

## Improving Mobility: Working Smarter Through New Technologies

A report on the 1996 Accomplishments of the Federal Highway Administration  
Office of Research and Development in Intelligent Transportation Systems

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Congestion, aging infrastructure, and environmental and safety concerns impede mobility, driving the country to find solutions that will achieve improved safety and capacity, cleaner and more efficient vehicles, and a regeneration of the transportation infrastructure. Innovative research and new technologies in Intelligent Transportation Systems provided by Federal Highway Administration (FHWA) researchers working to bring forward smarter and better developed transportation-related products and practices that will improve mobility for all. Advanced transportation technologies and concepts are playing an important role in closing the gap between the state of the practice and the state of the best practices in resolving transportation concerns related to congestion and traffic management.

The research to do this is organized into four areas:

- Traffic Management Systems .
- Automated Highway Systems
- Enabling Technologies
- Information Systems and Other Research

The following is a brief list of some of the strides forward that have been taken in the past year, 1996 in each of these research areas.

### **Traffic Management Systems**

National Transportation Communications for ITS Protocol (NTCIP) - In 1996, significant advancement of the NTCIP has been accomplished. FHWA R&D sponsored and took the initial lead in organizing a committee of city, state and industry leaders in the field for the development of the NTCIP. The work has lead to significant strides forward and the beginning of a standard for communications among traffic control devices. This standard for transmitting data and messages between electronic devices, has been well received within the transportation community, with the first full version now completed. Following this initial success, R&D efforts were expanded to the establishment and hand-off of lead responsibilities to a joint AASHTO/ITE/NEMA Committee to oversee the further development of the NTCIP and to incorporate additional functionality to meet the needs of the entire transportation community. The committee will identify processes, products, and activities that should be added or modified in the development of the standard. FHWA R&D continues to be the catalyst in fostering the development and support of the NTCIP effort.

Surveillance and Detection - The Jet Propulsion Laboratory under contract to the FHWA R&D awarded eight contracts to advance or develop new detection technologies. In 1996, prototype sensors, ready for field testing, were delivered by these contracts. These sensors, based on technologies developed for the defense industry including video imaging systems, passive infrared, radar, line of sight, and induced radiation detection techniques, were developed and laboratory tested. All of these sensors were retrofitted to traffic applications based on the functional requirements documented in another earlier R&D study. At least ten jurisdictions have expressed an interest in field testing these new detection technologies. To facilitate this, JPL worked to insure that the sensors developed are NTCIP compliant. Prototypes of seven of these sensors were delivered in late September 1996, with the remaining prototype due for delivery in October 1996 for continued testing.

Small Business Innovation Research (SBIR) - R&D has been active in supporting and directing efforts of small businesses which have resulted in the commercialization of products in use today and beneficial to the highway community. Products include the first all-digital commercial loop test meter, a laser ranging vehicle sensor used on toll roads in California and elsewhere, and a new detector system using digital signal processing technology and neural networks to find more information from inductive loops.

Advanced Operational Analysis Technologies - FHWA R&D made significant improvements in the development of traffic software, particularly in the area of simulation modeling. It established a configuration management system for simulation model (CORSIM) development to control and coordinate the software changes needed, track version releases, and better incorporate user requests. The first phase of a new windows version of the FHWA Traffic Software Integrated System (TSIS) was completed, providing a common open architecture for supporting public and private traffic engineering. The first phase of new input/output software enhancements are being released to the transportation profession. The major enhancements made to the FHWA's CORSIM simulation model, will allow for better evaluation of traditional traffic design/operations analyses, including new ITS technology assessment.

Dynamic Traffic Assignment (DTA) and Synthetic Origin-Destination (OD) Matrices - Two parallel research and development activities are currently being undertaken under the sponsorship of the FHWA R&D by Massachusetts Institute of Technology (MIT) and The University of Texas at Austin (UTX). Functional requirements analysis, conceptual design, and mathematical model formulations for a deployable real-time simulation-based DTA system are completed by MIT and UTX, respectively. The conceptual design and model formulations for each proposed DTA system were delivered in 1996 and were reviewed and approved. Development of the two proposed prototype DTA systems with OD estimation and prediction capabilities are underway and will be completed in June 1997. Also, an Application Program Interface (API) has been built in the FHWA's microscopic traffic simulation model (CORSIM). The API interface allows MIT and UTX to develop and evaluate the design of their proposed DTA systems using that powerful traffic simulation tool developed by FHWA. Real-Time Traffic Adaptive Control System (RT-TRACS) - In 1996, much progress was made within the RT-TRACS project. The prototype control strategies developed under separate contracts were incorporated into the RT-TRACS implementation system. Initial laboratory simulation testing showed that the strategies within the RT-TRACS system produce statistically valid improvements in traffic throughput and reduced average delay. This

comparison was made between RT-TRACS strategies and traditional optimized pre-time traffic signals system. In fact, testing in one scenario with one strategy yielded benefits in excess of 20%. While it is probable that not all deployments of this control system will yielded such improvements, it is expected that the gap between the performance of RT-TRACS and optimized pre-timed signals will expand as the field research testing of RT-TRACS gets underway in 1997.

Traffic Management Center Research - Under this broad heading are two significant R&D initiatives. The first is the Traffic Research Laboratory (TReL) being developed to test the performance and interactions of today's highly complex and advanced traffic management techniques. The second is a human factors simulation facility for studying the design of Traffic Management Centers (TMC).

*The Traffic Research Laboratory (TReL)* - Significant development of the TReL has taken place in 1996. The initial version of the TReL test bed has been completed, and can now achieve the following: 1) Minimize expenditures in research support activities, by allowing FHWA to test and evaluate not only individual R&D components, but the integration of these products operating as a system. 2) Answer questions on new concepts, deployment, and changes in infrastructure, which will result in long term savings. 3) Increase research product quality by assessing its validity. 4) Acceleration of traffic management modernization through evaluation. 5) Address critical issues in both traditional traffic engineering and ATMS through large scale experiments on combined technologies. The FHWA TReL will bring us closer to realizing the benefits of deploying ITS technologies.

*Advanced Traffic Management Centers* - The Georgia Tech Research Institute, working under the direction of FHWA R&D continued to explore the use of simulators for studying human factors issues in the design of TMCs. In 1996, the researchers examined work stations to see how future operators and roadway travelers might interact in the ITS era. Volunteer research subjects sat at work stations in Atlanta to act as drivers viewing traffic conditions as though they were driving along selected city corridors. Researchers observed and compared driver reactions to changing messages on travel conditions simulated both for the drivers and for other volunteer research subjects trained as ITS TMC operators. The diversion decisions made by drivers reacting to information received on their in-vehicle displays are used as input to the traffic model and, in turn, to the traffic conditions seen by TMC operators. This feature allows researchers to study system-level human factors question by putting both drivers and TMC operator "in the loop" at the same time.

### **Automated Highway System**

Automated Highway System (AHS) - The FHWA R&D has fostered a strong relationship and is an active partner with the National AHS Consortium (NAHSC) in its goal to develop the AEIS prototype. The R&D played an integral role in forging this coalition, helping bring together systems integration contractors, university research organizations, and other major automobile and highway industry players and stakeholders to work in a consensus environment to define the prototype AHS.

NAHSC efforts focused in the following areas in 1996 and will continue their study on, into 1997:

- AHS Concept Development: Various conceptual approaches to implementation are being defined and evaluated (through analysis, simulation, and site-specific case studies) to assess performance and deploy ability. The last of three phases of iterative analysis and down selection is just beginning, the output of which will guide development of the prototype system.
- Technology Development: Several key technology areas are being further developed in the areas such as radar discrimination, machine vision, control algorithms, and actuators.
- Societal and Institutional Analyses: Impacts are being assessed in areas such as institutional structures, liability, land use, sustainability, and deployment cost/benefit for various users.
- Stakeholder Involvement: The NAHSC is actively involving stakeholders in the technical analyses and decision-making through collaboration with Associate Participants, public workshops, and focus groups, all geared towards the building of a national consensus on the best way to use and deploy this future capability.
- 1997 Demonstration: The demo will establish that AHS is desirable, feasible, and deployable. In early August 1997, a combination of passenger cars, heavy trucks, and transit buses will operate in automated mode on the median HOV lanes of I- 15 north of San Diego. An accompanying exhibition will showcase products and technology developments that will lead the way to deployment. Associate Participants have been invited to participate and several are planning to do so.

### **Enabling Technologies**

Communications and Navigation Systems - This is a broad area of enabling research that is of vital importance to ITS. The following is a list of 1996 accomplishments in the specific areas of research.

*Dedicated Short Range Communications (DSRC)* - In the area of DSRC, several major milestones were reached. First was the issuance of a Certificate of Spectrum from the National Telecommunications and Information Administration. This certificate allows the FHWA to use 75 MHz between 5850 MHz and 5925 MHz for 15 years. Second, a draft petition to the Federal Communications Commission, requesting 75 MHz between 5850 MHz and 5925 MHz, was developed based on technical requirements of the ITS program. This petition forms the basis for a petition to be submitted by the Intelligent Transportation Society of America this fall.

220 MHz - Additional frequency coordination occurred with the five channel pairs that have been assigned to FHWA. These frequencies have been used to support the tests in Atlanta, the Direct project in Detroit, and the development of a high data rate modulation scheme at Purdue University.

Subcarrier Traffic Information Channel (STIC) - FHWA R&D sponsored a contract with the National Radio Systems Committee this year for the STIC laboratory testing. Independent testing of the STIC system was completed at the Institute for Telecommunications Sciences. The report "Testing and Evaluation of the Subcarrier Traffic Information Channel" was published and the information it contained was used to refine an FM subcarrier coverage model. This model was then used to generate another report, "IVHS FM Subcarrier Corridor Assessment," showing the coverage of the STIC system in the Gary-Chicago-Milwaukee corridor, Atlanta, GA, and I-95 from Richmond VA to Portland ME.

AM Subcarrier - A low to medium frequency (LF/MF) coverage model was developed to assist in the evaluation of an operational test of using AM Subcarrier. This model was used to accurately model the coverage of the system being tested and has been further refined to support other modeling efforts in other parts of the LF/MF spectrum, including the Coast Guard's Differential GPS system.

Public Safety Wireless Advisory Committee (PSWAC) - R&D participated in the PSWAC, a group tasked with determining the public safety spectrum requirements through the year 2010. Specific achievements included having the committee include in their document the requirements of the Federal Highway Administration for ITS. The final report is now available and has several sections that deal specifically with ITS and other transportation requirements.

Communication Alternatives Test and Evaluation - In addition to supporting several of the topics above, several papers were generated including "An Overview of ATM Networks in ITS," "An Overview of SONET," "Survey of Traffic Surveillance Technology in ITS," "Performance Analysis of an Automotive Whip Antenna at 220 MHz," and finally, a "Review of the Phase II System Architecture work for Communications at July 96 NAR." Additional work is ongoing and results are expected shortly in the areas of DSRC and other communication systems.

GPS - L5 - In support of the Office of the Secretary of Transportation (OST), a Cost/Benefit Analysis was performed for the second civilian downlink frequency, referred to as L5. This was delivered to OST in May and an expanded version illustrating additional applications of L5 was delivered in September 1996.

GPS - DGPS - In the area of Differential or Augmented GPS, a preliminary assessment of the technical feasibility of expanding the US Coast Guard system to cover the remainder of the US was completed in March. A final report detailing the system expansion will be completed shortly. Work commenced on a plan for implementation.

Federal Radionavigation Plan (FRP) - FHWA participated in the update of the 1994 FRP. This update is referred to as the 1996 FRP and is scheduled for release by the end of December.

Commercial Vehicle Information Systems Network (CVISN) - The FHWA R&D, in partnership with the Office of Motor Carriers, developed an architecture for a national Commercial Vehicle Information Systems Network (CVISN) pronounced "see vision."

CVISN is not a new system, but rather a way for existing systems to exchange information through the use of standards and the US commercially available communications infrastructure 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, and service bureaus to name a few.

A prototype version of Carrier Automated Transaction (CAT) software was developed to allow carriers to obtain credentials for registration, fuel tax, oversize/overweight, and HazMat. The CAT software runs on a personal computer and will also allow carriers to file quarterly tax reports and perform other routine carrier to state transactions.

R&D worked in partnership with International Registration Plan Inc. (IRP, Inc.) and International Fuel Tax Agreement Inc. (IFTA Inc.). These are nonprofit companies formed by the states and managed by a Boards of Directors who are State Administrators. Through this partnership, R&D began designing interstate exchange capabilities in support of the CVISN architecture.

Draft standards were developed through the American National Standards Institute to allow information interchange among all commercial vehicle information systems including state credentialing systems, national systems, roadside enforcement officers, and commercial users such as shippers, banks, and insurers. These same standards will also allow all US vehicles to register electronically from a personal computer.

A state specific systems design of the CVISN architecture was begun in Maryland and Virginia. These prototype states will implement all CVISN services identified by the CVISN architecture in a comprehensive integrated system.

Evaluation Support for Operational Tests - This past year, an ambitious effort was undertaken to review, document, and coordinate the seventy-plus ongoing operational tests. First, a series of four workshops involving the program managers and lead evaluators of all the FHWA operational tests was conducted to review and discuss all these tests. Second, each FHWA operational test was reviewed individually either on site or in Washington to better document and understand the current services planned, evaluation goals, and status. Third, a series of thirteen internal workshops were conducted to review the operational tests by functional area in order to better coordinate the evaluation efforts to ensure maximum input to the national program. 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.

ITS Research Centers of Excellence - FHWA R&D has three competitively selected and one Congressionally mandated Research Centers for Excellence (RCEs) established to provide ITS research solutions, promote ITS technologies and provide professional development to prepare ITS professionals to design, build and operate intelligent transportation systems. These are located at the University of Michigan, Texas A&M, Virginia Polytechnic Institute and State University, and the University of Minnesota. These institutions have accomplished much in the past year. Below are just a few of the highlights:

- Research in Commercial Vehicle Operations involved the application of Automated Vehicle Location (AVL) systems to snow and ice removal and the extension of AVL systems to include dynamic route guidance for vehicles in a time-sensitive (e.g., Just-In-Time) delivery environment.
- One center implemented in the field a first generation real time multimodal traffic adaptive control system they developed.
- They developed a first generation prototype (exhibited at ITS America) of a Houston Metro Police Vehicle equipped with an open architecture in vehicle computer and communications system to expedite incident response and management. A major feature of this vehicle is that it significantly reduces the computer and telecommunications “clutter” found in many police vehicles.
- A draft plan for expediting commercial vehicle movement through regulatory facilities along the Texas Mexico border was prepared. This plan informs people of what is going on in ITS and what the opportunities are both for applying ITS to border crossings and to developing tools to meet those needs.
- RCE researchers are working with the TTI Rail Research Initiative staff to develop a Intelligent Transportation System - Positive Train Separation initiative between the RCE, Washington State DOT, Burlington Northern Railroad and Union Pacific Railroad to develop a test bed for integrating information from positive train control systems with automatic train location systems and intrusion detection systems for highway railroad grade crossings with ITS systems.
- The RCE’s evaluation of the Houston Metro AVL system with the METROLIFT paratransit service quantified the positive benefits of this application in terms of the cost and quality of the service.
- One center has developed and demonstrated a Wide-Area Incident Management Software System (WAIMSS) as well as point diversion modules, which is scheduled for use in the new Suffolk, Virginia TMS in 1997.
- Center researchers have developed and fabricated optical fiber-based sensors for vehicle (i.e., cars vs. truck) classification, weigh-in-motion, and visibility condition classification.
- RCE researchers have developed and tested sensor and communication technology, including a wireless communications digital receiver, ultra-wide band communications, and a passive acoustic sensor for vehicle detection, position location, and automated control.
- A researcher conducted two multi-session workshops teaching the KRONOS macroscopic simulator to public and private sector transportation professionals.
- A study was begun in a first gerontechnology research project in conjunction with Penn. State aimed at applying ITS technologies to improve the mobility of our aging population.

- One center successfully integrated live traffic video into their research facility. This video consists of over 40 channels from surveillance and machine vision camera sources located along both freeways and intersections in the Twin Cities area.
- The Texas center acts as the Clearinghouse for the Univ. of Michigan, Virginia Polytechnic Institute and Texas A&M RCEs. They have published two annual reports and several issues of the RCE Quarterly report "Intelliscopes" and coordinate the hosting of ITS RCE outreach booths at the ITS and TRB annual meetings. In total, the RCEs have published more than 135 papers, given more than 45 conference presentations and acquired more than one and one-half million dollars in matching funds.

Innovations Deserving Exploratory Analysis - The IDEAs program was developed by FHWA to encourage innovative ideas and concepts which 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 which cuts across modes and technologies. As a result, NHTSA and FRA now each contribute \$500k per year to this program. The program developed a technology for significantly reducing the wiring at signal controlled intersections by using off the shelf power control communications technology similar to the Radio Shack home control system. A communications scheme for wireless modems was developed to maximize the use of the severely limited ITS bandwidth. A vehicle classification sensor was developed which allows determination of whether a vehicle is a car, truck or bus and what kind of truck or bus. A sensor is being developed which allows a truck to determine if its driver is drowsy or drunk. The IDEA program met with the AHS program managers panel and presented 4 projects which were of interest to the AHS managers. This meeting will be repeated periodically to allow the technology interchange to continue. Six product reports were finished on new technologies and summaries are being placed on the World Wide Web. Approximately 47 projects have been awarded in the three years of the project while another 18 are in the process of negotiation.

### **Information Systems and Other Research**

In-Vehicle Information Systems (IVIS) - The FHWA researchers, working with those at the Oak Ridge National Laboratory Organized built on a workshop on MS held in October 1995 by creating a stakeholder group vested in the development and testing of IVIS designs. Since then, the IVIS program has been broadened to include in-vehicle traveler information on vehicle status routing and navigation, regulatory information, collision avoidance, traffic conditions and safety advisories. This year, driver performance data showed that the IVIS information generally led to quicker braking response times to traffic signals and signs and consequently, to less abrupt braking. Older drivers seemed to benefit most from IVIS, especially in simulated fog, where IVIS provided more time to perceive the sign and react appropriately.

Advanced Rural Transportation Systems (ARTS) - Efforts to study and deploy ITS along the rural transportation system were accelerated this past year, with ARTS accomplishments occurring on two levels. First, a Rural Action Team composed of U.S. DOT officials interested in ITS, including R&D representatives, drafted a strategic plan laying out a vision and goals for making rural transportation successful. Focus areas include safety and



accessibility, efficiency, economic vitality, and environmental conservation. Actual implementation of CARTS-related projects incorporating ITS technologies was accomplished through two field tests. One was to assess the use of satellite communications for Mayday systems, and the other was to develop a portable surveillance and delay advisory system for work zones. Additional projects include a technology scan to identify successful, low-cost technologies for rural environments, e.g. weather information networks, and a focus on the use of enhanced radar detectors to display warning messages inside the vehicle.

Highway Overpass Height Measuring System - This system, which provides an accurate profile of the underside of highway overpasses, was designed and fabricated in cooperation with the Office of Engineering R&D. It is a self-contained instrument which easily mounts on any vehicle and measures the overpass height while traveling up to 60 miles per hour. The laser device is synchronized with a vehicle wheel sensor to accurately correlate the overpass height with precise distance traveled, thereby providing an instant bridge profile. Currently, a new microprocessor is being incorporated into the system in order 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.

The year 1996 has been a busy year for FHWA R&D and 1997 promises still more accomplishments that will improve safety and mobility for the nation's traveling public