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SMART HIGHWAYS

Challenges Facing DOT's Intelligent Vehicle Highway Systems Program

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GAO/T-RCED-94-253

Mr. Chairman and Members of the Subcommittee:

We appreciate the opportunity to testify on the results of the review that the Subcommittee requested of the Department of Transportation's (DOT) Intelligent Vehicle Highway System (IVHS) Program. IVHS encompasses numerous surface transportation applications of electronics, telecommunications, and information processing technology, ranging from electronic toll collections to futuristic fully automated highways. The Intelligent Vehicle Highway System Act of 1991 established a federal program to research, develop, and operationally test IVHS systems and to promote their implementation. Designed to facilitate the deployment of technology that will enhance the efficiency, safety, and convenience of surface transportation, the program is intended to benefit travellers by improving access and saving time, the economy by increasing the productivity of the transportation sector, and the environment by reducing vehicle emissions. The act authorized $659 million for this program for fiscal years 1992 through 1997. For fiscal years 1992 through 1994, the IVHS program received its full authorizations, as well as additional appropriations, for a total of $580 million.

Our testimony today focuses on three areas: DOT's obligation of IVHS funds to date, the progress made in implementing IVHS technologies, and issues that may affect the attainment of IVHS goals. In summary, we found the following:

-- For fiscal years 1992 and 1993, DOT has obligated $272 million for 232 IVHS projects and activities. Over half of this sum--about $159 million--was obligated for operational tests to evaluate the effectiveness and feasibility of specific IVHS technologies. About $60 million has gone to fund basic research and development, and $28 million has been directed to deployment support projects.

-- IVHS technologies are in various stages of maturity: Some are already being used, while others will require additional research, development, testing, and advances in technology applications before they are ready for implementation. For example, electronic toll collection is already being used in Oklahoma, Texas, Michigan, Pennsylvania, and New York and is planned for use in Virginia and California. In addition, some states are using weigh-in-motion technology to help enforce truck weight limits without requiring trucks to stop at check points. In contrast, other IVHS technologies, such as on-board navigation systems and the proposed automated highway system, will require further development and testing before the feasibility of fully deploying these technologies is known.

-- A number of issues could affect the full achievement of IVHS goals. First, IVHS technologies will be costly and their commercial success is uncertain. Their deployment will require substantial investments by the public sector, private industry, and consumers; deployment costs are expected to exceed $200 billion by the year 2011. Second, the development of a system architecture and standards is critical to ensure compatibility among different IVHS technologies and reduce risks to the private and public sector. Third, an effective plan is needed to disseminate information to users on the benefits and successes of IVHS technologies in order to stimulate demand for additional applications. Finally, concerns about maintaining users' privacy must be overcome before consumers accept IVHS technologies.

BACKGROUND

Before discussing the IVHS program in detail, we would like to provide some background information about the purpose and goals of the IVHS program and how it operates. The United States' IVHS program was established partly in response to the technological successes of the European and Japanese programs in the 1980s. In the Intermodal Surface Transportation Efficiency Act of 1991, the Congress noted that the United States would lose its competitive advantage unless it took action to catch up in this rapidly developing field. At a time when congestion is costing the nation an estimated $100 billion annually in lost productivity, IVHS technologies offer the automobile and the electronics, computer, navigation and communications industries business opportunities to enhance the nation's competitive advantage. Accordingly, the IVHS Act established a comprehensive program to develop IVHS technologies in order to reduce traffic congestion, increase economic productivity, and enhance highway safety. The IVHS program is a three pronged effort that fosters the development of IVHS through (1) basic research and development, (2) operational tests that serve as the bridge between basic research and full deployment, and (3) various deployment support activities that facilitate the implementation of IVHS technologies.

DOT provides federal-level guidance for the IVHS program. In December 1992, DOT issued an IVHS strategic plan, outlining the broad goals and objectives of the program. By the end of 1994, DOT intends to issue a program plan that will specify the steps needed to deploy the full range of IVHS services. Within DOT, the Federal Highway Administration has primary responsibility for implementing the IVHS program. However, the Federal Transit Administration and the National Highway Traffic Safety Administration also have active roles in funding and managing various IVHS projects.

The nationwide effort to develop IVHS extends well beyond the federal government. State and local governments, private industry, and the research community, including members of academia, are active participants in shaping the program and conducting research and operational tests. Much of the input from these participants comes through the Intelligent Vehicle Highway Society of America (IVHS America). IVHS America and its technical committees serve as a federal advisory committee to DOT and as the primary organizational representative of the IVHS community. DOT identifies research and operational test needs, and establishes contract relationships with program participants. Contracts have been established with 72 academic institutions, national laboratories, and private firms; the federal share of the total costs for each of these projects ranges from 50 to 100 percent.

FUNDING FOR IVHS HAS INCREASED SIGNIFICANTLY SINCE 1991

Federal IVHS funding has grown significantly in recent years. Before the act's passage in 1991, federal funding of IVHS research and technology was about $4 million in fiscal year 1990 and $25 million in fiscal year 1991. By fiscal year 1993, federal obligations had grown to $165 million. This year, DOT plans to spend about $310 million on IVHS activities. As of March 1994, the program had 232 ongoing or planned projects. (See app . 1 for funding information.)

For fiscal years 1992 and 1993, DOT has obligated $272 million for IVHS projects.' About 59 percent, or $159 million, of this sum was obligated for operational tests; 22 percent, or $60 million, for research and development; and 10 percent, or $28 million, for deployment support projects. Appendix II breaks down IVHS obligations by project category.

IVHS Operational Tests

DOT currently supports 61 ongoing or planned operational tests. Ten projects account for nearly 70 percent of the obligations for operational tests through fiscal year 1993. These projects are generally testing different types of "smart" technologies, such as

-- cars that have on-board navigation systems that display information on congestion and travel times, thereby allowing the driver to elect the quickest route, avoid frustration, and reduce travel time;

‘DOT was not able to correlate the IVHS funding cited in its budget schedules with those in the project list. As a result, the fiscal year 1992 and 1993 funding levels do not fully reconcile.

-- buses that use navigational satellites to locate and schedule information to dispatchers and provide transit users real-time information on when the next bus is coming;

-- toll booths that reduce congestion and drivers' frustration by allowing travelers to pay tolls without stopping, using electronic tags attached to their windshield that are scanned by equipment at the toll booths; and

-- trucks with vehicle identification systems that automatically capture registration information to assist states in tax collection.

All of these technologies are directed at improving the efficiency of the existing transportation systems and reducing travel time. Appendix III contains a list of the major operational test projects.

Research and Development Projects

In addition to conducting operational tests, DOT promotes IVHS by funding its research and development. In general, research and development projects identify how existing and emerging technologies can be used to enhance the surface transportation system. Through fiscal year 1993, DOT had obligated $60 million, or 22 percent, of the total funding for IVHS on research and development. About a third of this funding for research and development, or $21 million, went to projects supporting the automated highway system (AHS).

DOT has emphasized automated highway research because the IVHS Act established a goal that it develop a fully automated roadway or an automated test track by 1997. By that year, FHWA intends to provide proof of the technical feasibility of AHS concepts, designs, technologies, and functions. The long-term goal of the AHS program is to create a fully automated highway system in which vehicles will interact with the highway and each other to operate with minimal assistance from drivers.

Other major research projects focus on improving highway safety through IVHS technologies. Projects are exploring the feasibility of moving packs of vehicles at high speeds using electronic sensing and communications or developing advanced technologies to prevent or decrease the severity of rear-end collisions. A list of major IVHS research and development projects appears in appendix IV.

Deployment Support Projects

About 10 percent, or $28 million, of the federal IVHS funding has been directed to deployment support projects. One-third of these funds have targeted the development of an IVHS architecture, or framework, that will integrate the various IVHS technologies to maximize their benefits. Other projects are addressing environmental and legal barriers to the deployment of IVHS technologies and are funding early IVHS studies in 36 cities around the nation. Appendix V lists the major IVHS deployment support activities.

PROGRESS MADE IN IMPLEMENTING IVHS TECHNOLOGIES

The IVHS program is focused on the development of a collection of IVHS technologies intended to improve travel and traffic management for users of automobiles, commercial vehicles and public transit. IVHS technologies are in various stages of maturity: Some are available today, while others will require additional research, development, testing, and advances in technology applications before they are ready for deployment. IVHS technologies have been deployed when their considerable benefits have exceeded their costs. For example, numerous toll facilities have already implemented electronic toll collection. Other technologies, such as in-vehicle route guidance, have not been widely implemented in the United States, in part because of a limited consumer market to date.

Travel and Traffic Management Systems

Travel and traffic management systems are intended to provide drivers and local transportation officials with real-time information on traffic conditions and thereby improve traffic flows and minimize congestion. Emerging IVHS technologies will allow drivers to use home computers to obtain traffic information before beginning a trip and use on-board navigation systems to receive similar traffic information in their vehicles. Advanced Traffic Management Systems (ATMS) will also allow localities to better monitor and manage the movement of traffic on streets and highways. Parts of these technologies are already being used to better manage traffic flows and congestion. For example, by 1990, 26 cities had installed or were planning to install freeway surveillance and control systems. In addition, 36 cities are expected to develop plans for partial ATMSs by 1996.

Electronic toll collections have been among the most widely deployed traffic management IVHS technologies. Electronic toll and traffic management systems have been used throughout the nation because they save drivers time and provide a quick return on investment to their public and private sector users. More than one-half million electronic tags have been issued to vehicles using 20 toll roads, bridges, tunnels, and airports in the United States. On the Oklahoma Turnpike alone, about 230,000 drivers use the tags to pay tolls electronically. When a tagged vehicle passes the electronic toll booth, a sensor reads the tag and deducts the toll, and a sign informs the driver when the account balance is low so the driver can replenish the account. Tags are provided free to users, who receive a lo-percent discount on their tolls. Electronic toll collection technology has been implemented in Dallas, Detroit, Philadelphia, and the New York Thruway and is planned for the Dulles Fastoll project in Virginia and for several California roads. The technology is being considered for the I-95 corridor from Washington, D.C., to Maine.

Compared with the deployment of electronic toll collection technologies, the deployment of automobiles with route guidance systems has been limited in the United States. Attempts to introduce these systems in California in 1984 and 1993 met with limited success because consumers lacked interest in them. In contrast, Japanese industry sold about 500,000 navigation systems, priced between $2,000 and $6,000, between 1987 and 1993; sales for an additional 350,000 systems are projected for 1994. Japanese consumers' demand for the navigation systems followed the Japanese government's already heavy investment in advanced traffic management systems. DOT's IVHS program is supporting operational tests of on-board navigation systems, most notably through the ADVANCE program in Chicago and the FAST-TRAC project in Oakland County, Michigan. The operational tests, which will be completed in 1996, are described in appendix III.

Technologies for Commercial Vehicles

As we noted in our June 1994 report on highway user fees, Automatic Vehicle Identification (AVI) and Weigh-in-Motion (WIM) technologies are increasingly being employed by states to facilitate the safe and efficient passage of trucks over state lines and gather information to assist states in tax collection.[2] AVI equipment enables states to identify commercial vehicles fitted with transponders as the vehicles pass specific points on the highway. Once a vehicle has been identified, a computer can determine whether it has been registered and has had a recent safety inspection, as well as record its weight and track its passage into or out of a given state. Oregon uses AVI and WIM technologies to administer and enforce its axle-based weight-distance user fee. According to Oregon officials, these technologies have helped minimize that state's administrative and compliance costs.

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2 HIGHWAY USER FEES: Updated Data Needed to Determine Whether All Users Pay Their Fair Share (GAO/RCED-94-181) June 7, 1994.

The most visible of the state efforts employing AVI and WIM is the HELP/Crescent project in six western states. HELP equips trucks with AVI transponders that electronically transmit credentials (registration, legal weight, etc.). In addition, the project places AVI readers and WIM scales along the highway to record operating weight and miles traveled. In combination, these technologies allow trucks equipped with transponders to bypass ports-of-entry and weigh stations as information about their weight and registration is automatically verified and recorded. The HELP project allows such trucks to travel with minimal stops along an interstate highway route from British Columbia, Canada, through Washington, Oregon, California, Arizona, New Mexico, and Texas. The other prominent AVI/WIM project is Advantage I-75, which will allow trucks equipped with transponders to travel on Interstate 75 from Florida to Michigan and on to Ontario with minimal stops. Both HELP/Crescent' and Advantage 75 are IVHS projects that are projected to cost a total of about $32 million; total federal share is expected to reach about $14 million. Overall, about 6 percent of the IVHS program's expenditures have supported the development of IVHS technologies designed to advance commercial vehicle operations.

Public Transit Technologies

Just as advanced traffic management systems will provide real-time traffic information, public transit IVHS technologies will provide real-time information about the availability of transit alternatives. For example, automatic vehicle location (AVL) technology can identify the actual location of transit vehicles using technology such as the satellite-based Global Positioning System.

AVL systems are nearing deployment in 12 cities around the United States and have been fully deployed in six U.S. cities and several Canadian cities, as well as overseas. AVL can benefit transit agencies and passengers in a number of ways. Data from AVL systems can be used to provide real-time updates to passengers on expected transit vehicle arrival times, as well as to warn passengers and system operators of delays. These technologies can thus reduce the uncertainty that many transit users experience, as well as facilitate connections from one transit agency's service to another's. The Kansas City

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3 The HELP/Crescent operational test was completed in 1993, and the program's operation was turned over to a private organization.

Transportation Authority has used its AVL system to provide real-time passenger information, fine-tune schedules, and improve on-time performance to over 90 percent. About 9 percent of the IVHS program's expenditures have supported the development of IVHS technologies that enhance the convenience and accessibility of public transportation systems.

Safety Technologies

IVHS technologies are also being developed to improve the safety of vehicles and drivers through collision avoidance systems. Many of the safety-related IVHS projects are embedded within DOT's efforts to develop a prototype automated highway system. Conceptually, AHS technologies will increase the capacity and improve the safety of highways by automating a vehicle's brakes, steering, and engine speed to allow high-speed travel at closer distances than human reaction time would permit. Drivers could buy vehicles with the necessary instrumentation or retrofit existing vehicles. Vehicles whose operation could not be automated would, during a period of transition, be driven in lanes without automation.

Some of the technologies that underlie AHS are now in the market or under development. These include sensors that detect obstacles in a vehicle's blind spots and collision-warning systems. In addition, concepts from the defense industry--advanced computing systems, sensors, advanced command and control systems--are being applied. Despite these preliminary successes, the outcome of ongoing AHS research and the prospects for widespread deployment are uncertain at best. Most AHS technologies are at least a decade from actual usage, and some state and local transportation officials question whether the envisioned systems will ever be practical.

ISSUES AFFECTING FUTURE ACCEPTANCE AND USE OF IVHS TECHNOLOGIES

Although IVHS technologies are being used commercially, the broad vision of the IVHS program to dramatically alter how Americans travel and commute to work may not be realized for many decades. High costs and market uncertainties present the biggest challenges to fully achieving the goals of the IVHS program. In addition, a system architecture must be developed to coordinate and integrate the many IVHS technologies; a plan must be devised for disseminating information on the benefits and successes of IVHS technologies; and a means must be found to ensure the privacy of travelers using advanced information systems.

High Costs and Market Uncertainties

The deployment of a nationwide IVHS transportation network will require substantial investments by the public sector, private industry, and consumers. IVHS America estimates that about $6 billion will be needed through the year 2011 to complete all research and development projects and operational tests and develop a system architecture. Because of the greater risk in assessing new technologies, the public sector is expected to contribute about 80 percent of the needed funding.

To deploy the vast array of IVHS technologies, nearly $210 billion will be required by the year 2011, according to IVHS America. Consumers and the private sector are expected to bear about 80 percent of these costs, including the costs for the computers and information display equipment that are to be installed in vehicles.

Because IVHS technologies are expensive, both public and private investment in them is uncertain. Given current budgetary pressures, state and local governments may not have the funds needed to purchase, maintain, and operate sophisticated IVHS hardware and software systems. According to a 1993 Oak Ridge National Laboratory study, for example, the public sector would have to spend from $8.5 billion to $26 billion between 1993 and 1997 to install ATMSs in the nation's 75 largest metropolitan areas. But until the public sector has invested in the necessary communications infrastructure, the private sector will have little incentive to sell and install IVHS vehicle equipment. However, the public sector may not be motivated to provide the infrastructure until a substantial number of vehicles has been equipped with IVHS technologies.

Consumers' responses to IVHS technologies are also difficult to predict at this time. Some IVHS applications may be quite marketable because of their price, high perceived benefits, or both. The success of electronic toll collection on the Oklahoma Turnpike is a case in point. However, an automobile driver may be more willing to use an electronic tag for automated toll collection than to purchase an on-board route guidance system costing over $1,000.

The challenge of ensuring maximum benefit from IVHS technologies will not end with the operational tests supported by DOT, or even with the technologies' deployment. The hardware and software supporting these technologies will yield benefits only so long as they are well operated and maintained. Experience with currently used traffic control signal systems suggests that operation and maintenance problems may limit the benefits that consumers can derive from ATMS technologies. In March, we reported that many traffic signal systems around the nation were operating below potential because they were not properly maintained.[4]

This situation has implications for the future of ATMSs. ATMSs are more complex than current traffic control signal systems, since they are designed to collect and use real-time traffic data to adjust traffic patterns and advise drivers of road conditions. However, ATMSs will include many of the features of today's signal systems--coordinated signal systems, video surveillance of corridors, ramp metering, automated toll collection, and variable message signs. Unless maintenance is adequate, an ATMS could rapidly degrade to the operational level of the system it replaced. DOT estimates that operating and maintaining ATMSs could cost between $640 million and $1.8 billion annually.

Developing a System Architecture

The development of a system architecture and standards is critical for the successful deployment of IVHS technologies in the United States. According to a March 1994 IVHS America report, the lack of an IVHS architecture has hindered the European Community's progress toward an IVHS environment that is seamless across national boundaries and has delayed the anticipated common market for European IVHS products.

A system architecture will define the general framework within which the various parts of the IVHS system will work, while standards will specify in greater detail the technical requirements of individual IVHS applications. For example, the home stereo industry has developed a common architecture and set of standards. As a result, consumers can buy various stereo components--compact disc and cassette players, receivers, and speakers--from different manufacturers with the assurance that they will function electronically as an integrated unit.

Similarly, the development of a national IVHS architecture is critical to ensure compatibility among different IVHS technologies and to accelerate the implementation of IVHS by reducing the risks to private and public sector stakeholders. For example, a consumer may be unlikely to purchase on-board vehicle navigation equipment costing $1000 or more unless the equipment can be used in multiple locations. If the traffic management centers in other cities broadcast real-time traffic information in different formats, a navigation system geared to

[4] TRANSPORTATION INFRASTRUCTURE: Benefits of Traffic Control Signal Systems Are Not Being Fully Realized (GAO/RCED-94-105) March 30, 1994.

one format will have very limited usefulness. Without assurance of such compatibility, consumers will be reluctant to invest in proprietary equipment with limited range, and manufacturers will consequently have a limited market for IVHS products.

To develop a common national IVHS architecture by mid-1996, DOT instituted the IVHS Architecture Development Program and is studying alternatives produced by four groups of contractors. We believe that it is important for this effort to proceed expeditiously, particularly since the IVHS program is operationally testing many IVHS technologies, additional tests are planned over the next 2 years, and some IVHS technologies are being deployed before national standards have been developed.

DOT's Management of the IVHS Program

DOT is at a crossroads for the IVHS program as it begins to assess the results of operational tests, fund additional research efforts and develop a system architecture. As a result, it must now begin to address important issues affecting the management of the IVHS program. In February 1994, DOT established a Joint IVHS Program Office (JPO) to manage and oversee the IVHS program. The JPO's mission is to develop and execute policies and plans and provide program leadership for the IVHS program. This central focus within DOT is a positive step forward, particularly since the most striking attribute of the IVHS program is its sheer complexity.

The JPO will enable DOT to lay the groundwork for developing a system architecture and an information clearinghouse. The clearinghouse is particularly important, since one of the primary products of the IVHS program will be information--information from which consumers, private industry, and state and local governments can select. To date, DOT has not developed a comprehensive means of sharing information developed through its research and operational tests. According to IVHS program managers, DOT has placed limited emphasis on ensuring that the results of these efforts are publicized and made available to all interested parties. As we previously stated, many of the decisions to use the technologies will depend on the stakeholders' assessment of costs and risks. However, before stakeholders can make these decisions, they must have information about the technologies that are available. The JPO will play a critical role in developing a program to inform IVHS stakeholders of technology developments and status.

Resolving Privacy Issues

Concerns have arisen about whether IVHS technologies may infringe on users/travelers privacy. For example, some electronic toll systems may identify vehicles at toll collection points, thereby creating records of an individual vehicle's location at a certain time. Also, electronic truck clearance technology will require commercial vehicles to transmit data on delivery routes, schedules, and truck weights. Some trucking firms may be reluctant to participate for fear that competitors may obtain and use this information to their advantage. It is difficult to ascertain at this time how prevalent these concerns may be. However, because of restrictions in state privacy laws and potential users' concerns, the privacy issue is the focus of an IVHS project that DOT is currently funding.

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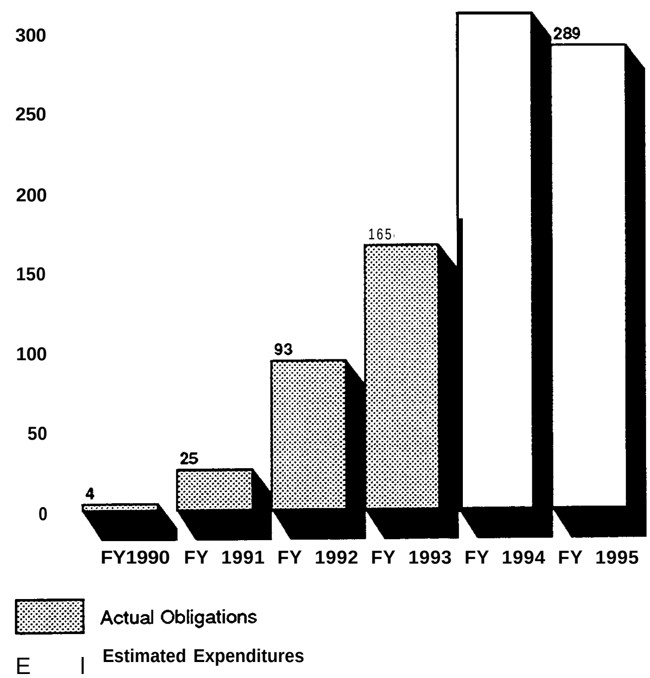
In summary, Mr. Chairman, the Department of Transportation has initiated an ambitious and wide-ranging program to foster the development of IVHS technologies. How travel in America will change as a result of these technologies will depend on the workings of the marketplace, the resolve of the public sector, and the leadership of DOT. Many questions will remain unanswered for several years. If the nation is to realize the potential benefits of a nationwide IVHS network, it will require technologies that are effective and affordable. It will also require a coordinated and cooperative partnership between the public and private sectors and an implementation framework that establishes a sound deployment strategy.

Mr. Chairman, this concludes my statement. We would be happy to answer any questions that you or other Members of the Subcommittee may have.

DOT OBLIGATIONS FOR IVHS ACTIVITIES, FISCAL YEARS 1990-95

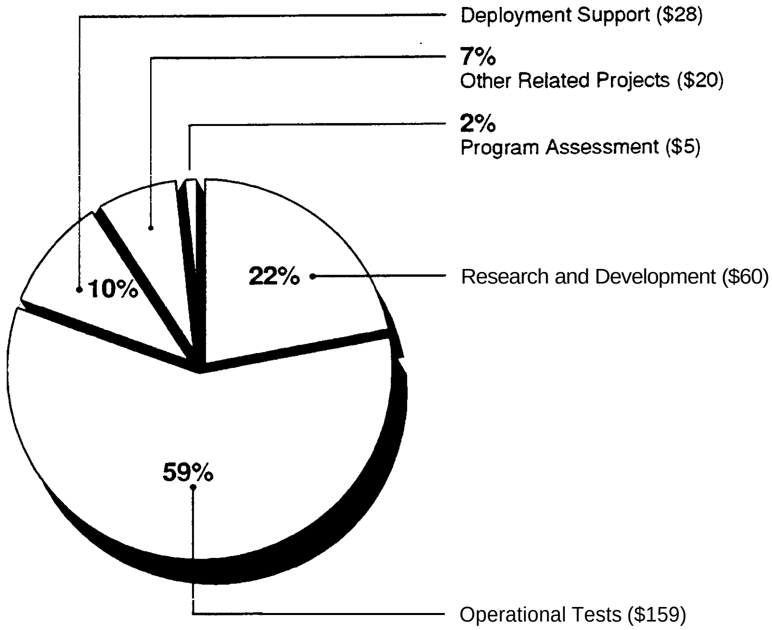
Dollars in Millions



Source: GAO's analysis of DOT's data.

IVHS PROJECT FUNDING, BY PROJECT CATEGORY, FISCAL YEARS 1992-93

Dollars in Millions



Source: GAO's analysis of data from DOT's March 1994 Intelligent Vehicle Highway Systems Project List.

THE 10 IVHS OPERATIONAL TESTS THAT RECEIVED THE MOST DOT FUNDING THROUGH FISCAL YEAR 1993

Project	**Description**	**Federal expenditures through** FY 1993
New Jersey Electronic Toll and Traffic Management End date: 1997	Three New Jersey toll authorities are coordinating efforts to implement a regionwide electronic toll collection system on selected New Jersey expressways.	$25,000,000
ADVANCE - IL End date: 1996	This cooperative effort will provide in-vehicle routing instructions to as many as 3,000 Northwest Chicago vehicles. The vehicles, in turn, will serve as probes and provide real-time traffic information to the Traffic Management Center.	$21,000,000
FAST-TRAC - MI End date: 1996	This project involves installing roadside traffic detectors to determine traffic conditions. This information will be relayed to in-vehicle navigation systems, which will show drivers information about traffic congestion and identify optimal routes.	$20,500,000
TRANSCOM Congestion Management Program - NJ, NY, CT End date: Ongoing	This consortium of 15 transportation and public safety agencies has undertaken a series of initiatives to improve responses to traffic incidents.	$11,400,000
RTD (Denver) Smart Bus - CO End date: 1994	This project will provide current bus location and schedule information to dispatchers by equipping buses with Global Positioning System (navigation satellite) receivers.	$8,320,000

Project	**Description**	**Federal expenditures through FY** 1993
Integrated Corridor Management - NJ, PA End date: Ongoing	This cooperative effort will provide regional traffic information through a multijurisdictional clearinghouse and further study the incident and traffic management needs of the region.	$6,000,000
HELP/CRESCENT - BC, WA, OR, CA, AZ, NM, TX Deployed: 1993	This multistate, multinational effort is developing a system to enable trucks to drive through the entire network without stopping at weigh stations or ports-of-entry. It used weigh-in-motion and automatic vehicle identification and location technologies to provide enforcement information to governments and fleet management information to the motor carrier industry. The system's operation has been turned over to Help, Inc., a new private organization.	$5,850,000
'CAPITAL' - Washington, DC. Area Operational Test End date: 3/95	This project is using cellular phone calls to locate vehicles to estimate traffic conditions and congestion. It will examine ways to process this information for use by a traffic management system or individual travelers.	$5,511,733
Suburban Mobility Authority for Regional Transportation (SMART) Project - MI End date: 6/96	SMART establishes an automated dispatch system for on-demand paratransit services in combination with automatic vehicle location to track the paratransit fleet.	$4,500,000

Project	Description	Federal expenditures through FY 1993
ADVANTAGE I-75 - FL, GA, TN, KY, OH, MI, Ontario End date: 3/97	This project allows transponder-equipped and properly documented trucks to travel any segment of the I-75 corridor with minimal stopping at weigh/inspection stations. Clearance decisions will be based upon size and weight measurements taken upstream and upon credentials and licensing information stored in a computer data base.	$4,024,685

Source: GAO's analysis of DOT's March 1994 Intelligent Vehicle Highway System Project List.

THE 10 IVHS RESEARCH AND DEVELOPMENT PROJECTS THAT RECEIVED THE MOST DOT FUNDING THROUGH FISCAL YEAR 1993

Project	**Description**	**Federal expenditures through FY** 1993
Automated Highway System - Precursor Systems Analyses End date: Fall 1994	The Federal Highway Administration has awarded 15 Precursor Systems Analyses research contracts to investigate issues and risks related to the design, development, and implementation of automated highway systems.	$14,100,000
Human Factors in Advanced Traveler Information Systems and Commercial Vehicle Operations End date: 3/96	This project investigates the factors that affect how drivers and travelers deal with in-vehicle navigation, signing, and warning systems.	$5,251,337
Human Factors Design of Automated Highway Systems End date: 3/96	This project will develop automated highway system scenarios in order to empirically test how drivers will perform and maneuver in an automated highway setting.	$5,086,582
Human Factors in Advanced Traffic Management Systems End date: 12/95	The goal of this study is to investigate and define the human factors involved in a fully functional advanced traffic management system.	$4,216,359
Real-Time Traffic Adaptive Control for IVHS End date: 7/97	This consortium of state and local departments of transportation, industry, and academic organizations will develop a prototype real-time, traffic adaptive signal control system	$3,403,382

Project	Description	Federal expenditures through FY 1993
Design of Support Systems for Advanced Traffic Management Systems End date: 9/97	This study will develop support systems for mature advanced traffic management systems and will determine how to integrate these with the other systems (e.g., signal control, ramp metering, etc.) within the control center.	$2,942,679
PATH End date: 9/95	Current activities are focused on developing technologies to support high-speed platooning, in which packs of vehicles follow each other closely, using electronic sensing and communications, to increase highway capacity and safety.	$1,775,000
Performance Specifications: Countermeasures Against Rear-end Collisions End date: l/97	This project will lead to the development of performance requirements for advanced technologies to prevent or decrease the severity of rear-end crashes.	$1,700,000
Networkwide Optimization End date: 11/95	The objective of this contract is to develop a computer package that will enable users to (1) coordinate signal-timing and ramp-metering functions, (2) develop metering rates for freeway on ramps, and (3) optimize signal timing at selected intersections and arterials.	$1,403,000
Quantitative Characterization of Vehicle Motion Environment: System Design End date: 12/94	This project will develop a measurement system that can quantify the motions of vehicles moving in traffic. It will help lay the foundation for developing collision avoidance instructions for drivers.	$1,400,000

Source: GAO's analysis of DOT's March 1994 Intelligent Vehicle Highway System Project List.

THE 10 IVHS DEPLOYMENT SUPPORT PROJECTS THAT RECEIVED THE MOST DOT FUNDING THROUGH FISCAL YEAR 1993

Project	**Description**	**Federal expenditures through** FY 1993
System Architecture Development End date: 7/96	DOT has contracted with four industry teams to develop candidate IVHS architectures.	$3,951,100
Commercial Vehicle Operations Institutional Issues Studies End date: Various	This project is supporting 47 states in identifying institutional issues that would impede or prevent the achievement of national commercial vehicle operations goals.	$2,155,000
System Architecture Consensus Building End date: 9/96	The contractor will develop an outreach program, including a series of regional briefings, on the progress of the IVHS architecture definition effort.	$2,000,000
System Architecture Manager End date: To be determined	The Architecture Manager will work closely with the contract teams, providing technical review and evaluation of the candidate architectures produced by the teams.	$1,900,000
Electromagnetic Compatibility Testing for IVHS End date: 6/96	This contractor will evaluate the electromagnetic compatibility-of various proposed IVHS communications components.	$1,350,000
IVHS and the Environment in Urban Areas End date: 8/94	The goals of this project are to identify and analyze potential environmental benefits from implementing advanced transportation systems and facilitate a greater understanding and dialogue among policy-makers, program administrators, and interested private organizations in selected urban areas.	$760,000

Project	Description	Federal expenditures through FY 1993
Commercial Vehicle Short Range Communication End date: 7/94	This project will evaluate and select a national standard for short range vehicle to roadside communication for commercial operations.	$646,464
IVHS Institutional Issues: George Mason University End date: 2/94	GMU will study critical issues associated with implementing IVHS in Northern Virginia specifically and in the United States generally. It will also solicit private sector involvement in implementing IVHS technologies, such as kiosks, and will conduct workshops on IVHS topics, such as institutional constraints.	$621,729
Dallas, TX Areawide Early Deployment Planning Study End date: 12/94	The goals of the Dallas plan are to (1) coordinate collection and dissemination of real-time traffic information, (2) optimize transportation system operations by coordinating operations among government agencies, and (3) encourage transit and high occupancy vehicle usage.	$600,000
Denver, CO Preliminary Engineering Early Deployment Planning Study End date: 12/94	This deployment project will develop the final design package for the Denver traffic operations center and the field elements needed to support it.	$500,000

Source: GAO's analysis of DOT's March 1994 Intelligent Vehicle Highway System Project List.

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