# Improved Technology Paves Way to Better Roads and Bridges

## Federal Highway Administration

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The purpose of the Federal Highway Administration, according to its primary charter, is to meet the nation's need for safe, efficient, and environmentally sound transportation of people and goods. But the agency also embraces another mission: to be the world's leader in surface-transportation expertise and innovation.

Improving and even maintaining the world's safest, most reliable, and most sophisticated surface-transportation system is becoming an ever greater challenge, particularly in light of an aging infrastructure, enormous traffic loads, and increasing congestion. At the same time, economic and environmental concerns are altering the way FHWA (and states) must meet this challenge. New technology applications are the keys to success. Presented here is a brief overview of some of the efforts through which the agency's Research and Technology Program is providing cost-effective solutions to some highway problems through technological innovation.

### Accident Prevention

More than 40,000 people die in traffic accidents each year; tens of thousands more are injured. In addition to the personal toll they take, these accidents deal the nation a staggering economic blow of $135 billion per year. Statistics collected by FHWA indicate that for several years the number of fatalities decreased even as traffic volume increased. However, this trend has been reversed. A growing number of drivers, an aging population, greater congestion, and faster vehicles are raising driving risks. To lower these risks, the agency is conducting several research programs designed to facilitate the flow of traffic in the event of accidents, stalled vehicles, and adverse environmental conditions; to make roadways safer; to increase the visibility of signs and lane markings; to reduce the dangers associated with roadside impediments; and, through human-factors engineering, to enhance the decision making of drivers.

Efforts to achieve these objectives are aided by systematic collection of the highway-safety data needed to properly address environmental and human factors in road accidents. For more than 30 years agency engineers relied on traditional, labor-intensive, and costly ($250 million per year) technologies for collecting these data. Through the Highway Safety Information System campaign, FHWA is now developing advanced data-collection technologies and improving data-analysis techniques to determine the reasons for traffic fatalities and identify ways to curb them. From global-positioning-system satellites to digital cameras at accident scenes, state-of-the-art technologies are being used to collect, disseminate, and analyze transportation-safety data. This activity is increasing the cost-effectiveness of data collection, improving the quality of existing data, allowing more appropriate allocation of highway-safety resources, and, ultimately, saving lives.

A logical first step in avoiding accidents is to design roadways that effectively eliminate as many dangerous conditions as possible. For more than 20 years, new roads have been constructed on the basis of periodically updated standards developed by the American Association of State Highway and Transportation Officials in cooperation with the Federal Highway Administration. But state and local governments still must deal with roads designed years ago on the basis of different standards. Redesigning and fixing all of these roads would be prohibitively expensive and not cost-effective; fortunately, correcting problems with the

most dangerous segments of roads is economically feasible. Using its interactive highway-safety design model, agency researchers are developing modeling technologies that allow designs to be tested in the context of different variables before a road is either built or reconstructed. Use of these modeling technologies will eventually save both lives and taxpayer dollars.

In research aimed at reducing the frequency of automobile accidents, engineers at the agency's photometry and visibility laboratory are exploring ways to make lane markings and road signs more visible. One area of investigation involves combinations of new reflective technologies, such as glare-resistant ultraviolet headlights and fluorescent-treated signs and lane markings. In static tests conducted at the Turner-Fairbank Highway Research Center, subjects using ultraviolet headlights were able to see ultraviolet-activated roadway markings nearly 30 percent farther away than with standard low-beam headlights. In dynamic tests, the mean subjective rating of the roadway delineation with ultraviolet headlights was 19 percent higher than with low-beam headlights.

In research aimed at reducing the seriousness of automobile accidents, the agency is focusing on embankments, guardrails, and other roadside barriers. At the National Crash Analysis Center, static crash tests are being examined to develop a material better able to contain collisions with these barriers and lessen their severity. Retrofits of existing barriers that work in concert with vehicle designs are expected to decrease the $38 billion annual cost of these collisions.

Drivers are often implicated as the causative factor in highway accidents. Through FHWA's Human Factors Highway Safety Research Program, computer simulation and modeling techniques are being used to interpret and anticipate ways in which drivers interact with their environment. Using a fixed-based simulator, engineers and psychologists can monitor a driver's reactions and response rates to specific driving variables.

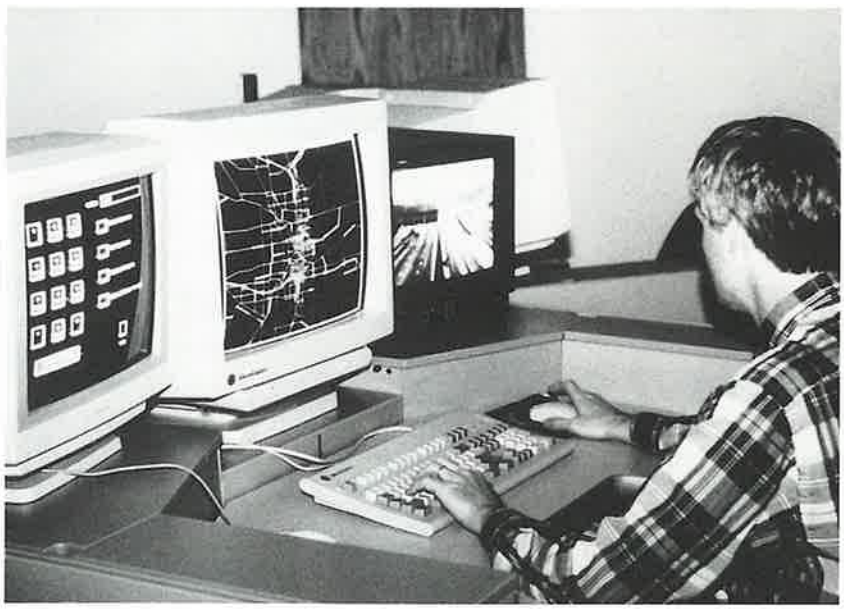
Near-gridlock conditions in many of the nation's metropolitan areas are being addressed through the Advanced Transportation Management Systems (ATMS) program. An integral part of the U.S. Department of Transportation's ambitious Intelligent Transportation Systems Travel Management User Services program, the ATMS program is an effort to incorporate traffic flow, traveler information, and public-transportation technologies into a multimodal network of information, products, and services. The network will allow adjustment of traffic-control devices as traffic conditions change and improve emergency response times with the aid of real-time location information. In addition, it will support "smart card" fare systems and long-term urban-transportation planning.

Advanced transportation-management systems are already helping to prevent the most common type of accident on heavily congested roads—rear-enders. Accident rates on I-35W in Minnesota fell 27 percent after implementation of such a system to maintain even traffic flow. Implementation of a similar system in Seattle resulted in a 62 percent decrease in accident rates during a 6-year period. On freeways where freeway-management technology is used, accidents have decreased 15 to 50 percent.

## Traffic Management

Anyone who has driven in a major metropolitan area appreciates the enormous personal, social, environmental, and economic costs posed by increasingly congested roadways. Using the technology of the automated highway system, FHWA is laying the groundwork for one of its most ambitious projects: an electronic transportation network complete with vehicle- and highway-based sensing and control technologies. With the system, major intercity links and automated transportation hubs could be created in metropolitan areas, thereby doubling or even tripling traffic throughput.

Agency researchers are developing other traffic information and management systems to improve traffic flow and reduce the likelihood of accidents. Advanced traveler information systems increase safety through use of appropriate technologies for alerting drivers to rapidly changing road condi-



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Federal Highway Administration and Georgia Tech Research Institute are investigating human-factors requirements for traffic-management operators.

tions. In urban areas, such systems are often incorporated into the Automated Traffic Management System program; the systems also have applications in rural areas. On highways near the Eisenhower Tunnel on I-70 outside Denver, a dynamic truck-speed warning system for long downgrades alerts truckers to safe speeds at the start of the downgrade on the basis of truck weight and road conditions. Studies indicate that 88 percent of trucks involved in runaway incidents in this area were operated by drivers unfamiliar with the area. The new warning system has reduced traffic accidents and accident-related delays.

As road congestion increases, the running of red lights becomes an increasingly hazardous occurrence, one made more frequent by the poor timing of traffic lights. Most traffic-light progression schemes are calculated on the basis of traffic volumes during rush hour, weekends, holidays, and so on. The agency is investigating real-time traffic-adaptive control systems that allow traffic-light timing to vary with changing traffic patterns through the use of state-of-the-art computational algorithms. The Automated Traffic Surveillance and Control Program in Los Angeles, California, incorporated computerized traffic-signal improvements to reduce travel times by 18 percent, increase average speeds by 16 percent, and decrease delays by 44 percent. In Abilene, Texas, the Traffic Light Synchronization Program has reduced travel time by 14 percent, decreased delays by 37 percent, and increased average speeds by 22 percent.

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Structural integrity of Woodrow Wilson Bridge in Virginia is being assessed with ultrasonic system. Bridge problems can be detected and investigated using such nondestructive evaluation technologies.

Perhaps nowhere are the monetary benefits of intelligent-transportation-systems technologies clearer than in the Commercial Vehicle Operations program, which is designed to facilitate interstate communications among state and federal motor-carrier regulatory agents, improve automated inspection procedures, and electronically screen for transponder-equipped legal vehicles. Some commercial trucking companies using these technologies are reaping significant savings because they have automated many formerly time-consuming, labor-intensive processes, including dispatching, inspections, and communications. With advanced vehicle-monitoring and communications technology, haulers for Trans-Western Limited of Colorado are able to drive an additional 80 to 160 kilometers (50 to 100 miles) per day. Frederick Transport of Ontario credits the technology with an increase of 20 percent in loaded miles, a reduction of $30 to $150 in monthly telephone charges, and a 9 percent increase in total miles traveled. Best Line of Minneapolis is saving $10,000 per month because its 300 drivers no longer have to wait an average of 15 minutes to speak with dispatchers. Telesat Canada's system increased loaded mileage 9 to 16 percent and reduced operating costs from $0.32 to $0.20 per mile.

Although the transportation woes of urban areas usually make the headlines, rural areas have their own set of problems, including long response times to accidents. Through a needs assessment survey, it was determined that the greatest concern of rural drivers is the delay in response time to disabled vehicles. This problem is being addressed through the use of sophisticated new "may-day" technologies developed by FHWA. One commercial application of these technologies enables the driver of a disabled vehicle to activate a signal that is immediately detected by a global-positioning-system

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High-performance concrete was used to construct Bristol Bridge in New Hampshire. FHWA researchers are developing, testing, evaluating, and promoting high-performance concrete, which could greatly extend service life of a structure.

satellite, which then relays the coordinates of the stranded motorist to a response team.

Researchers are instituting many applications of intelligent transportation systems in an effort to address other problems faced by motorists in rural areas. One application is the use of environmental sensors and variable-message signs to provide early warning of inclement weather conditions. Another application involves the development of advanced railroad-highway grade crossing systems in which interactive devices are used to communicate with both trains and vehicles, greatly enhancing the safety and mobility of travelers in rural areas. The use of basic collision-warning devices has already helped the Transport Besner Trucking Company reduce the accident rate of its drivers by 33 percent. Data from the Minnesota Department of Transportation indicate that 60 percent of accidents on rural freeways can be eliminated through the use of collision-avoidance and lane-keeping technologies. A 40 percent decrease in those accidents would result in 19,000 fewer collisions, 190 fewer fatalities, and an economic savings of $225 million per year.

## Assessment and Improvement of Infrastructure

Few issues will play a more prominent role in local politics across the country in coming years than the inevitable decay of transportation infrastructures. The need to rebuild, strengthen, and preserve the nation's transportation infrastructure will place enormous political, social, and economic demands on local, state, and federal resources for the foreseeable future. The agency that took a leading role in creating the world's finest surface-transportation system now spearheads efforts to refine, revamp, and improve the system.

Perhaps nowhere are the benefits of the research and technology program more in evidence than in improvements of the nation's roadways and bridges. In cooperation with the states and participants in the Strategic Highway Research Program, engineers developed a new asphalt Superpave system that will significantly extend pavement life. Given that 500 million metric tons of asphalt-concrete mixtures are used each year on more than 90 percent of U.S. roads and streets, the Superpave technology will save the nation tens of millions of dollars annually in pavement and road-user costs. In addition, researchers are developing, testing, evaluating, and promoting high-performance concrete and high-performance steel for use in the construction of bridges with two to three times the service life of existing bridges. They are also studying fiber-reinforced polymer composites that offer high weight-to-strength ratios and increased corrosion/deterioration resistance for use in structural applications.

In addition to this materials research, engineers are collecting information that will ultimately lead

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