

# 1996 RESEARCH AND TECHNOLOGY PROGRAM HIGHLIGHTS

**NOTE TO READER:**

**THIS IS A LARGE DOCUMENT**

Due to its large size, this document has been segmented into multiple files. All files separate from this main document file are accessible from links ([blue type](#)) in the [table of contents](#) or the body of the document.

1996

# research & technology

*program highlights*



Federal Highway Administration

This report highlights the activities and accomplishments of the Research and Technology Program of the Federal Highway Administration during fiscal year 1996-October 1, 1995 through September 30, 1996. Information was gathered through interviews with key FHWA officials and staff.

**FHWA ADMINISTRATOR**

Rodney E. Slater

**DEPUTY ADMINISTRATOR**

Jane F. Garvey

**RESEARCH AND TECHNOLOGY EXECUTIVE BOARD**

**Executive Director**

Anthony R. Kane

**Associate Administrator**

**for Policy**

Gloria J. Jeff

**Associate Administrator  
for Research and Development**

Robert J. Betsold

**Associate Administrator  
for Program Development**

Thomas J. Ptak

**Associate Administrator for  
Safety and System Applications**

Dennis C. Judycki

**Associate Administrator  
for Motor Carriers**

George L. Reagle

**Associate Administrator  
for Administration**

George S. Moore

**Director, Joint ITS Program  
Office**

Christine M. Johnson

**Regional Administrator, Region 3**

David S. Gendell

**Regional Administrator, Region 9**

Julie A. Cirillo

While supplies last, copies of this report are available without charge from:

Turner-Fairbank Highway Research Center  
Publications Office, HRD-10  
6300 Georgetown Pike, McLean, VA 22101-2296  
Telephone No.: (703) 285-3103

# contents

Reaching Out, Reaching Ahead. . . . .	2
Intelligent Transportation Systems. . . . .	6
Pavements . . . . .	12
Structures . . . . .	15
Materials . . . . .	19
Highway Policy, Planning, and Operations. . . . .	22
Environment. . . . .	28
Safety . . . . .	31
Freight and Motor Carriers . . . . .	34
Conclusion. . . . .	38
R&T Coordinating Groups. . . . .	40
Abbreviations . . . . .	41

# reaching out,

*Here in the Research and Technology Program of the Federal Highway Administration, we deal with pretty complicated ideas, cutting-edge technologies, and state-of-the-art innovations to*



*improve the overall condition of the US. transportation system. Our R&T program also has “intermodal interfaces” to ensure that we emphasize intermodalism-highways as a part of a comprehensive transportation system that includes all modes of transportation in efforts to meet increasingly complex social needs-and to ensure that our program is contributing to a coherent and strategic technology program for the U.S. Department of Transportation (USDOT). But because we are the RGT Program of FHWA, we need to get those ideas, technologies, and innovations into the minds and hands of those who can, in turn, get them out onto the roads.*

*So, on the one hand, we’re always looking ahead--to the next technology, the next big breakthrough. And on the other hand, we’re always looking outward-out to the field, where our work is implemented.*

## Closing the Technology Gap

In this report, we talk about some of the work we did in fiscal year (FY) 1996. We divide our accomplishments into, first, those things we did to close the gap between the state of the art and the state of the practice- between what we know in the laboratories and what our customers are doing out there on the highways. We have a lot of ways we try to close the gap- showcases, conferences, demonstrations, training, technology transfer, meetings, the World Wide Web, newsletters and technical assistance. We try to let people see, hear, touch, and use our innovations: if a picture is worth a thousand words, a demonstration is worth a thousand pictures. We pull out all the stops to get people to try what we know works. They'll be convinced when they see for themselves. And one new thing we're trying is a "lead State program." This approach to getting Strategic Highway Research Program (SHRP) products adopted and used invites States to become the

advocate or champion of a specific technology. We ask them- rather than us- to promote the technology. We give them technical support in their efforts; they get the prestige of leadership and innovation- and, of course, the latest and best technologies.

But it cuts both ways. We need to know what the folks in the field who deal with practical problem-solving and technology applications want to know. We need to know what our customers don't know or don't like. That knowledge gap is another one we're constantly trying to close. In the "old days," we operated primarily from an oversight role; over the years, that stance has shifted increasingly to technical assistance. But you don't provide assistance where it isn't needed or wanted. So we solicit input. We survey and canvass. We visit and observe. We use focus groups, hold conferences and collect case studies. This past year, for example, through the National Quality Initiative, we published our first-ever National Highway User Survey to find out how satisfied the average driver is with

# reaching ahead





the highway system. We also beefed up our Priority Technologies Program; this two-year-old effort lets our field offices take the lead in prioritizing the innovative technologies they want deployed. These examples of “bottom-up” feedback are vital to ensuring that we provide the products and services our customers want.

We close another gap when we highlight and publicize the innovations of one country, field office, State, metropolitan planning organization, or private company. We share these best practices through tried-and-true methods of technology transfer. We use the best practices as benchmarks for our own efforts. The international scanning tours we take are a good example of that approach.

The purpose of the International Technology Scanning Program is to observe, discuss, and document successful transportation-related practices of foreign countries for dissemination to the U.S. transportation engineering and contracting community. Four successful scanning reviews were undertaken in 1996, facilitating future cooperation and exchange in the areas of bridge coatings, pavement technology, traffic management systems, and traffic monitoring. The ultimate objective of the scanning program is to implement in the United States the most advanced technology and practices.

The key to closing gaps is communication-up, down, and across. We have set up several institutions to house this communication, notably our 57 Local Technical Assistance Program technology transfer cen-

ters and 5 new Superpave regional centers. Internationally, our involvement with key organizations—such as the Organisation for Economic Co-operation and Development, and the World Road Association (formerly the Permanent International Association of Road Congresses), and the Pan American Institute of Highways—ensures communication flow. And we formalize our efforts to close information gaps with cooperative agreements with private sector partners, States, and foreign countries.

### Pushing the Envelope

We also talk in this report about projects we did this year that pushed the envelope. Wild and crazy things that shouldn’t work, but do. Erudite, elegant analyses that further our understanding and appreciation of complex economic or environmental phenomena. Futuristic research with brand-new materials and techniques. Breathtakingly complex computer models. Highways and cars that talk to each other.

We push the envelope in other ways as well—notably, in the cutting-edge ways in which we are closing the information gap and the innovative ways in which we are contracting to have our work done. We are Trendsetters in our management and training techniques, as well as in our research.

For example, we just initiated a prestigious annual lecture series on current and future trends in this country that will affect transportation in the next 10 to 20 years. The first lecture was presented by Jeremy Rifkin, author of *The End of Work*. We live in a remarkable time; massive changes are going on in this country. We are trying to capture and highlight these changes through this lecture series.

We’re using the hottest technologies available to get information around the world and down the block. We put on two courses this year via “distance learning”-satellite transmission. This technique lets us reach well over 1,000 students at a time.

We’re putting masses of information on the Web and on CD-ROM’s. These searchable media let people get exactly what they need when they need it—a capability an unindexed user’s manual could never offer. We’re

also producing computerized interactive training for self-paced instruction.

An important note about training: it used to be that highway-related technology turned over about every 20 or 25 years, so whatever courses you put together would be current for a couple of decades. Today, in about 80 percent of the courses we offer through our National Highway Institute, the technology turns over every 5 years. And in some areas, we can't even put formal courses together; instead, we offer twice-yearly seminars covering the state of the art of the moment. We have to do more training and encourage more people to take the training—all because the boundaries are being pushed so rapidly in so many areas.

We're also using more creative ways to get the job done. This does not just refer to the innovative contracting that we're using in our design and construction projects but also to our new practice of working with contractor consortia. We use these consortia on our most complex projects, such as the Intelligent Transportation Systems work, which demand both consensus and creativity. Our elaborate project plans may appear recursive, with draft work moving back and forth between committee and field, but that's how you ensure good designs that everyone can believe in, buy into, and back up.

## **Making It Last**

Whether we're closing the gap or pushing the envelope, our goal remains the same: to create a quality, durable product. So we feature in this report exemplary projects that were made to last.

## **Managing the R&T Program**

To ensure that our R&T program focuses on high-priority areas that address critical national highway transportation issues and that the program is in sync with the strategic goals of the U.S. Department of Transportation (USDOT) and FHWA, we have developed an R&T management structure that ensures the direct involvement of FHWA's top managers and input from a broad spectrum of external experts.

The Research and Technology Executive Board (RTEB) provides policy direction for the R&T program; agrees on R&T program priorities, and reviews our progress in meeting goals, accomplishments, priorities, and milestones for the R&T program. RTEB is chaired by the FHWA's Executive Director, and its

members include FHWA's six Associate Administrators, two Regional Administrators, and the Director of the Joint Program Office for Intelligent Transportation Systems (ITS). The RTEB members are listed on the inside front cover of this report.

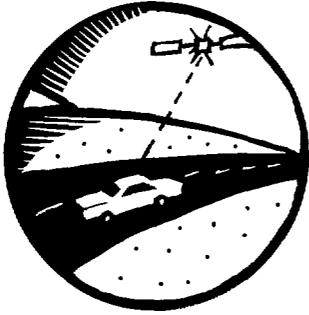
The Research and Technology Coordinating Groups (RTCG's) are cross-organizational groups within FHWA that identify the transportation problems or issues that R&T development can help resolve; determine our role in resolving the problem or issue; formulate their portion of the R&T program budget, including information on goals, products and milestones, anticipated accomplishments, and major new initiatives; and report to the RTEB on their plans, products, and accomplishments. There are nine RTCG's: safety; intelligent transportation systems; pavements; structures; motor carriers; international; policy and information management; planning, environment, and right-of-way; and highway operations. The chairmen of the RTCG's are listed on page 40.

The Research and Technology Coordinating Committee (RTCC), special committee convened by the Transportation Research Board (TRB) at our request, assists us in identifying gaps in research; in considering ways to increase State, local, and private sector participation in highway research; in addressing issues related to the implementation of research results; in identifying areas of duplication; and in providing a mechanism for gathering research needs. The RTCC is composed of 15 to 20 members selected from among researchers, administrators, research users, and practitioners from the public, private, and academic sectors.

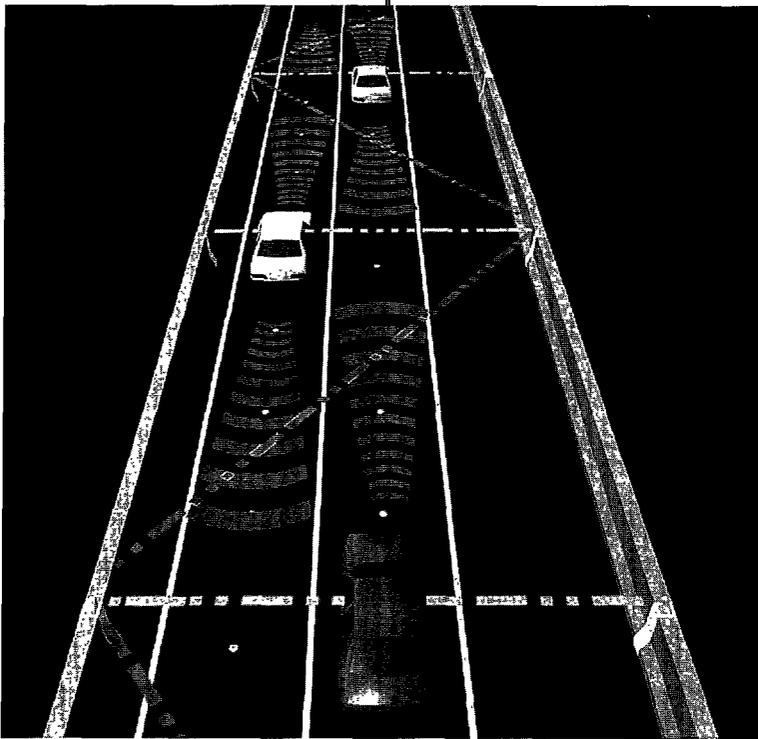
We also actively seek input to our program from expert groups such as the Intelligent Transportation Society of America and the National Motor Carrier Advisory Committee. These groups provide information on R&T activities in specific areas, monitor research progress, and recommend applications of research findings.

## **Reaching Ahead**

We are proud of our achievements in 1996, proud to have given customers what they want as well as what they need, proud to have moved the state of the art up another notch or two, proud to know our work will last through our own and our partners' and customers' efforts, and proud to have traveled a good distance along the road to a better future.



# intelligent transportation systems



*This year, we've laid much of the groundwork for a deployment of a basic Intelligent Transportation Systems (ITS) infrastructure and a first generation of ITS technology and strategies. We've completed the ITS architecture and launched the standards development process. We're supporting a first wave of training programs to bring people up to speed with ITS. We've developed some standards; without these, the whole project would be irrelevant, since the very*

*point of ITS is to ensure seamless, transparent, smooth interoperability. This cannot be achieved without standards defining the rules for that interoperability to take place. As in the 1960'S when we were creating the capacity to develop the Interstate system, we are now having to develop a national capacity for deploying the smart transportation system, To this end, we're prototyping, experimenting, testing, documenting, and training.*

## Closing the Gap

- **National ITS Architecture.** In FY 1996, a 3-year effort to build the national ITS architecture was completed. What that means is that we've established the framework within which ITS will operate-with full compatibility and interoperability-across the country. The architecture isn't a design or blueprint for ITS; rather, it's the structure within which ITS can be designed-the rules and boundaries that will define how the information will transfer seamlessly through the system. Our documentation establishes both a logical and physical architecture. The logical architecture describes what needs to be done functionally for the various ITS services to be provided. The physical architecture explains where these activities are going to occur. The architecture comprises three layers-a transportation layer, a communications layer, and an institutional layer-and deals with four types of communication-two-way wide area, dedicated short range, vehicle to vehicle, and one-way wide-area broadcast.

Our approach to creating the architecture was as careful and innovative as the product we were after. Four teams, each made up of 10 private industry companies, spent 18 months developing their own individual architectures. In the next phase of the project, we had two independent teams-competitively selected-take the best parts of the four architectures and add anything extra that was needed. Throughout this process, we conducted outreach to stakeholders, held design reviews, solicited public comment-all to see how workable the architecture was and to ensure that it was not developed behind closed doors. Next, we synthesized the efforts of the two teams into a single consensus architecture.

- **Commercial Vehicle Information Systems and Networks (CVISN).** We developed an architecture for national deployment of CVISN (pronounced "see vision"). CVISN is not a new system; it is a way for existing systems to exchange information to improve customer service, increase efficiency resulting in lower costs, and improve safety. The CVISN architecture provides a detailed design for electronic business transactions to help achieve these objectives. These include automated transactions with carriers, States, Canada and Mexico, shippers, banks, insurers, service bureaus, and others.

Through a partnership with International Registration Plan, Inc., and International Fuel Tax Agreement, Inc.-nonprofit organizations formed by the States-we began designing interstate exchange capabilities in support of the CVISN architecture.

Draft standards, which were developed through the American National Standards Institute, and the Carrier Automated Transaction (CAT) software, which runs on a personal computer, enable all commercial vehicle information systems and users to exchange information and to electronically obtain credentials for registration, fuel tax, oversize/overweight, and hazardous materials. The CAT software also allows carriers to file quarterly tax reports and perform other routine carrier-to-State transactions.

State-specific systems designs of the CVISN architecture were begun in Maryland and Virginia. These States will implement all CVISN services identified by the CVISN architecture in a comprehensive, integrated system.

- **National Transportation Communications for ITS Protocol (NTCIP).** NTCIP allows traffic management devices within the same communications infrastructure to incorporate other

*We've established the framework within which ITS will operate-with full compatibility and interoperability-across the country.*

*We continue to be the catalyst in fostering the development and support of the NTCIP, and our efforts in FY 1996 led to significant strides forward and the beginning of a standard for communication among traffic control devices.*

devices-for functions such as data collection, weigh-in-motion, vehicle classification, and environmental monitoring-regardless of the type of device or manufacturer. Previously, to ensure internal compatibility, all components and upgrades in a system had to come from the same vendor. We continue to be the catalyst in fostering the development and support of the NTCIP, and our efforts in FY 1996 led to significant strides forward and the beginning of a standard for communication among traffic control devices. With this success, we expanded our effort by establishing a joint committee with the American Association of State Highway and Transportation Officials (AASHTO), the Institute of Transportation Engineers (ITE), and the National Electrical Manufacturers Association (NEMA) to oversee the further development of the NTCIP

■ **Evaluation Support for Operational Tests.** In FY 1996, an ambitious effort was undertaken to review, document, and coordinate more than 70 ongoing operational tests. First, four workshops involving the program managers and lead evaluators of all the FHWA operational tests were conducted to review and discuss all these tests. Second, each operational test was reviewed to better document and understand the current services planned, evaluation goals, and status. Third, a series of 13 internal workshops were conducted to review the operational tests by functional area to better coordinate the evaluation efforts. Two other major activities undertaken this past year include the documentation and assessment of the transportation efforts of Atlanta for the Olympic Games, and the initiation of the evaluations of the two CVISN prototype States.

■ **Traffic Research Laboratory (TReL).** The initial version of the FHWA TReL test bed has been completed and can: (1)

minimize expenditures in research support activities by allowing us to test and evaluate individual R&T components and the integration of these products operating as a system; (2) answer questions on new concepts, deployment, and changes in infrastructure that result in long-term savings; (3) increase research product quality by assessing its validity; (4) accelerate traffic management modernization through evaluation; and (5) address critical issues in both traditional traffic engineering and advanced traffic management systems through large-scale experiments on combined technologies.

■ **Advanced Operational Analysis Technologies.** We made significant improvements in the development of traffic software, particularly in the area of simulation modeling. We established a configuration management system for simulation model development to control and coordinate the software changes needed, track version releases, and better incorporate user requests. We completed the first phase of a new Windows version of the FHWA Traffic Software Integrated System (TSIS), which provides a common, open architecture for supporting public and private traffic engineering. The first phase of new input/output software enhancements is being released. The major enhancements made to our CORSIM simulation model allow better evaluation of traditional traffic design/operations analyses, including new ITS technology assessment. The mathematical model formulations for the two proposed simulation-based Dynamic Traffic Assignment systems are complete, and the development of the prototypes of the two systems will be completed early next year.

- **ITS Models and Showcases.** The move toward a fully integrated Intelligent Transportation Infrastructure (ITI)

-announced by Secretary of Transportation Federico Pena as Operation Timesaver-began this year with the initiation of IT1 model projects in four metropolitan areas. Each of these areas will showcase various IT1 technologies and applications. Thus, the New York-New Jersey-Connecticut region will deploy a regional transportation management system that connects member agencies via a virtual, as opposed to an actual, transportation management center. Phoenix's model project will feature an integrated transportation management system that coordinates freeway and traffic signal systems across jurisdictional boundaries. San Antonio will equip 400,000 vehicles with intelligent vehicle registration tags that will let these vehicles serve as traffic probes, sensing and reporting on current travel times throughout the metropolitan area. And Seattle will provide inter-modal transportation management and integrated, real-time highway and transit information services for the entire Seattle area. The IT1 model deployment program works on the principle that the best way to convince users of the viability of a new technology is for them to see it functioning elsewhere. We are hoping local decision-makers will view these models like a model home, and that they will then pick and choose the individual IT1 elements they think work best for them in their own deployments.

In addition, the Atlanta Traveler Information Showcase has been so popular that it has been extended through early 1997. The showcase started as a 4-month demonstration of the most complex, integrated transportation management and traveler information system yet attempted in the United States. It was originally scheduled to run from June 1 to September 30 to coincide with the 1996 Centennial Olympic Games, the

Tenth Paralympic Games, and the start of operations of the Atlanta Regional Advanced Transportation Management System. The showcase-a joint project of FHWA, the Federal Transit Administration, and State and local agencies-involves the use of hand-held computers, in-vehicle navigation units, on-line



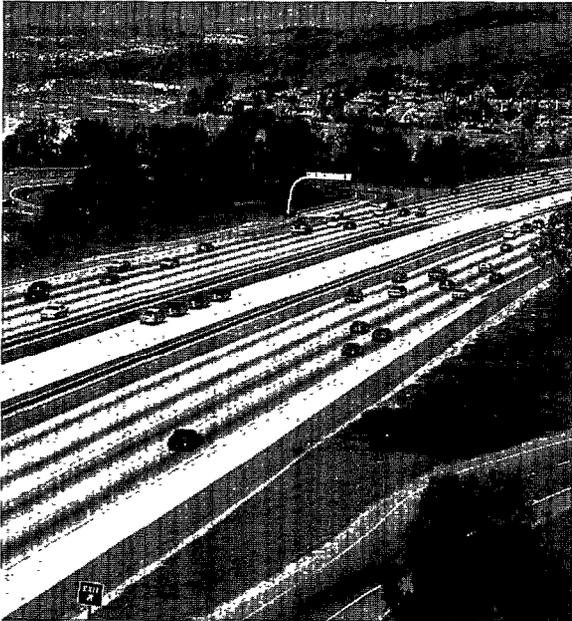
computer information services (Internet), cable television, and interactive television to obtain up-to-the-minute local travel information. The menu of travel information services includes real-time congestion reports, travel incidents by location, road maintenance sites, parking availability, transit bus and train schedules and routes, schedule of public events, and electronic yellow pages information.

■ **Professional Capacity for IT1 Deployment.** As part of Operation Timesaver, we created a management plan to develop professional capacity (education, training, and skills development) for IT1 transportation management and traveler information services. Building professional capacity goes beyond traditional training. IT1 requires civil engineers to develop capabilities outside their original background; they

Consumers will be seeing more electric cars and "smart cars" on the road.

have to understand communications and systems engineering, among other disciplines. This will remain a major ITS program focus area in FY 1997.

■ **Border Crossings.** Commercial vehicles encounter a lot of paperwork in crossing our northern and southern borders. These procedures cause back-ups and delays and are especially critical with regard to North American Free Trade Agreement (NAFTA) implications. In conjunction with the U.S. Department of the Treasury and the U.S. Immigration and Naturalization Service, we are looking at mainline clearance as a mechanism to reinvent paper-intensive processes. In the operational tests currently under way at two



I-15 in San Diego, CA; site of the 1997 full-scale, live exhibition of AHS technology.

northern border sites and two southern border sites, trucks have been instrumented to allow for electronic transmission of data while they are in operation. In other words, the data required at the borders is being collected "on the fly." Trucks don't have to line up; traffic is not stalled. The major challenge of this effort lies less in the technical aspects of electronic transmission and more in the complexity of standardizing data elements from some 80 separate pieces of paper required by various government entities.

The standardization issue is one of several significant border issues affecting transportation that comes under the Border Technology and Exchange Program. By increasing understanding of each other's operational systems, the program has engendered a greater sense of cooperation and trust between the United States, Canada, and Mexico.

## Pushing the Envelope

■ **Real-Time Traffic Adaptive Control System (RT-TRACS).** RT-TRACS is a traffic management and control system based on the hypothesis that varied traffic conditions within a transportation network require different control algorithms that must be coordinated. The prototype control strategies developed under separate contracts were incorporated into the RT-TRACS implementation system during FY 1996. Initial laboratory simulation testing showed that these prototype strategies produced statistically valid improvements in traffic throughput and reduced average delay. In fact, testing in one scenario with one strategy yielded benefits in excess of 20 percent. Field research testing of RT-TRACS gets under way in 1997.

■ **Automated Highway System (AHS).** One of the most eagerly awaited milestones in the gradual process to develop a national AHS is the August 1997 "proof of technical feasibility" demonstration that will fulfill the mandate of the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA). Although this demonstration is still several months away, several important preliminary steps were taken in FY 1996. The high-occupancy vehicle lanes in a 12-km segment of I-15 in San Diego were modified for a full-scale, live exhibition of AHS technologies, involving at least 20 cars and trucks. The National AHS Consortium, including FHWA, has finalized the designs for the demo cars and initiated work on the demo buses. In parallel, we've narrowed down the range of AHS implementation approaches and performed extensive analyses in traffic flow, safety, infrastructure configurations, land use, and technology capability.

■ **Highway Overpass Height Measuring System.** This system is a self-con-

tained instrument that is easily mounted onto any vehicle and measures the overpass height while traveling up to 100 km/h. The laser device is synchronized with a vehicle wheel sensor to accurately correlate the overpass height with precise distance traveled, thereby providing an instant and accurate bridge profile. Currently, a new microprocessor is being incorporated into the system to increase the sampling rate of the unit. Although not the originally intended use, this device could be used to easily and accurately map overpasses for height obstructions when planning routes for oversized vehicles.

- **Driver-Vehicle Interface.** This year in a cooperative effort with the National Highway Traffic Safety Administration (NHTSA), we put together a 5-year program covering various issues related to the driver-vehicle interface. This research covers the type of display to be used, how to integrate systems within the vehicle, status displays, the various types of information that could be included on these displays-and how all of these can be integrated together as subsystems and as a system. As part of this effort, we are doing outreach to the 11 professional committees around the world that are interested in this work.

- **Surveillance and Detection.** At the end of FY 1995, the Jet Propulsion Laboratory under contract to us awarded eight contracts to advance or develop new detection technologies. In FY 1996, prototype sensors, ready for field testing, were delivered by these contracts. These sensors-based on technologies developed for the defense industry and including video imaging systems, passive infrared, radar, line of

sight, and induced radiation detection techniques-were developed and laboratory tested. All of these sensors have been retrofitted to traffic applications and are NTCIP compliant.

- **ITS Research Centers of Excellence.**

These programs-located at the University of Michigan, Texas A&M University, Virginia Polytechnic Institute and State University, and the University of Minnesota-are now in their fourth year and have established themselves as true centers of excellence. Each has a comprehensive ITS research program under way, and during FY 1996, these institutions had a long list of accomplishments.

- **Innovations Deserving Exploratory Analysis (IDEA).** We developed the IDEA program to encourage innovative ideas and concepts that are not part of the ITS research program and might not be developed by the normal ITS community. The program has been very successful in stimulating new and original thinking that cuts across modes and technologies. Approximately 47 projects have been awarded in the 3 years of the project, and another 18 are being negotiated. The program developed a technology for significantly reducing the wiring at signal-controlled intersections by using off-the-shelf power control communications. A communications scheme for wireless modems was developed to maximize the use of the severely limited ITS bandwidth. A vehicle classification sensor was developed to determine whether a vehicle is a car, truck, or bus and which kind of truck or bus. A sensor is being developed to determine if a truck driver is drowsy or drunk.

*Initial laboratory simulation testing showed that RT-TRACS proto type strategies produced statistically valid improvements in traffic throughput and reduced average delay.*



# pavements

*In a very real sense, pavements are the basis of our business.*

*Not surprisingly then, we have devoted considerable resources to ensuring that we're getting it right. One of the biggest projects—certainly one of the most ambitious—is the Long-Term Pavement Performance (LTPP) program. For the last 8 years under this program, we have collected data on numerous pavement sections around the country, recording observations on climate, loading, design, materials, construction, maintenance, and the environment; we will continue to do so until the year 2007.*

*But this year, we reached a significant benchmark with LTPP. In March 1996, the LTPP partners—that's the field people, the ones in the States who are conducting and supporting LTPP—convened in Irvine, CA, for an opportunity to hear about some of the LTPP results. The emphasis was product-oriented; this was reflected in the conference's title, "Improving Pavements With LTPP: Products for Today and Tomorrow." As with so much research FHWA is conducting these days, we let our customers—our partners—tell us what they wanted. In response, we have formed a field-based implementation team to move LTPP products out.*

## Closing the Gap

■ **Superpave Regional Centers.** Five centers were established in FY 1996; these are in Alabama, Indiana, Nevada, Pennsylvania, and Texas. The centers serve as a focal point for spearheading, publicizing, and promoting Superpave technology and efforts. They bring together efforts done in FHWA, industry, and the States.

- **Superpave Training by FHWA at the Asphalt Institute.** Since 1994, 18 Superpave mix and 18 binder courses have been presented. Almost 600 engineers and technicians from FHWA, State departments of transportation, and industry-nearly all the "front line" technical people implementing Superpave--have been trained.

■ **Improved Design for Concrete Pavements.** By summer 1997, AASHTO will adopt a revised design procedure for concrete pavements. This design, verified using LTPP data, provides increased reliability and includes many additional design capabilities. The revised procedure will enable pavement design engineers to realistically consider various features such as joint load transfer and drainage in the design of support foundation layers. This should result in more cost-effective concrete pavement designs.

- **International Audience for Pavement Distress Course.** In September 1996, we presented an eight-day training course in Reno on Pavement Distress Identification and Techniques for Rehabilitation and Design. The primarily international audience included representatives of 20 foreign countries and 10 State departments of transportation. This special training course aimed to expose the international participants to U.S. technology and to share problems and solutions across all participants. It was extremely well-received, and featured

field visits to the Reno Superpave laboratory and to the newly opened WesTrack pavement testing center.

■ **Hot-Mix Asphalt Training in Russia.** In partnership with a U.S. company, we organized and presented a training course on hot-mix asphalt to 91 Russian paving superintendents, civil engineers, construction foremen, managers, equipment operators, and technicians. The 1-week course was presented five times in all.

■ **Spanish-Language Self-Paced Pavement Course.** The Pan American Institute of Highways (PIH) has created a self-help pavement management course in Spanish. The eight-module computer course is available through all PIH centers.

## Pushing the Envelope

■ **Pavement Cost Estimation.** In FY 1996, we completed development of a state-of-the-art model for pavement cost allocation. Results of this work will be incorporated into cost-allocation procedures.

*Almost 600  
engineers and  
technicians-nearly  
all the "front line"  
technical people  
implementing  
Super-pave-have  
been trained.*

WesTrack, the new 2.9-km test track in western Nevada.



*To date, two-thirds of all States are using the Superpave mix technology, and 100 projects are under way,*

■ **Crumb Rubber in Asphalt Pavements.** Two patents developed in our chemistry laboratory may revolutionize the way crumb rubber is used in asphaltic concrete pavements. Our researchers have uncovered a way of extending the material properties of crumb rubber asphalt-or recycled tires-for use in different pavement temperatures and as a component in U.S. highways nationwide.

#### **Making It last**

- **Superpave.** Superpave continues to be the latest word in asphalt pavement durability and sustainability. Its composition ensures that asphalt pavements designed in accordance with Superpave specifications will be stronger, last longer, provide a good ride, and be cheaper over the long term. Through the five regional Superpave centers, we are promoting and publicizing the use of Superpave across the country. To date, two-thirds of all States are using the Superpave mix technology, and 100 projects are under way.

- **WesTrack.** WesTrack is a new 2.9-km test track in western Nevada about 60 km southeast of Reno. The track was completed in October 1995, and truck loading was initiated in March 1996. The load is applied to the test sections through the use of four identical triple-trailer trucks, each of which is loaded with tied-down steel plates, weighs 676 kN (more than 152,000 lb) and operate autonomously (computer controlled and without a driver) 20 hours each day, 7 days a week. When the current 2-year study of hot-mix asphalt (HMA) paving materials and construction is completed, we expect the performance data to add significantly to the development of performance-related specifications for HMA construction and to provide an early verification of the Superpave performance-prediction models and mixture analysis system. Both of these accomplishments should, in turn, lead to improvements in the quality of HMA construction.

# structures

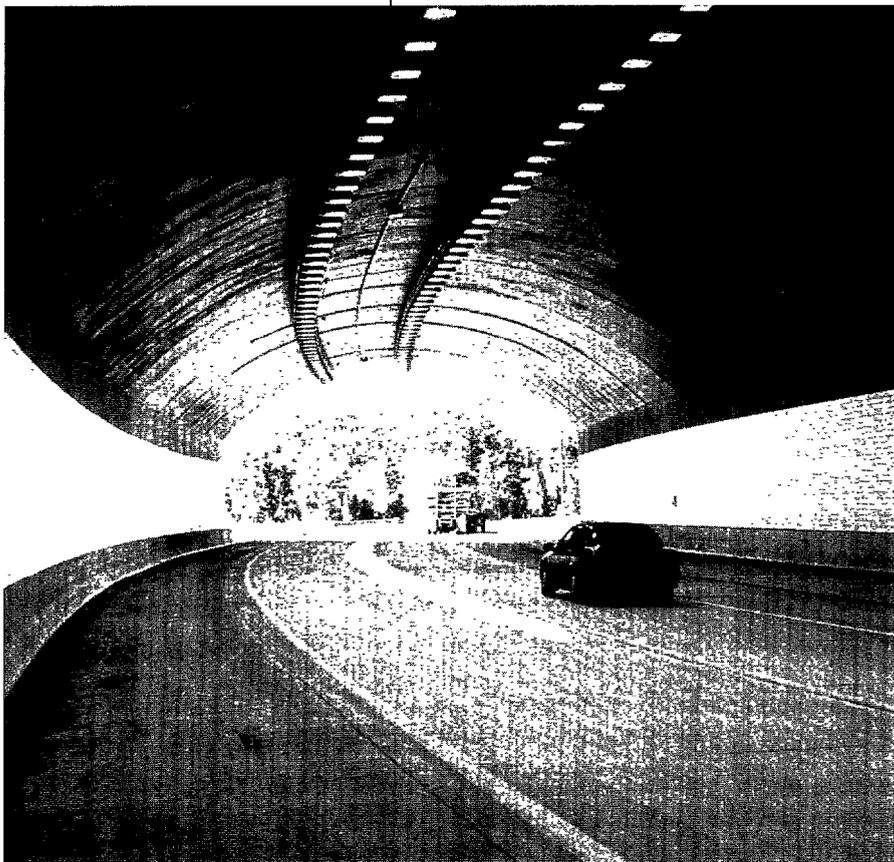


*We participate in structural projects large and small, near and far-and have done so for years. Recently, however, we have increasingly been called upon to provide expertise and advice on non-Federal projects. For example, we participated in the District of Columbia-Maryland- Virginia Woodrow Wilson bridge improvement/tunnel alternatives study; the San Mateo, CA, Devils Slide Tunnel study; and a road-tunnel rehabilitation effort in New York City, among others. We are also working on international efforts. Notably, we're helping conduct a risk analysis on the transport of dangerous goods through road tunnels. This research project, sponsored by the Organisation for Economic Co-operation and Development, addresses the fact that most tunnels do not allow gas tankers, fuel oil tankers, etc., to use road tunnels. We've using computer modeling to assess whether it would be safer if this cargo were permitted in the tunnels rather than having to go around and through small communities.*



## Closing the Gap

■ **New Tunnel Ventilation System.** Last November, we finished a series of never-before-attempted full-scale fire tests in an abandoned road tunnel in Charleston, WV. Based on these tests, we have determined the viability of a longitudinal ventilation system using jet



FHWA was asked to provide technical expertise on several U.S. tunnel projects in FY 1996.

fans. This system has been used for many years in Europe and Asia (although never tested under adverse conditions) but has never been tested and evaluated for use here. The tests generated much interest. Almost 900 people attended them, and documentation has been compiled on CD-ROM and video. Also, the system is now being used in several new construction projects.

■ **Soil Nail Walls.** This technology has been under development in the United States for several years. Essentially, the technique entails installing horizontal steel bars ("soil nails") into a slope or

excavation as construction proceeds from the top down, creating a vertical or near vertical reinforced soil section. In 1993, an International Scanning Tour for Geotechnology found that Europe has been using soil nailing to reinforce and strengthen in-place soil deposits for 20 years. Now, we're promoting the routine use of soil nailing here as well. We've announced a new demonstration project that has provided technical assistance on more than 40 applications. We have also developed a *Soil Nailing Field Inspectors Manual* and a *Manual for Design and Construction Monitoring of Soil Nail Walls*. As part of the demo project workshop, these manuals are being delivered to the field along with fully designed example walls and a design computer program.

■ **Technical Assistance in Russia.** As part of an ongoing effort, we worked this past year with a U.S. company to develop a bridge inspection and maintenance training program tailored for Russia.

- **Computerized Bridge Management System.** Pontis 3.1 was released this summer: this program gives the engineering community an analysis tool for prioritizing repair, rehabilitation, and maintenance needs across their bridge inventory. Currently, 38 States are Pontis users.

- **New Bridge Inspection Course.** In response to bridge owner demand, we developed a new National Highway Institute (NHI) course to aid bridge inspectors in identifying and understanding problems caused by stream instability and scour at highway bridges over waterways. The course focuses on scour and stream-stability-related problems that could be encountered during bridge inspections. It has been quite well accepted; it was presented more than 10 times in less than a year.

■ **Support for Scour.** To ensure that States have the latest and best technology and guidance on scour and stream stability, we updated and metrified both our hydraulics engineering circulars and our NHI training course on these topics. We have also announced a new demonstration project that supports the field evaluation and the demonstration of state-of-the-art equipment for monitoring scour at highway bridges.

### Pushing the Envelope

■ **Progress in the Central Artery.** Boston's Central Artery Project is the largest transportation project in the United States, comprising 12 km of underground construction in downtown Boston. Not only is it big; it's cutting edge. The project is continually applying state-of-the-art technologies and setting new industry standards for what is achievable in an area characterized by aging infrastructure and heavy traffic.

The Ted Williams Tunnel—a 1.6-km-long, twin tube, four-lane road tunnel stretching beneath the Boston Harbor from Logan Airport to downtown Boston—received the 1996 Outstanding Civil Engineering Achievement Award, the most prestigious award granted by the American Society of Civil Engineers.

Some \$750 million in new construction contracts were awarded in FY 1996; this construction, much of which is underground road tunnel projects, will be done while maintaining current traffic levels and patterns. To do so, the existing structures will need substantial underpinning.

The project this year awarded the largest deep soil-mixing contract ever let in the United States—about \$150 million—since the concept was introduced from Japan about 5 years ago. To construct a depressed highway section

in Fort Point Channel, a waterway that winds through the Central Artery project, construction engineers need to excavate up to 20 m below ground—a depth with serious implications for ground stability. To stabilize the ground and enable very wide and deep excavations in Boston's notoriously poor soils, deep soil-mixing will be used to resist lateral pressures and prevent overall ground failure.

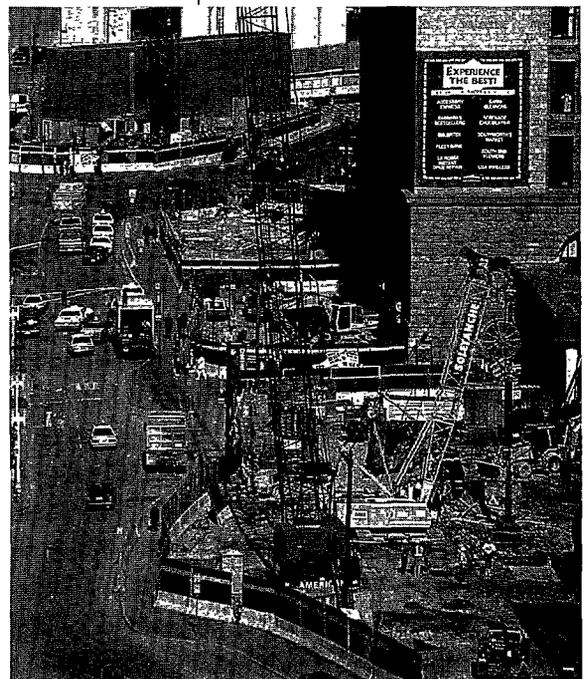
- **Better, Faster, Nondestructive Evaluation of Bridge Decks.** FHWA just received delivery of an infrared bridge deck scanning system which essentially looks into the concrete to see precisely what and where the damage is. The system is mounted in an instrumented van and is now being pilot tested in several States. An additional benefit of the system is that it can scan bridge decks at about 32 km/h; this relatively rapid pace could make complete closure of lanes during bridge inspections unnecessary.

### Making It Last

■ **Japanese Shaking Table Tests.** The 1995 Kobe earthquake proved again that bridge columns are most vulnerable to seismic pressures. If the columns fail, generally the bridge fails as well. Japan sponsored a series of tests this past year to assess the vulnerability of various bridge column design standards. FHWA—as part of our cooperative agreement with the government of Japan—participated in the design, conduct, and analysis of these “shaking table” tests performed at the Public Works Research Insti-

*An infrared scanning system for faster, nondestructive evaluation of bridge decks is being tested in several States.*

Progress continues on Boston's Central Artery Project.



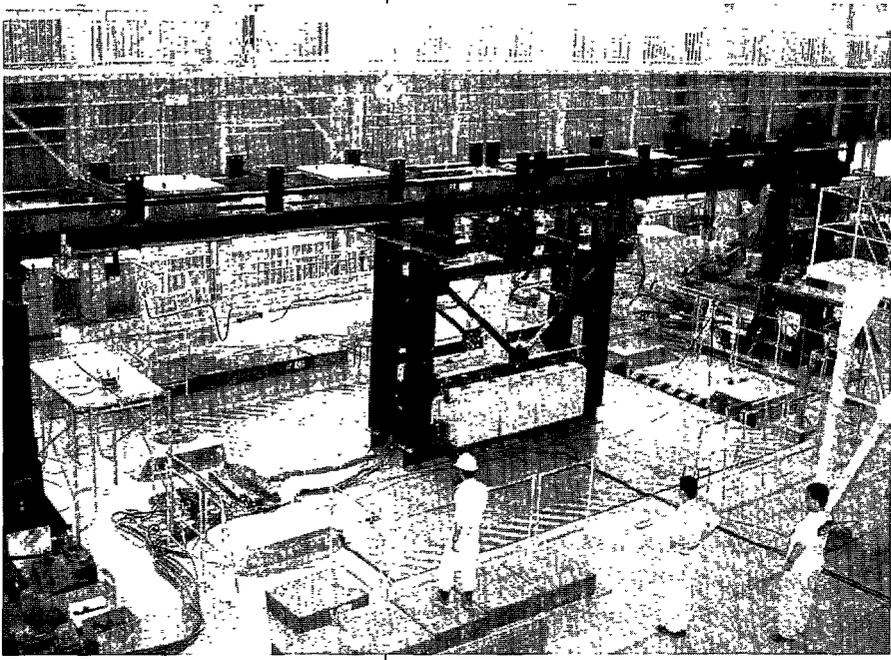


PHOTO COURTESY OF PWRI

PWRI's shaking table facility in Tsukuba, Japan.

tute (PWRI) in Tsukuba, Japan. The shaking table is a 7.6-m by 7.6-m structure that can be programmed to simulate earthquake motions at increasing levels of severity. Model columns were designed and placed on the table; these were modeled using: (1) 1990 Japanese earthquake design standards for bridge columns, (2) post-Kobe Japanese standards, and (3) current U.S. standards. The columns were subjected to "earthquakes" both at the level of severity

assumed by the respective standards (that is, the maximum level earthquake that the columns had been designed to withstand) and above that level of severity. While analysis of the findings is still ongoing, the essential results are that all columns met their assumed design earthquake and that only the U.S. column withstood higher levels of severity (up to and including the maximum capacity of the table). The ramifications of modifying design criteria based on these findings are being examined.

- *Scour Evaluation Program.* Begun in 1990, our Scour Evaluation Program monitors States' progress in evaluating the current U.S. inventory of 484,916 bridges over waterways for scour. As of September 1996, 98.7 percent of these bridges have been screened, and 51 percent evaluated. Of those evaluated, most are considered low risk, and only 10,276-2.1 percent are scour critical. The bridges that have not been evaluated fall into two groups: those that are scour-susceptible (27 percent) and those with unknown foundations (21 percent). The program's goal is to evaluate 100 percent of the bridges over waterways.

# materials



*From the simple to the sophisticated, from the traditional to the cutting edge, from ordinary dirt to fiber-reinforced polymer composites, we're evaluating, studying, and using a broad range of materials in highway applications. As an agency based in civil engineering, we understand that success with any material means that its properties meet your design objectives, and that you design with those properties in mind. Long-term success with a material means moving beyond that stance to not just solving today's problems, but to trying to anticipate tomorrow's--and to create solutions before the problems even arise.*



New Hampshire DOT has completed their first high-performance concrete bridge project.

*That's why we introduce new materials slowly. We watch the experience of other countries, other periods of time, in working with certain materials. We go on scanning tours, we do laboratory tests, we build limited structures-pedestrian bridges, for example. When we see that it works, we get the specs together and spread the word in the field. That's what we've been doing this year with high-performance concrete (HPC). That's what we'll be doing, eventually, with fiber-reinforced polymer composites.*

*High-performance concrete is more durable, longer lasting, and requires less maintenance than ordinary concrete.*

## Closing the Gap

■ **High-Performance Concrete-Star of Texas Showcase.** A Strategic Highway Research Program (SHRP) showcase was held last March in Houston. It was the first SHRP showcase to feature high-performance concrete for bridges-thus signaling that the material is ready to move out of the lab and onto the highways. The event attracted national attention and almost 200 transportation experts, to hear and discuss the experiences of those States that are already working with HPC. Presenters at the 3-day event included FHWA engineers and researchers, university professors, State bridge designers, and precast fabricators and construction contractors-all of whom were personally involved with the HPC bridges being built in Texas, Nebraska, New Hampshire, and Virginia.

· **Northumberland Scanning Tour.** The Northumberland Strait Crossing in Prince Edward Island, Canada, is being constructed entirely out of HPC. This past year, an FHWA-sponsored team of Federal, State, and private-sector officials visited the site to observe, investigate, and document detailed program and technical information on the project's development, construction, and planned operation. The project is a complex one, and the completed bridge will be operated for its first 35 years by a development consortium. Scanning tours like this one allow us to "get a leg up" on issues, challenges, and solutions we likely will face in applying new materials, technologies, and innovations.

## Pushing the Envelope

■ **Nine Ongoing HPC Projects.** HPC is an engineered concrete of superior strength and durability. Tests in this country and abroad over the past 20

years have proven its utility. It is now moving out of the laboratory and testing stage and into actual implementation. As of the end of FY 1996, nine ongoing projects in eight States-COLORADO, Georgia, Nebraska, New Hampshire, Ohio, Texas (two projects), Virginia, and Washington-featured HPC. Because the material is more durable and longer lasting, it requires less maintenance than ordinary concrete. Moreover, any cost differential in using HPC is minimal. By FY 1997, the HPC projects in Nebraska, New Hampshire, and Texas will all be operational.

· **High-Performance Steel.** In FY 1996, we received the first batch of high-performance steel fabricated in the United States. Specifically, we have steel plates of 70 ksi and 100 ksi and two steel girders in our labs awaiting testing in FY 1997. Tennessee is working on a design and will put out a request for bids shortly to build the country's first high-performance steel bridge. Nebraska has also made a commitment to build a bridge out of the new material.

· **Mechanically Stabilized Earth.** Soil is a plentiful and inexpensive construction material. Recent research and development at FHWA laboratories and elsewhere has shown that good-quality fill material can be used to create free-standing structures such as bridge piers and abutments and earth retaining walls. The basic concept behind the mechanically stabilized earth method is to combine soil, reinforcing materials of steel or polymers, and an appropriate facing to produce a composite material with improved engineering properties. The resulting combination provides savings in cost and construction time compared with other conventional earth retaining systems. A new demonstration project is under way to promote this technology. Industry involve-

ment with the technology is extensive and several proprietary systems have been developed.

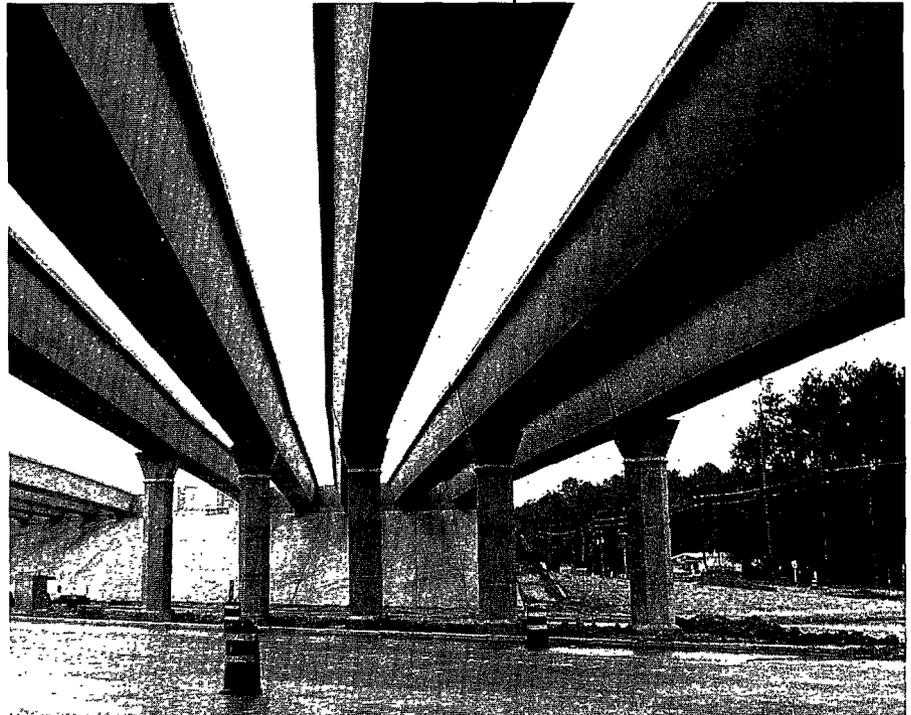
- **Carbon Wrapping.** In FY 1996, we proved conclusively that wrapping existing bridge columns with carbon (an advanced composite material) strengthens their seismic resistance. This proof was made in San Diego with a full-scale test of retrofitted bridge columns. This project was a direct result of work performed by the Defense Department's Advanced Research Projects Agency.

### Making It last

- **Aluminum Bridge Decks.** Besides looking at new materials, we're revisiting the use of some old ones. Scandinavia has built 40 bridges in the last 10 years using an old standby-aluminum. Like composite materials, aluminum offers light weight, corrosion resistance, and quick installation. Pittsburgh's Smithfield Bridge, built in 1933, was the first in this country to use an aluminum deck. That deck was removed in 1994, and we're subjecting it to rigorous forensic evaluation. Our aim is to use aluminum to replace crumbling conventional concrete bridge decks. The lighter weight aluminum will increase the bridge's carrying capacity, since it will reduce the amount of dead weight in the bridge; it will also extend service life. Upgrading a bridge's status through rehabilitation is a more efficient use of funds than hav-

ing to rebuild it completely. Currently, we're looking at the forensic results to determine, among other things, how to improve cross sections so they better resist surface loads.

■ **Longer Lasting Paint.** F H W A research is proving that super-zinc-rich bridge coatings are very durable and



longer lasting than the lead-based paints they replace. Our researchers have developed a chart showing the expected service life from various generic coatings, including metallic coatings. They have found that these coatings offer up to 35 years of service life, compared to the 10 years provided by lead-based paints.

The Louetta Overpass in Houston, TX, uses high-performance concrete and a new U-Beam design.



# highway policy, planning, and operations



*In the R&T area of highway policy, planning, and operations, we're emphasizing quality of data and increased customer orientation. What this comes down to is that we have many users of our data-how can we provide them with better and more timely data? An example of our response is the Highway Performance Monitoring System (HPMS). This long-term system (initially established in 1978) collects and reports on performance data from all of the States. The HPMS steering committee looks at short-term refinements to HPMS and, in the long term, strategically reassesses the system. How*

*are our policy needs changing? Are we getting the data we need? Do we need the data we get? This kind of thinking underlies many other operational and planning projects as well: Are we doing what we should? Do people know about it? How can we improve.*

## Closing the Gap

□ **Personal Travel Survey.** On behalf of the USDOT, we conduct a Nationwide Personal Transportation Survey (NPTS) every 5 years; the preliminary data from the 1995 NPTS is now being analyzed. We allowed State and local governments to add their own surveys to the NPTS phone survey of 20,000 households. The States of Massachusetts and New York and the metropolitan planning organizations (MPO's) for Oklahoma City and Tulsa took us up on our offer. Our analysis is revealing that more trips and travel were reported in the 1995 survey than in previous years; we attribute this to the fact that in this survey cycle we let respondents use a travel diary to record their household transportation; in previous years, we relied on recall alone. Currently, we are testing a global positioning system (GPS) device for use in future NPTS surveys and other surveys of household travel. The device is installed in volunteers' cars along with a small hand-held electronic notepad. The participant records the purpose of the trip; the GPS device automatically records trip location and distance data. Use of this system would enable us to obtain-unobtrusively-more comprehensive data than we have received in the past.

■ **Employment Impacts of Federal-Aid Highway Investment.** One of our principal responsibilities is to manage and track Federal-aid program funding to States and to estimate, from a Federal perspective, the impacts from those investments. To this end, to be able to answer the following questions: How many full-time equivalent jobs are supported per \$1 billion of highway infrastructure investment, in which industries, and at which skill levels? Using various techniques (e.g., input-output analysis, regression analysis, and survey data collection), we have been able to

answer these questions in a publication entitled *Highway Infrastructure and Job Generation*, publication no. FHWA-PL-96-015. For instance, FHWA developed a PC-based model to more closely examine the direct (e.g., highway construction industry) employment impacts of Federal-aid highway investment. This PC-based model allows the user to set various program parameters such as total investment levels, multistate region, highway improvement type, and urban/rural status in an effort to estimate the number of highway construction industry jobs supported for \$1 billion of investment funds. This model is currently available to States and localities on request. Work continues on this model to make it more user friendly, to improve its estimating capabilities, and to update it with recently released data on Federal-aid highway projects.

■ **Highway Statistics.** We just released the 50th edition of Highway Statistics, a massive publication featuring extensive highway-related data sets. The data tables are also available via the Internet (<http://www.bts.gov/fhwa/yellowbook/>).

· **Incentives to Reduce Congestion.** Our Congestion Pricing Pilot Program encourages States, local governments, MPO's, and toll authorities to test and evaluate innovative congestion pricing products in various settings. Currently, 10 projects are under way; we expect several of these to move next year from the planning phase to actual implementation. These include a project that establishes peak and off-peak bridge toll differentials by reducing tolls in off-peak hours; one that sells excess capacity on a high-occupancy-vehicle lane (HOV) to single-occupant vehicles; one that sells excess peak-period capacity on an HOV-3, on which all vehicles must have at least three people, to HOV-2 vehicles; and one that will charge variable time-of-day tolls on

*Currently, we are testing a GPS device installed in cars to unobtrusively obtain more comprehensive data in future NPTS surveys.*

*FHWA'S role in these congestion reduction efforts is to provide funding and technical support to local project initiatives.*

new lanes that offer an alternative to a highly congested non-toll route. In addition, we are supporting a study of the operation of new variable toll express lanes constructed and operated by a private company in Orange County, CA. These and similar projects enable us to make better use of existing facilities. FHWA's role in these efforts is to provide funding and technical support to local project initiatives; this includes helping ensure that information about pricing innovations is shared among communities and among stakeholders within each community. Such information-sharing and support-building activities are critical to a project's success. We also facilitate exchange through a "listserve" maintained by the University of Minnesota, a congestion pricing Web page, a quarterly e-mail publication-congestion Pricing Notes-and regional workshops. In FY 1996, we also conducted informal focus groups addressing the concept of equity with regard to congestion pricing. These groups were held in low-income areas in Washington, D.C., Harlem, and Brooklyn. The input we received was extremely useful in developing guidance for our congestion pricing projects. Participants had an opportunity to contribute in a very real way to the development of transportation policy.

■ **Traffic Data Acquisition.** In May 1996, we held our biennial National Traffic Data Acquisition Conference in Albuquerque. More than 400 people from 47 States and 10 countries attended to discuss current techniques and challenges in collecting and analyzing highway traffic data. About 30 vendors also displayed their latest equipment available for use in this data collection.

■ **Vehicle Detector Clearinghouse.** Testing vehicle detectors is an expensive and time-consuming task that is necessary to make wise purchasing decisions.

It is clearly wasteful and inefficient for each transportation agency to do their own testing; however, the lack of standard test protocols for vehicle detectors makes it difficult to avoid duplicative testing. A March 1995 study, funded by FHWA and conducted by New Mexico State University, found that both vendors and users acknowledged the need for standardization and testing of equipment and generally supported the concept of a National Vehicle Detector Test Center. A pooled-fund project was approved for the purpose of establishing such a vehicle test center. However, because of the lack of sufficient funding to set up and adequately maintain a test center and the lack of standard test protocols that are acceptable to all, it was decided to establish, as an interim step, a Vehicle Detector Clearinghouse through New Mexico State University. The mission of the clearinghouse is to gather, organize, and share information-especially product test results-and to be a catalyst for developing standard test protocols so that, no matter who performed the tests, the results would be widely acceptable.

■ **Winter Maintenance Technologies and Equipment.** The blizzards of 1996 spawned-not surprisingly-major interest in highway winter maintenance activities. We had numerous winter maintenance showcases around the country, and a large-scale winter maintenance conference for Eastern States this past September. This conference attracted 75 exhibitors and 600 participants.

- **Innovative Contracting.** Innovative contracting is a new approach to bidding highway design and construction projects; it aims to make these projects more efficient. Because the concept is new, we have been attending numerous conferences around the country on the topic, discussing such ideas as lane

rentals, warranties, design/build contracts, A+B \*bidding, etc. Currently, we are working with Utah on a \$1.4 billion design/build project; this is the largest innovative contracting vehicle thus far in the highway community.

- **Geographic Information System (GIS) Development.** We, in partnership with the States, are developing a GIS for the National Highway System (NHS) and other roads and streets functionally classified as principal arterials and rural minor arterials. The National Highway Planning Network (NHPN) is the basis for this system. We are in the process of establishing a linear referencing system (LRS) on NHPN and using LRS to relate highway, bridge, and other attributes to NHPN. GIS information will be made available to the public via the Internet at <http://www.byways.org/fhwa>. This GIS will be used for planning activities at national, State, and local levels. An annual updating mechanism for NHPN and LRS has been included in the Highway Performance Monitoring System (HPMS) and LRS information is reported in both the HPMS and National Bridge Inventory data bases to enable these data bases to be related to NHPN.

■ **Intermodal Ground Access to Airports.** We have developed an airport access planning guide to provide policy and planning guidance for use by airport, State, local, and metropolitan planners to manage and plan for intermodal ground access for all types of airports. It identifies key components of an airport access work program and contains detailed sections on airport ground-side access planning methods, data collection methods and analysis, identification of current travel patterns and emerging trends, forecasting techniques, estimating mode split, evaluating alternatives, and project implementation.

- **ISTEA-Mandated Planning.** ISTEA emphasizes planning as a prelude to decision-making for the expenditure of ISTEA capital funds, and so, much effort over the past 5 years has been devoted to giving States and MPO's improved methods and procedures for carrying out the mandates of ISTEA.



This past year, we contributed to two efforts that provided valuable information for policy-makers and planners at all levels of government as they seek to improve the planning process to guarantee the maximum pay-off from increasingly precious capital investment funds: (1) a conference on Major Investment Studies (MIS), conducted under the auspices of the Transportation Research Board, and (2) the completion of a staff study and report by the Advisory Commission on Intergovernmental Relations on progress in meeting the requirements of ISTEA. The conference covered bringing increased awareness of economic, financial, environmental, and other quality-of-life factors to transportation planning and decision-making. The study dealt with

The Blizzard of 1996 made highway winter maintenance activities a hot topic once again.

*The study estimates that for every dollar invested in roads during the period from 1950 to 1989, the commercial sector of the economy saved an average of 24 cents per year in production costs.*

equity issues, financial planning, public involvement, and strengthening the analytical basis for decision-making.

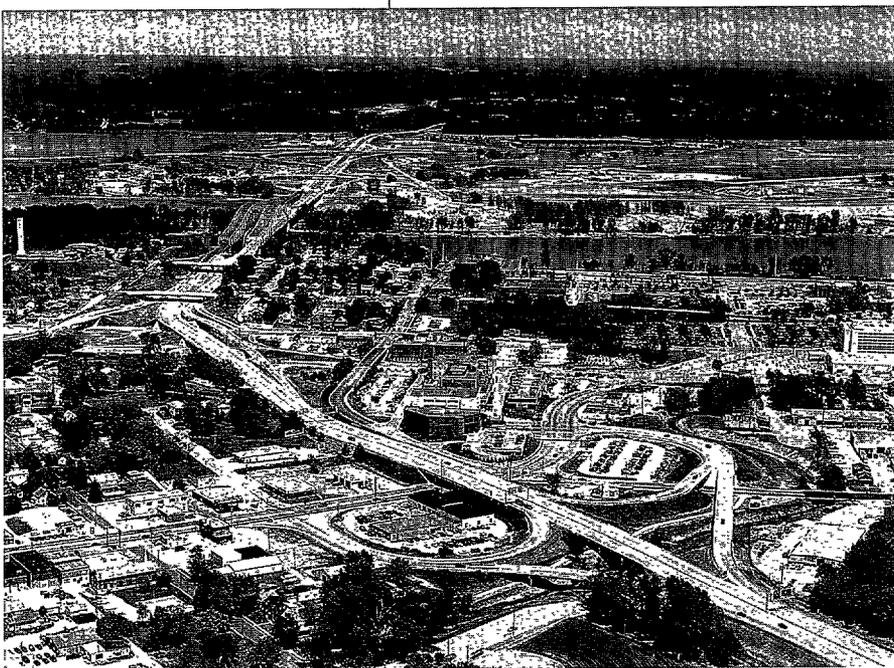
### Pushing the Envelope

- **Highway User Cost Allocation.** For the first time in 14 years, we are conducting a new highway cost-allocation study to evaluate the responsibility of different highway users for highway-related costs. Our Integrated Cost-Allocation Model lets us bring all estimated highway costs together—that is, costs for pavements, bridges, safety, transit, and other highway-related improvements—allocate them to different vehicle classes, and then compare those allocations with the user fees paid by those vehicles through Federal fuel and other excise taxes. We completed the model in FY 1996 and have estimated both the marginal costs of travel by different vehicles as well as the total costs of highway use for each of the four cost areas; we are now looking to expand the model for State and local government use.

■ **GIS and National Defense.** One of our major customers is the Department

of Defense (DOD). DOD employs “just-in-time” mobilization; this entails moving large numbers of personnel and materiel quickly and efficiently to their point of embarkation, and then replacing them at their previous locations with reserves. To make this system work, DOD needs us to develop a system where we can convey information-in real time-on the physical and operating characteristics of their routes to embarkation, the congestion points, etc. This has never been done before; we’re planning to use a geographic information system (GIS) to provide the needed data. Using GIS, data on specific roads can be uploaded for customer access and input to DOD modeling capabilities. We’re refining this system-DOD calls it the Power Projection Platform-with the agency.

■ **Improved Travel Demand Modeling.** TRANSIMS, our transportation planning simulation program, made a major leap from theory to practice in FY 1996 when it achieved an “interim operating capability” in the Dallas-Fort Worth area. Simply put, TRANSIMS is running a very detailed planning simulation of vehicle movement in and through a 41-km<sup>2</sup> area—that is, a large, real-world complex of roads, intersections, and signal configurations has been captured by the simulation approach. TRANSIMS is displaying the interactions of some 267,000 planned trips, showing 12,000 vehicles at any given time. “Cellular automata” is the mechanism that makes this detailed modeling possible. This technique is a rule-based method of simulation used in such fields as genetics, biological population systems, and physics. Certain simplifications must be made in using this high-power simulation method, and experts have asked whether these-sometimes gross-simplifications yield valid results. The Dallas-Fort Worth demonstration proves



that they do. The method was compared to empirically derived speed-volume-density relationships to show that the cellular automata approach matches patterns actually seen on the roads. The TRANSIMS success means that transportation planners will soon be able to use a detailed traffic simulation system that covers a large geographic area and better matches reality. Armed with this, planners can test out the effects of different traffic management, pricing, and system investment policies.

■ **Productivity Estimates.** One of the country's foremost econometricians has completed a study for FHWA on the effects of highway infrastructure investment on the costs of production in 35 sectors of the economy. The research provides empirical estimates of the linkages between highway capital investment and economic performance. Previously, these linkages were only intuitively acknowledged. The study estimates that for every dollar invested in roads during the period from 1950 to 1989, the commercial sector of the economy saved an average of 24 cents per year in production costs. Although the research finds that the net rate of return on highway capital-not includ-



ing local roads-has declined from a high of 47 percent during the peak years of the construction of the Interstate Highway System to 16 percent in the 1980's, this is expected with the development of a ubiquitous and mature road system. Importantly, even in the later periods, returns on highway investment exceeded private sector rates of return and the Government's opportunity cost of capital. Finally, there is strong evidence that highway capital contributes positively to U.S. productivity growth rates.

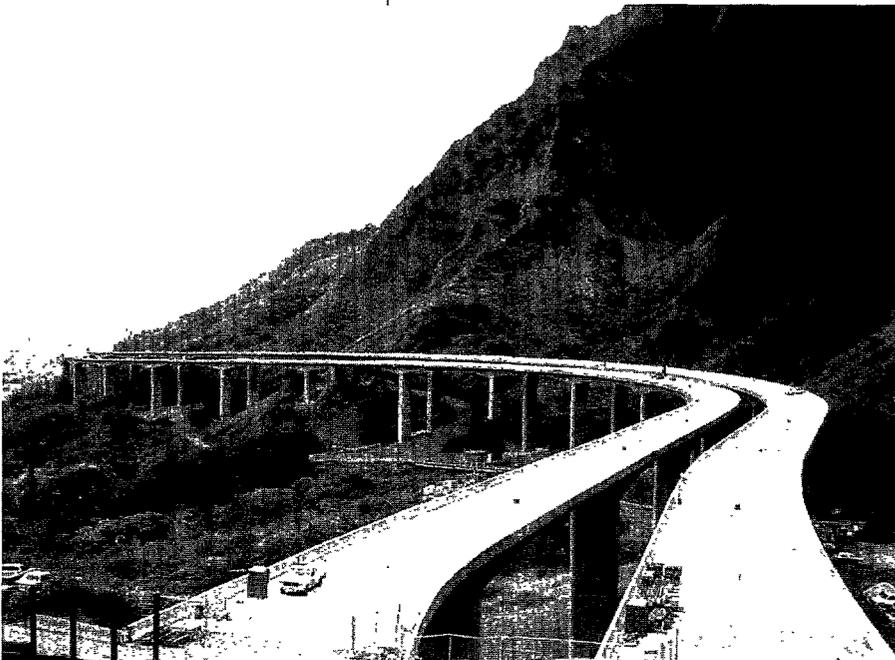
Investing in highway infrastructure projects benefits our economic productivity.



# environment

*Even as the environment itself is made up of complicated and delicate interconnections, so too is much of our work in this area. Incorporating environmental considerations and stewardship into all appropriate FHWA policies, procedures, and decisions requires a total, active commitment by all FHWA employees and careful*

*coordination with sister agencies-notably the U. S. Environmental Protection Agency (EPA)-and stakeholders such as States and interest groups. It is FHWA policy to aggressively pursue improved communications and collaboration with our Federal, State, and local partners in this effort and to seek new*



*partnerships with tribal governments, businesses, transportation and environmental interest groups, resource and regulatory agencies, affected neighborhoods, and the public.*

## Closing the Gap

Many of our FY 1996 environmental projects entailed getting the latest and best information-via user manuals, videos, seminars, CD-ROM's, or brochures-into the hands of decision-makers and planners.

■ ***Pan American Cooperation.*** We convened, through the Pan American Institute of Highways and in partnership with the World Bank, the first ever meeting of all the environmental units of North, Central, and South American highway agencies. Our transportation/environmental problems are the same; this conference, held in Pereira, Colombia, affirmed our commitment to work together to solve them. Participants will meet to share techniques and approaches at a second meeting near the Brazilian rainforest.

- ***MOBILE Vehicle Emission Model.*** To estimate vehicle emissions, EPA created the MOBILE model which has since become the Nation's standard in assessing the emission impacts of various transportation inputs. Changes to the model over the years have significantly revised the estimate of emissions attributed to roadway use; moreover, the model's structure and assumptions have never been documented. This year, we bridged this gap by documenting the model, its assumptions, and its revisions so transportation planners and analysts will better understand the vehicle use and speed assumptions used by air quality officials. We are also working with EPA to develop MOBILE's next generation.

■ ***Research on Transportation and Wildlife Mortality.*** Since the 1970's, FHWA has been sponsoring research on highways and wildlife mortality. This spring, the Florida Department of Transportation and FHWA cosponsored a conference on this topic, featur-

ing North America's leading experts in the field. The conference considered species ranging from salmon and desert tortoises to wolves, panthers, and black bears; it describes experiences with such mechanisms as deer reflectors, underpass systems for amphibians, and wildlife crossing designs and use. The resulting report, which is more than 300 pages, represents a comprehensive approach to the topic and will be a useful reference for years to come.

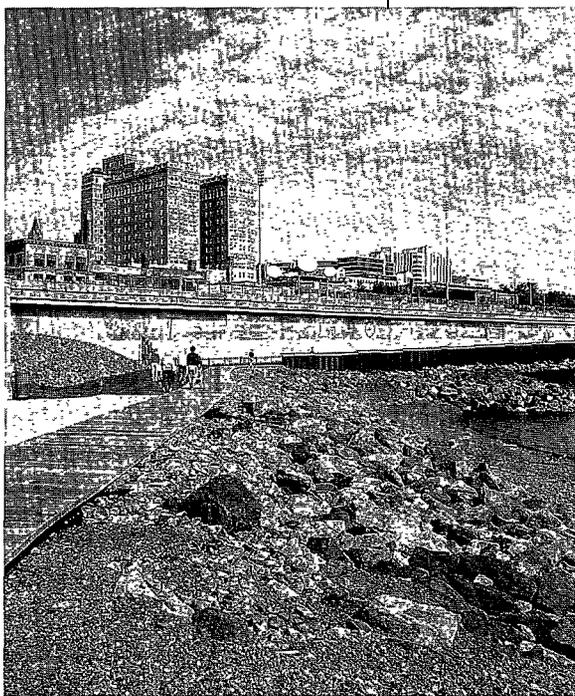
■ ***Water Quality Best Management Practices.*** Another comprehensive effort was realized this year with the publication of Evaluation and Management of Highway Runoff Water Quality. This massive self-contained desk reference is a compilation of all past water quality research performed by the agency since the late 1970's. The manual gives highway designers and environmental professionals appropriate impact prediction and mitigation tools for their highway runoff project planning and development activities. The report lets these professionals select, screen, and implement documented best management practices in this area.

- ***"Show and Tell."*** Several videos, CD-ROM's, and full-color booklets were produced this year to document the success of some of our environmental efforts.

The Congestion Mitigation and Air Quality Improvement Program is a highly well-received, flexible source of transportation funds for air quality improvement innovations implemented in the field. *Innovations in Transportation & Air Quality: Twelve Exemplary Projects* highlights exciting, unusual, and successful efforts recently funded by this program.

The brochure "Leaving a Place Better Than We Found It: Success Stories from the Visual Database of Transportation Enhancements" dis-

*Many of our FY 1996 environmental projects entailed getting the latest and best information-via user manuals, videos, seminars, CD-ROM's, or brochures-into the hands of decision-makers and planners.*



Lake Park Place off of I-35 in Duluth, MN.

cusses and illustrates top practices highlighted in a CD-ROM multimedia data base of more than 200 U.S. transportation enhancement projects.

We produced a video highlighting three exemplary highway projects where environmental sensitivity was key to project success; a separate video illustrates the performance of various highway traffic noise barriers.

- *A User-Friendly Community Impact Assessment.* This year, we issued *Community Impact*

*Assessment: A Quick Reference for Transportation Analysts*, a guide for assessing the impacts of proposed transportation actions on communities. A companion piece, *Community Impact Mitigation Case Studies*, highlights six illustrative project experiences.

## Making It last

### - *Simpler Conformity Requirements.*

This year, we helped draft amendments streamlining the requirements of a regulation mandating that State and local transportation plans conform with air quality plans. Through outreach meetings, and public notice and comment, stakeholder input was received and incorporated in the drafting process. So far, two of three rules have been finalized, and public reaction is very positive.

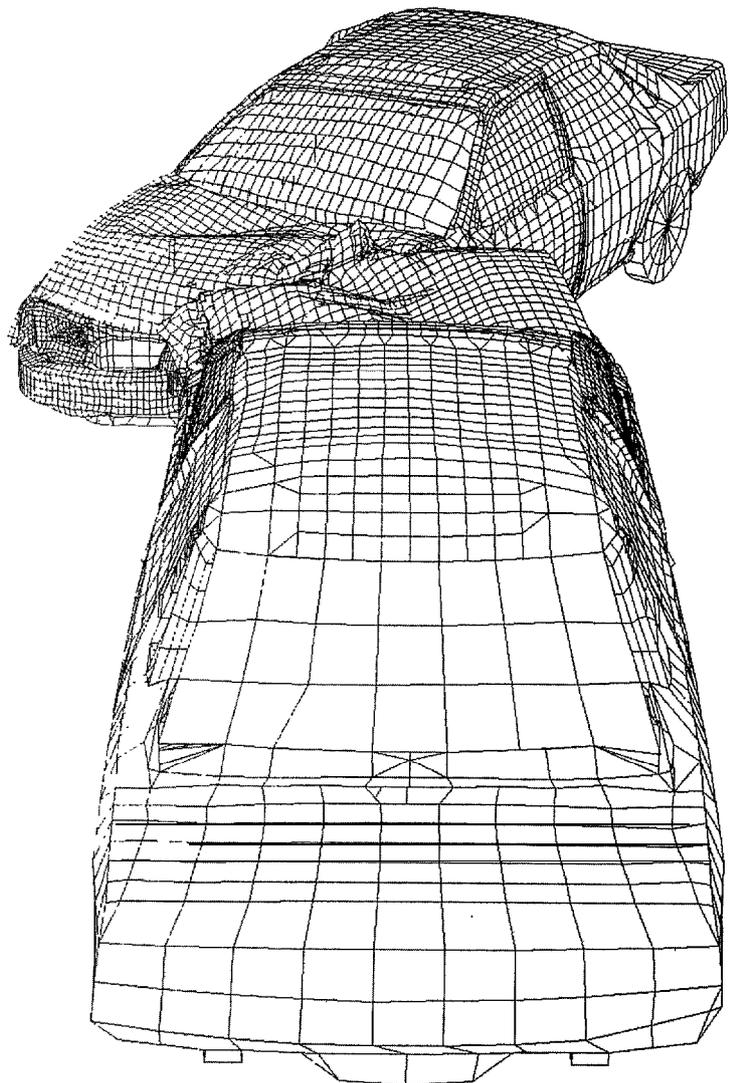
■ *Emissions Status.* We also produced, with the Office of the Secretary of Transportation, the Federal Transit Administration, and EPA, the second triennial report on reducing transportation-related emissions. The report, required under the Clean Air Act, took well over a year to produce, and entailed extensive coordination among agencies, massive literature reviews, and myriad data analyses.

# safety



*Safety is the top priority for highway improvement, according to the 1996 National Highway User Survey. The survey analysts used three methods to determine priorities. In two of these methods, pavement condition was the number one priority with safety as number two; however, when asked through direct comparisons, the driving public chose safety as the top priority.*

*In late November 1995, President Bill Clinton directed Secretary of Transportation Federico Pena to develop an action plan to help States ensure highway safety, Pena initiated his "Secretary's Action Plan to Reduce Highway Injuries and Related Costs," which focuses on 10 key safety issues. FHWA and NHTSA have already achieved many of the major milestones of this plan.*



In addition, we have numerous ongoing research and outreach efforts in the safety area, and we are constantly developing new initiatives to address customer needs and to incorporate emerging technologies into safety models. We work with State, private sector, and Federal partners-including NHTSA,

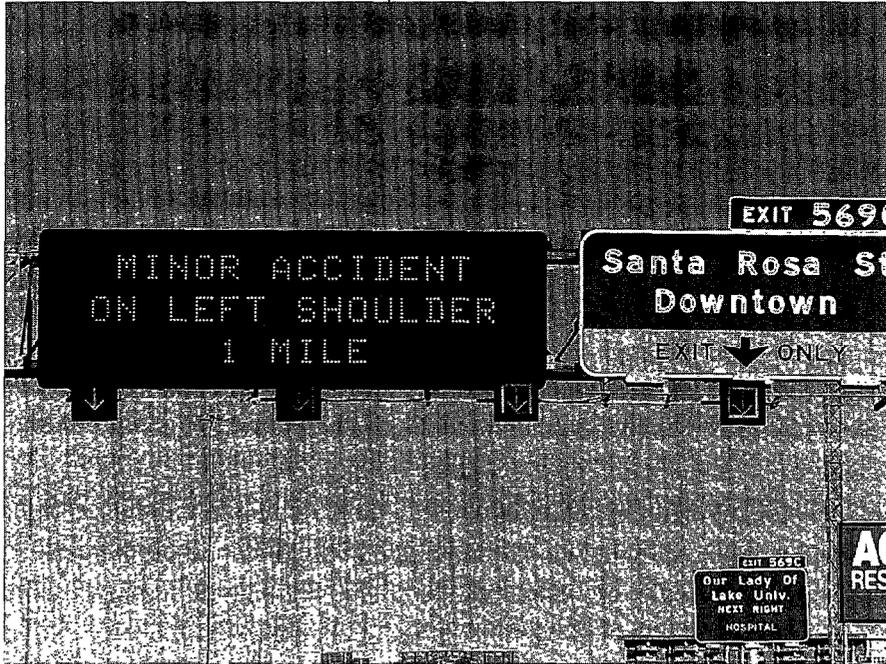
protect consumers. Coincidentally, the American National Standards Institute (ANSI) was updating its sunglass standard at the time this new finding arose. The originally proposed revision to the ANSI standard didn't even address narrowband light sources, but, because of this new research finding, the new standard will.

## Closing the Gap

Much of our safety work is aimed at public education-closing the gap between what the public knows and what it should know about safe driving practices. We're coordinating some of this work with NHTSA, which currently has more experience in this area than do we. On another front, our National Highway Institute presented nine highway safety-related courses 69 times in FY 1996.

- *Safety in Work Zones.* Work zones pose a particular safety hazard, and this past year saw a lot of activity aimed at mitigating this hazard. For one thing, we updated our NH1 course, "Design and Operations of Work Zone Traffic Control." We also developed two new NHI courses: "Construction Zone Safety Inspection" and "Developing Traffic Control Strategies for Work Zones." In addition, a contract is under way to develop work zone safety public outreach material for eventual use by the State DOT's in their statewide work zone safety campaigns. Last and perhaps more lasting, we completed the initial steps to establish a National Work Zone Information Clearinghouse. This initial work was funded by FHWA; the contractor will assume the operational and financial support of the clearinghouse after a couple of years.

- *'Read Your Road.'* In FY 1996, we wrote this handy little booklet on signage and pavement markings; we are now looking for private sector partners



FHWA alerted the Sunglass Association of America to a safety problem regarding sunglass wearers and their ability to read variable message signs.

with whom we jointly sponsor many projects and enterprises such as the National Crash Analysis Center.

Our specialized resources and expertise also lead to our getting involved in many unforeseen efforts. For example, after hearing about problems regarding sunglasses and changeable message signs using light-emitting diodes (LED), we ran some tests at our Photometric and Visibility Laboratory. We determined that the yellow-amber LED signs use LED's operating around 590 nm; some sunglasses don't permit light at that wavelength to penetrate, making the message invisible. We alerted the Sunglass Association of America to our findings, and now sunglass manufacturers are in the process of modifying their standards to permit transmittance of narrowband light sources and thereby

to print and distribute the booklet through their networks. In addition, we have developed two high-tech, state-of-the-art information kiosks with touch screens. These can be used at county fairs and other local exhibitions as a way to build public awareness of road signage and markings and their meanings.

- **Reduced Red-Light Running.** Recognized by the 1996 National Performance Review Status Report as a model of partnering with State and local organizations, our campaign to reduce the number of incidents of red-light running (RLR) has been implemented in more than 50 communities across the country, and RLR materials have been shared with representatives from New Zealand, Italy, England, and Poland. The \$600,000 that we awarded to communities for RLR implementation grants were matched with more than \$1.2 million in private sector contributions to local RLR campaigns.

■ **Advanced Law Enforcement Response Technology (ALERT).** ALERT is a computer-based system to help police officers collect complete, standardized information at accident sites. Improved collection of traffic accident data will lead to improved safety on the road by giving transportation planners better information. In partnership with NHTSA, Texas DOT, Texas Department of Public Safety, Texas Transportation Institute, and the College Station (Texas) Police Department, we have developed and are field testing ALERT. Private industry took the lead in modifying software and hardware to conform to the requirements of ALERT and provided equipment, licensing, and long-term support for the project, significantly reducing the government's cost to support the project.

## Pushing the Envelope

- **Nighttime Visibility.** The level of retroreflectivity determines how well a sign or pavement marking can be seen at night with the proper light source. Over the last several years, we have developed technologies that can measure retroreflectivity at high speeds and by day. Currently, six vans that measure pavement-marking retroreflectivity are being demonstrated in the field. A van to measure sign retroreflectivity will be ready for production shortly. This equipment will allow us to set guidelines for minimum levels of sign and marking retroreflectivity, ensuring an appropriate level of retroreflectivity for traffic control devices and improving nighttime highway safety.

We also tested fluorescent pavement markings on the edge lines and lane lines on a section of parkway in Maryland and at the Federal Bureau of Investigation (FBI) Academy in Quantico, VA, to evaluate their visibility with and without ultraviolet (UV) headlights. With UV lights, the fluorescent markings, based on a concept developed in Sweden, increased the visibility of the edge and lane lines by about 30 m, compared to using standard low-beam headlights and either worn markings or new thermoplastic markings.

■ **Safe Highway Design.** Our Interactive Highway Safety Design Model (IHSDM) continues to become increasingly sensitive and sophisticated. This computer model lets highway designers evaluate geometric design alternatives from a safety standpoint during the planning stages—rather than retrofit later. The most recent improvement to IHSDM is an ability to test two-lane roadways.

*Our campaign to reduce the number of incidents of red-light running was recognized as a model of partnering with State and local organizations.*