategies for the Future	Road Engineering Assn. of Asia and Australasia	Wellington, New Zealand	Fiona Knight (www.wcc.govt.nz/wfcc/default.htm) +64 4 499 6600 Fax: +64 4 496 6666
May 4-6 1998	ITS America 8th Annual Meeting	ITS America	Detroit, Mich.	Bonnie Jessup (www.itsa.org) (202) 484-2896
May 10-13 1998	Third International Workshop on Concrete Block Paving	Columbian Institute of Cement Producers, Pan American Institute of Highways, et al.	Cartagena de Indias, Colombia	Secretariat, PAVE COLOMBIA 98 (icpc.med@venus.interpla.net.co) +57 4 2605400 Fax: +57 4 2303248
Jun 7-9 1998	International Congress on Underground Construction in Modern Infrastructure	Swedish Natl. Road Admin., Swedish Natl. Rail Admin., et al.	Stockholm, Sweden	Secretariat (congrex@congrex.se) +46 8 459 66 00 Fax: +46 8 661 91 25
Jun 14-19 1998	CIMTEC '98 (9th International Conf. on Modern Materials and Technologies): World Ceramics Congress and Forum on New Materials	Gruppo Colorobbia, Academy of Ceramics, et al.	Florence, Italy	CIMTEC '98 (www.dinamica.it/cimtec98) +546 664143 Fax: +546 664138
Jul 18-23 1998	Structural Engineers World Congress		San Francisco, Calif.	Dr. Ang, Univ. of Calif. at Irvine (714) 824-8528
Sep 9-12 1998	ITE 68th Annual Meeting	Institute of Transportation Engineers	Toronto, Ont., Canada	ITE (202) 554-8050 Fax: (202) 863-5486
Sep 13-16 1998	8th International Symposium on Concrete Roads	Associacao Tecnica da Industria de Cimento	Lisbon, Portugal	ATIC Fax: (351 1) 352 50 99
Oct 25-28 1998	ATA Management Conference and Exhibition	American Trucking Associations	New Orleans, La.	Gail Wright (703) 838-1755
Nov 6-10 1998	AASHTO Annual Meeting	American Assn. of State Highway and Transportation Officials	Boston, Mass.	Hannah Whitney (202) 624-5800
Nov 8-12 1998	5th Annual World Congress on Intelligent Transport Systems	ITS America, VERTIS, ERTICO	Seoul, Korea	Sandra Fitzgerald (www.itsa.org) (202) 484-2902



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In addition to the NHI article in this issue of *Public Roads*, you will find articles and other information about the National Highway Institute in the following publications:

Vial (Highway Sector) — July/August issue
Engineering News Record — Aug. 4 issue
Urban Transportation Monitor — August issue
Caminos del Perú (Roads of Peru) — August issue
Research and Technology Transporter — September issue
Constructor de Caminos (Road Constructor) — October issue

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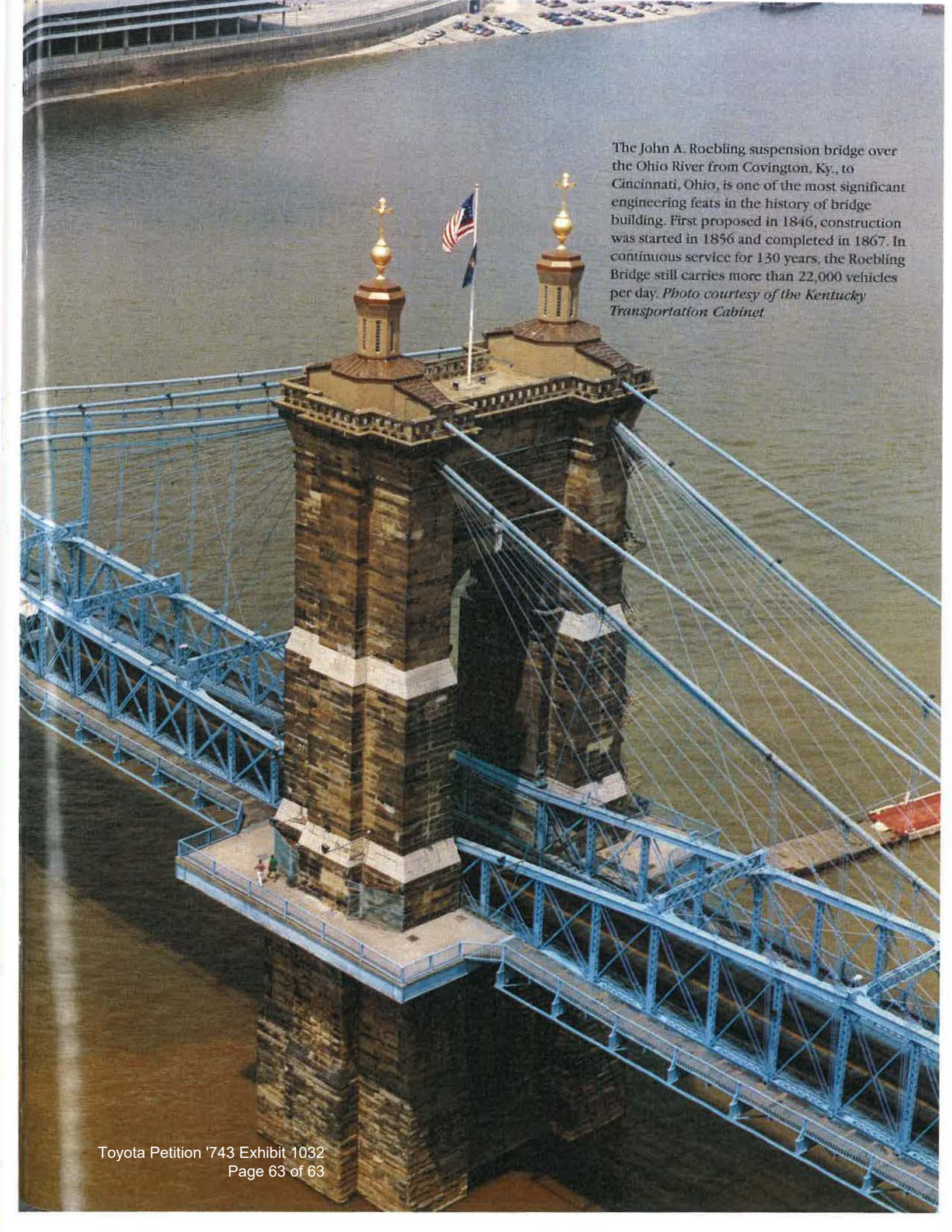
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An aerial photograph of the John A. Roebling suspension bridge over the Ohio River. The bridge features two large, ornate stone towers with gold-colored domes and crosses on top. A flagpole with the American flag stands between the towers. The bridge deck is supported by a complex system of blue steel trusses and suspension cables. The river is visible in the background, and a parking lot with many cars is seen at the top of the image.

The John A. Roebling suspension bridge over the Ohio River from Covington, Ky., to Cincinnati, Ohio, is one of the most significant engineering feats in the history of bridge building. First proposed in 1846, construction was started in 1856 and completed in 1867. In continuous service for 130 years, the Roebling Bridge still carries more than 22,000 vehicles per day. *Photo courtesy of the Kentucky Transportation Cabinet*