US DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINSTRATION

Implementation of the

NATIONAL

INTELLIGENT

TRANSPORTATION

SYSTEMS PROGRAM

1996 Report to Congress

Joint Program Office for
Intelligent Transportation Systems

150022

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THE SECRETARY OF TRANSPORTATION
WASHINGTON, DC. 20590

September 26, 1997

The Honorable Albert Gore, Jr.
President of the Senate
Washington, D.C. 205 10

Dear Mr. President:

The enclosed report to Congress is submitted in accordance with the requirements of section 6054(c) of the Intermodal Surface Transportation Efficiency Act of 199 1, Public Law 10 l-240. It describes the Department's accomplishments over the last year in advancing the national Intelligent Transportation Systems program. It also provides an assessment of what has been learned in the research program over the life of ISTEA and sets new horizons for the deployment of ITS infrastructure and the development of the intelligent vehicle.

An identical letter has been sent to the Speaker of the House of Representatives.

Sincerely,

Rodney E. Slater

Enclosure

THE SECRETARY OF TRANSPORTATION
WASHINGTON, D.C. 20590

September 26, 1997

The Honorable Newt Gingrich
Speaker of the House of Representatives
Washington, D.C. 205 15

Dear Mr. Speaker:

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IMPLEMENTATIONS OF THE NATIONAL INTELLIGENT TRANSPORTATION SYSTEM PROGRAM

1996 Report to Congress

Joint Program Office for Intelligent Transportation Systems

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FOREWORD

This report is forwarded to Congress according to Section 6054(c) of the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA). This is the third in a series of reports summarizing the progress of the Intelligent Transportation Systems (ITS) Program administered by the U.S. Department of Transportation (U.S. DOT). Specifically, this report:

- Presents the goals and accomplishments of the ITS Program, which supports the development and strategic deployment of ITS technologies and services in the United States.
- Identifies the actual and potential benefits and cost effectiveness of ITS services.
- Fulfills ISTEA's requirement to prepare a final report to Congress that identifies the nontechnical constraints encountered by ITS research, development, and deployment projects.
- Describes the directions of the next phase of the ITS Program, including U.S. DOT's strategy to foster interoperable and integrated ITS deployment.
- Recommends legislative measures to support ITS deployment in metropolitan and rural areas and advance the use of ITS technologies that uniquely support commercial vehicle operations.

The first implementation report, transmitted to Congress in June 1994, described the achievements of U.S. DOT in the ITS arena, including early activities predating ISTEA's official establishment of the Intelligent Vehicle-Highway Program in 1991. The second report, submitted in April 1996, detailed specific accomplishments and activities of the ITS Program and outlined new research and testing priorities. It also identified new goals and programs to support the deployment of ITS products and services.

This report summarizes program status since the April 1996 report and describes the major accomplishments of and lessons learned from the program since its inception. The report also describes how the program's continued achievements, supported by ISTEA's reauthorization, will advance the deployment of ITS technologies and services to fulfill the needs of the surface transportation system into the 21 st century.

READER'S GUIDE

ISTEA required U.S. DOT to report on specific aspects of the ITS Program. The following paragraphs list both the reporting requirements and the sections of this report that address those requirements.

(A) ANALYZE THE POSSIBLE AND ACTUAL ACCOMPLISHMENTS OF INTELLIGENT TRANSPORTATION SYSTEMS PROJECTS IN ACHIEVING GOALS AND OBJECTIVES FOR REDUCING CONGESTION, IMPROVING SAFETY, PROTECTING THE ENVIRONMENT, AND CONSERVING ENERGY.

Chapter II outlines the near-term results of the Federal ITS Program, including demonstrated and potential benefits in traffic flow improvements, maximized use of existing infrastructure, protection of natural resources, expanded traveler choices, and cost savings. *Chapter III* describes in detail the research and testing being conducted to evaluate the benefits of longer term technology development and ongoing efforts to monitor the ITS Program's progress in fulfilling ISTEA goals.

(B) SPECIFY COST-SHARING ARRANGEMENTS MADE, INCLUDING THE SCOPE AND NATURE OF FEDERAL INVESTMENT, IN ANY RESEARCH, DEVELOPMENT, OR IMPLEMENTATION PROJECT UNDER THE PROGRAM.

Chapter II describes in detail U.S. DOT's ongoing cooperative efforts with the Intelligent Transportation Society of America, five standards development organizations, and private industry. *Chapter IV* outlines DOT's strategy for encouraging partnerships to advance ITS deployment. *Appendix C (Summaries of ITS Field Operational Tests)* and *Appendix D (Policy Review of the ITS Priority Corridors: Executive Summary)* provide additional detail on specific projects and cost-sharing arrangements.

(C) ASSESS NONTECHNICAL PROBLEMS AND CONSTRAINTS IDENTIFIED AS A RESULT OF EACH SUCH IMPLEMENTATION PROJECT.

Appendix E (Nontechnical Constraints and Barriers to the Implementation of Intelligent Transportation Systems) describes institutional, legal, and other nontechnical impediments to ITS deployment.

(D) INCLUDE, IF APPROPRIATE, RECOMMENDATIONS OF THE SECRETARY FOR LEGISLATION OR MODIFICATIONS TO THE ITS STRATEGIC PLAN.

Chapter V recommends congressional actions to strengthen the ITS Program in the reauthorization of ISTEA in 1997.

EXECUTIVE SUMMARY

With the passage of ISTEA in 1991, Congress established a new era for transportation, calling for more efficient and safe use of existing highway and transit infrastructure and emphasizing intermodalism-the seamless integration of multiple transportation modes. In this spirit, Title VI of ISTEA established the Intelligent Vehicle-Highway Systems Program (later renamed the Intelligent Transportation Systems Program), prescribing- the "widespread implementation of intelligent [transportation] systems to enhance the capacity, efficiency, and safety of the Federal-aid highway system and to serve as an alternative to additional physical capacity of the Federal-aid highway system."

> ***It is the policy of the United States to develop a National Intermodal Transportation System that is economically sound, provides the foundation for the Nation to compete in the global economy, and will move people and goods in an energy efficient manner. The National Intermodal Transportation System shall consist of all forms of transportation in a unified, interconnected manner, including the transportation systems of the future. . .***
>
> INTERMODAL SURFACE TRANSPORTATION EFFICIENCY ACT, SECTION 2

During the past 5 years, the national ITS program, administered by the U.S. DOT, has advanced the state of the technology, demonstrated substantial public benefits, fostered new models of institutional cooperation, and begun to change how Americans travel. The program has laid the foundation for an information and communication infrastructure that will enable the Nation to realize the vision set forth in ISTEA: to manage multiple transportation facilities as one unified system for greater customer service, efficiency, safety, and quality of life.

WHAT IS OUR MISSION?

Surface transportation systems-the networks of highways, local streets, bus routes, and rail lines-are the ties that bind communities and facilitate commerce, connecting residents to work, homes, schools, services, and each other. During the past 20 years, however, transportation systems have struggled to keep pace with Americans' growing and changing travel needs. The General Accounting Office has projected that congestion in metropolitan areas could worsen by 300 to 400 percent over the next 15 years unless significant changes are made. Traffic accidents claim more than 41,000 lives each year. In addition, many of the administrative systems supporting commercial freight and mass transit services are antiquated and cumbersome.

ITS services offer promising solutions that respond to these pressing challenges. These systems are diverse and versatile, combining telecommunication, computer, and sensing technologies to provide real-time information to both traffic managers and travelers on traffic, weather, navigation, and vehicle diagnostics-in much the same way the air traffic control system does for air traffic-to achieve greater system efficiency, safety, and convenience. In the future, ITS will provide vehicles with crash warning and collision avoidance capabilities that will dramatically enhance our surface transportation system's safety.

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

Guiding Principles of the ITS Program

The multifaceted ITS Program compelled U.S. DOT to reexamine its traditional way of doing business. In May 1994, the Department established the ITS Joint Program Office (JPO) to manage the program. This action resulted in unprecedented interagency cooperation involving most of U.S. DOT's modal administrations-the Federal Highway Administration (FHWA), the National Highway Traffic Safety Administration (NHTSA). the Federal Transit Administration (FTA), the Federal Railroad Administration (FRA), and the Research and Special Programs Administration (RSPA). The ITS program is guided by four key principles:

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

examines human behavior and response related to the safety and usability of ITS products and services.

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

- **Enabling research** focuses particularly on the comprehensive system architecture and associated standards. Research lays the foundation for national compatibility among all ITS components. This area of interest also investigates human factors to ensure that ITS services are safe and user friendly. In addition, research attempts to improve the capabilities of technologies, such as communication and location-referencing systems, that enable ITS services to function effectively.
- **Advanced metropolitan travel management systems** include a great range of ITS services that address traffic management, traveler information, and transit management. Services include advanced traffic management systems (ATMS), advanced traveler information systems (ATIS). and advanced public transportation systems (ARTS).
- **Advanced rural transportation systems (ARTS)** apply many of the ITS services in other categories to address the unique safety and mobility problems of diverse rural communities.
- **Commercial vehicle operations (CVO)** can be enhanced through advanced technologies and information networks to increase productivity and efficiency for both fleet operators and State motor carrier regulators. The Federal ITS/CVO program focuses particularly on ITS applications to safety, inspection, and other regulatory processes associated with commercial vehicles.
- **Advanced collision avoidance and vehicle safety systems** aim to improve driver and pedestrian safety through human-centered vehicles equipped with technologies that can warn of or help the driver avoid impending crashes or can automatically signal for help immediately after a collision.
- **Automated highway systems (AHS)** will take the potential of vehicles equipped with crash avoidance technology to a new level. Research in this area is centered on the potential benefits and feasibility of a "smart" vehicle that can communicate with a "smart" infrastructure. Because the AHS will share many subsystems with collision avoidance systems, such as vehicle-based sensors, com-

putational elements, and the driver interface, the two research programs are closely coordinated.

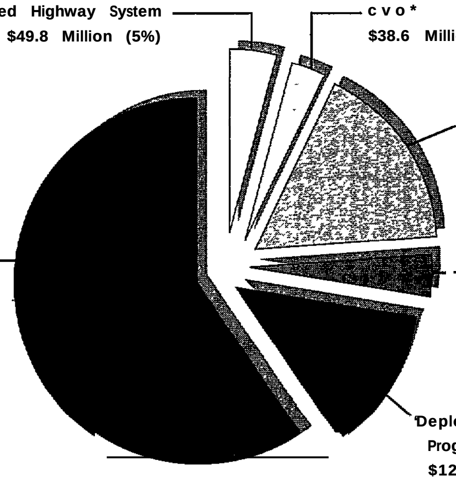
WHAT HAS BEEN FUNDED?

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

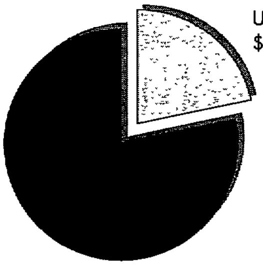
The U.S. DOT has worked diligently to build partnerships with State and local governments, academia, and the private sector in conducting three major activities of the program: basic and applied research, field testing, and deployment support.

EXHIBIT E-I
WHAT HAS BEEN FUNDED?

FY 1991-1996
Total ITS Funding - $991.1 Million



Operational Tests/Corridors
Total = $562 Million



* CVO funds are also included in R&D Operational Tests and Deployment Planning

** $26.2 million for Deployment Planning $22 3 million for Technology Transfer $60 9 million for Program Support and $15 3 million for Mainstreaming

Note Of the $991 1 million mode available to the FHWA for the ITS Program, $410 2 million (41 4%) has been earmarked by Congress leaving $580 9 million (58 6%) to be expended at the discretion of the U S DOT. Also note that in addition to funding provided for FHWA, NHTSA, and FTA received $3 1.5 million and $13 2 million respectively

Basic and Applied Research

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

Operational Tests/Priority Corridors

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

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

The ITS Priority Corridors Program, created by ISTEA, has been extremely effective in teaching us about the institutional arrangements necessary to advance inter-modal approaches to regional and multistate transportation needs. In March 1993, U.S. DOT designated the four locations that met the ISTEA Section 6056(b) criteria as ITS priority corridors: the Northeast Corridor along Interstate 95, stretching through six States from Maryland to Connecticut; the Gary-Chicago-Milwaukee Corridor; the Houston, TX metropolitan area; and the Southern California Corridor centered around Interstate 5 and Interstate 10 from Los Angeles to San Diego.

Deployment Support

State and local governments need assistance in overcoming the complex obstacles to adoption and deployment of advanced technology. The ITS Program has spent roughly 13 percent of its funding to facilitate understanding, acceptance, and deployment of ITS services. These programs include technical workshops, forums that bring together elected officials and transportation professionals, and training programs to build the essential professional capacity to support advanced transportation systems.

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

What Have We Accomplished?

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

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

In 1992, the U.S. DOT and ITS America published complementary ITS visions and strategic plans. In

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

2. LAUNCHED AN AGGRESSIVE RESEARCH AND TECHNOLOGY PROGRAM.

The national ITS Program has helped ITS evolve from relatively visionary concepts to viable and attractive solutions for transportation problems. To a large degree, general concerns about the technological limitations of ITS have either been refined to specific questions or resolved. Among its many achievements, the program has advanced the development of new concepts, such as real-time adaptive traffic control; improved vehicle-tracking technologies used in public transportation, emergency response, and CVO; developed guidelines to help ensure that traffic management systems and in-vehicle navigation displays are user friendly and safe; and promoted architecture and standards to ensure that ITS services are compatible and interoperable. The program's most significant accomplishment may well be the breakthroughs it has made in showing the value and, in several cases, the technical feasibility of smart vehicles that can sense objects, avoid collisions, monitor driver alertness, and provide route guidance information. The U.S. DOT is now poised to launch a major series of operational tests and begin integrating these systems in a human-centered in-vehicle configuration.

3. TESTED AND PROVED THE VIABILITY OF NUMEROUS TECHNOLOGIES AND APPLICATIONS.

The U.S. DOT's 83 operational tests, 28 of which are completed, are demonstrating the viability of first-generation ITS technologies and services. These tests have identified and resolved technical issues, created new models of institutional cooperation, and shown how myriad technologies can reduce congestion, improve emergency response time, increase transit system productivity and passenger convenience, and reduce the environmental impact of transportation. We are now seeing products and services refined by the operational test program-such as Boston SmarTraveler's real-time travel information service and Help, Inc.'s Pre-Pass electronic clearance system for trucks-become self-sufficient and competitive in the marketplace.

4. DEVELOPED A NATIONAL ARCHITECTURE TO SUPPORT ITS SERVICES.

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

5. BEGAN DEVELOPMENT OF STANDARDS FOR HARDWARE AND SOFTWARE COMPATIBILITY.

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

6. EVALUATED SOCIETAL BENEFITS OF INDEPENDENT AND INTEGRATED ITS.

The DOT report entitled *Review of ITS Benefits: Emerging* Successes, and other documents, such as *Benefits Assessment of Advanced Public Transportation Systems, Assessment of Intelligent Transportation Systems/Commercial Vehicle Operations User Services: ITS/CVO Qualitative Benefit/Cost Analysis* and *Preliminary Assessment of Crash Avoidance Systems Benefits,* have shown how ITS technologies can positively affect transportation efficiency, productivity, safety, and user satisfaction (see Exhibit E-2). Research on the public benefits of ITS establishes a compelling national interest in launching the ITS infrastructure. The infrastructure will allow us to both accomplish the vision and mission of ISTEA and engender a wide new array of private sector goods and services in much the same way that the Internet has.

7. IDENTIFIED AND PROPOSED SOLUTIONS TO REMOVE NONTECHNICAL BARRIERS TO IMPLEMENTING AND MAINSTREAMING ITS.

The U.S. DOT initiated a major investigation into the institutional and legal issues associated with intergovernmental cooperation, public-private partnership, intellectual property rights, procurement, privacy, user acceptance, staffing and education, socioeconomic issues, and environmental issues. The results are documented in the 1994 report to Congress, *Nontechnical Constraints and Barriers to the Implementation of Intelligent Vehicle-Highway Systems,* and the 1996 update of that report (see Appendix E).

8. CREATED NEW MODELS OF PUBLIC-PRIVATE PARTNERSHIPS.

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

9. SET NATIONAL GOALS TO ENCOURAGE WIDESPREAD ITS DEPLOYMENT.

U.S. DOT has established a national goal to build the ITS infrastructure by 2005. Three specific "systems" of infrastructure have been defined to date: the metropolitan intelligent transportation infrastructure, Commercial Vehicle Information Systems and Networks (CVISN), and the infrastructure associated with rural applications. This national goal has helped create a positive environment within Federal, State, and local governments and has inspired confidence among private sector developers. The U.S. DOT is monitoring progress on achieving this goal in 75 metropolitan areas and is making plans to monitor deployment of CVISN. See Exhibits E-3 through E-5 for illustrations of metropolitan ITS infrastructure and CVISN.

10. LAUNCHED A MODEL DEPLOYMENT INITIATIVE TO DEMONSTRATE THE BENEFITS OF ITS INFRASTRUCTURE.

In 1996, the U.S. DOT created the model deployment initiative (MDI) to showcase the benefits and cost effectiveness of ITS services integrated along the lines

EXHIBIT E-2
BENEFITS OF SELECTED ITS PROGRAMS

ITS TECHNOLOGY	-FINDINGS
ATMS	• *Traffic signal control:* In Lexington, KY, coordinated computerized traffic signals reduced "stop-and-go" traffic delay by 40 percent and reduced accidents by 31 percent between 1985 and 1994. The Abilene. TX computerized traffic light system decreased travel time by 14 percent, increased travel speed by 22 percent, and decreased delay by 37 percent. In the Detroit area, the adaptive signal system decreased left-turn accidents by 89 percent and decreased delay by up to 30 percent. • *Freeway management: Minnesota's* freeway management system increased speeds by 35 percent and reduced accidents by 15 to 50 percent, although demand increased by 32 percent. In Seattle, ramp metering along Interstate 5 kept traffic moving and cut accident rates by more than 38 percent over a 6-year period, despite a 10 to 100 percent increase in traffic. • *Incident management:* Initial operation of Maryland's incident management system had a benefit/ cost ratio of 5.6:1 Minnesota's Highway Helper reduces the duration of a stall by 8 minutes. - *Electronic toll collection*: On the Tappan Zee Bridge toll plaza, electronic tolls handle 1,000 vehicles per hour compared with 350 to 400 vehicles per hour handled by manual tolls. New York's E-Z Pass electronic toll system nearly tripled traffic speeds compared to stop-and-pay tolls.
ATIS	• *In-vehicle navigation:* TravTek's in-vehicle navigation systems in Orlando decreased wrong turns by 33 percent and decreased travel times by 20 percent for drivers unfamiliar with the area. • *Multimodal traveler information:* In Boston, 30 to 40 percent of travelers adjusted travel behavior after receiving real-time traveler information from SmarTraveler. In Montgomery County, MD, the local cable station reaches 180,000 homes to show traffic conditions on major highways, giving commuters mode-of-travel options.
APTS	· *Fleet management* In Kansas City, with the implementation of the Transit Management System, transit officials cut operating costs by $400,000, avoided $1.5 million in new bus purchases, and reduced response time to emergencies from 4 minutes to 1 minute. The computer dispatching system in Sweetwater County, WY has helped increase monthly transit ridership from 5,000 to 9,000 passengers, while reducing mileage-related operating costs by 50 percent over a 5-year period. • *Electronic fare payment:* New York estimates $49 million has been accrued in increased ridership from smart cards: Atlanta estimates annual cost savings of $2 million in cash handling; and Ventura County, CA, estimates $5 million has been saved in data collection costs. • *Multimodal traveler information:* An automated transit information system implemented by the Rochester-Genesee Regional Transportation Authority spurred an increase in calling volume by 80 percent. A system installed by New Jersey Transit reduced caller wait time from 85 seconds to 27 seconds and reduced the caller hangup rate from 10 percent to 3 percent, while accommodating more calls.
ARTS	• *Mayday systems:* Mayday devices, if effectively deployed in 60 percent of rural crashes, could eliminate 1,727 fatalities each year through speedier incident notification.
ITS/CVO	• *Fleet management:* Best Line of Minneapolis estimates it saves $10,000 per month using its computer-aided dispatching system. Schneider of Green Bay, WI reported a 20 percent increase in loaded miles from its advanced vehicle monitoring and communication systems. · *Electronic safety inspections:* An early information network in Oregon increased the number of truck weighings and safety inspections by 90 percent and 428 percent, respectively, between 1980 and 1989, although staff increased by only 23 percent. Onboard safety monitoring systems, along with electronic clearance and automated roadside safety inspections, could reduce fatalities by 14 to 23 percent. • *Electronic* pre-clearance: A 1994 study estimates a benefit/cost ratio to the Government of 7.2: 1 for electronic clearance, 7.9: 1 for one-stop/no-stop shopping, and 5.4: 1 for automated inspections.
Advanced Vehicle Control and Safety Systems	• *In-vehicle collision avoidance systems:* Lane change/merge, rear-end, and single-vehicle roadway departure collision avoidance systems could eliminate 1.1 million crashes annually. • *Blind spot detectors:* The use of the Eaton-Vorad collision-warning device by Greyhound reduced accidents by 20 percent.
AHS	• A preliminary analysis predicts capacity enhancements of 300 percent for platooned operation (e.g., AHS vehicle convoys) and 200 percent for mixed operation, (e.g., AHS vehicles navigating among conventional vehicles) compared to current freeway operation.

WHAT IS THE INTELLIGENT TRANSPORTATION INFRASTRUCTURE?

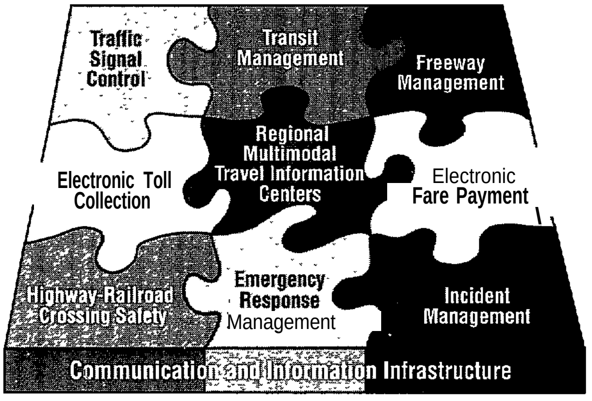
No single technology "fix" can address America's growing demand for and changing patterns of travel. To realize the promise of a truly national transportation system, ITS products and services must be seamlessly integrated and interoperable. Therefore, a critical goal of the ITS Program is to develop an intelligent transportation infrastructure-a communication and information backbone-that supports and unites key ITS services.

This intelligent transportation infrastructure is not just a collection of components; it is a unified system that will allow components to communicate with each other and work together. The infrastructure will function much as the local- and wide-area networks used in most workplaces do.These networks allow electronic file sharing, mail, and other information exchanges within a single building or between geographically dispersed sites, even though individuals in the workplace may have different brands of computers and software of varying capabilities. Workers increase their productivity and utility, and so does the workplace as a whole.The ITS infrastructure is expected to have a similar effect on the efficiency and productivity of our national transportation system.

The needs of three specific types of users-metropolitan residents, commercial carriers, and rural residents-have emerged from the national ITS Program's efforts:

- ***The** metropolitan intelligent transportation infrastructure **will integrate advanced traffic management, traveler information, and public transportation systems. In January 1996, then Secretary Federico Pena announced Operation Timesaver, a national goal aimed at deploying ITS infrastructure in 75 of the Nation's largest metropolitan areas within the next decade, with an eye toward cutting travel times in metropolitan areas by 15 percent.**
- **will integrate ITS/CVO** user **services to achieve safe and efficient shipping operations and enable electronic business transactions. The U.S. DOT's goal is to encourage the public and private sectors to build CVISN in all interested States by the year 2005.**
- ***The** rural initiative **has identified seven clusters of technologies to upgrade transportation systems in 450 communities, on rural roads, and in the national highway system, as warranted, and link rural areas with metropolitan and commercial operations.**

EXHIBIT E-3
METROPOLITAN ITS
INFRASTRUCTURE



defined by the national ITS architecture. By 1998, four sites-the New York City tristate area, Phoenix, Seattle, and San Antonio-will showcase the benefits of the metropolitan ITS infrastructure. In the same time frame, eight States will demonstrate CVISN: California, Colorado, Connecticut, Kentucky, Michigan, Minnesota, and, in a joint project, Oregon and Washington.

II. DEVELOPED PLANS TO MEET EDUCATIONAL AND HUMAN RESOURCE NEEDS.

The transition to electronic management of surface transportation represents the same transition the Federal Aviation Administration (FAA) underwent as it moved from using a civil engineering staff to oversee the construction of airports to *managing* the air system more effectively, which required a very different set of technical skills. ITS applications use information system, communication, and navigation technologies that are unfamiliar to surface transportation professionals. The ITS concept also emphasizes system management, operations, and performance

EXHIBIT E-4
VISION: SAFE AND EFFICIENT SHIPPING OPERATIONS

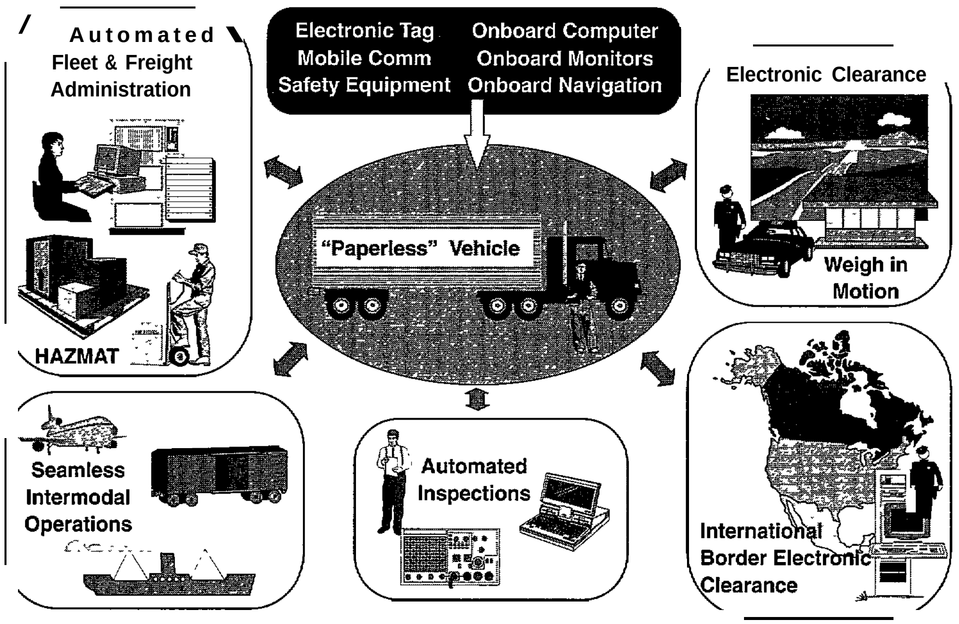
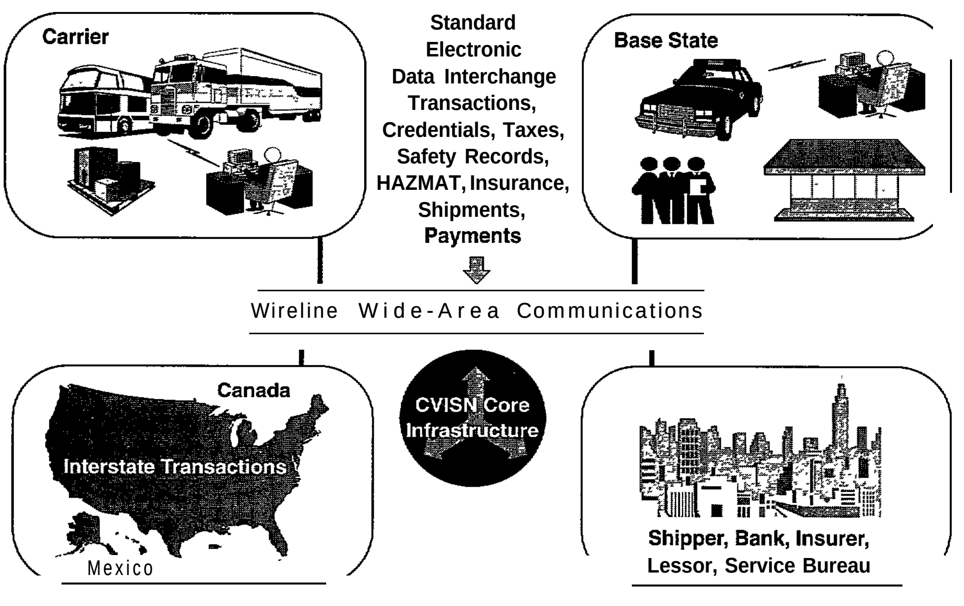


EXHIBIT E-5
VISION: ELECTRONIC BUSINESS TRANSACTIONS



measurement, instead of construction and maintenance, and often requires unprecedented cooperation within and between the public and private sectors. The U.S. DOT's national strategic plan and 5-year program for building professional capacity address the need to retool the skills of the Nation's professionals in the transit, highway, and CVO fields.

WHAT HAVE WE LEARNED?

The program has demonstrated that the ITS concept, even at this early stage, is technically viable, highly cost effective, and increasingly accepted as an essential component of a modern surface transportation system. To realize the full long-term potential of ITS, however, an information and communication infrastructure is necessary to ensure that ITS services are integrated, intermodal, and interoperable. In addition, research performed by NHTSA and FHWA has demonstrated the potential for major breakthroughs in accident reduction and built the foundation for future human-centered smart vehicles. The major findings of the national ITS Program are documented in the 1996 report, *Key Findings From the Intelligent Transportation Systems (ITS) Program: What Have We Learned?* The following paragraphs outline the major lessons learned thus far in the ITS Program.

ITS WILL DELIVER SIGNIFICANT PUBLIC BENEFITS.

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

Enhancing Efficiency and Use of Existing Capacity. The U.S. DOT estimates that deploying the intelligent transportation infrastructure in 50 of our largest metropolitan areas will reduce the need for new roads, while saving taxpayers 35 percent of required investment in urban highways. Better management of transportation systems is central to achieving the efficiency envisioned by ISTEA; however, managing any part of the system-transit, highways, or streets-more effkiently is nearly impossible unless system managers have access to information, such as the locations of traffic incidents. This information must also be supplemented with the means to respond and make adjustments to the system or communicate with travelers. ITS field tests and deployments have shown that strategic application of information and control systems can significantly improve efficiency for system managers:

- ITS infrastructure in 75 of the largest metropolitan areas is estimated to have a benefit-cost ratio of 8.8 to 1.
- Freeway management systems allow existing physical infrastructure to handle 8 to 22 percent more traffic at 16 to 62 percent greater speeds compared to congested conditions.
- Incident management programs have reduced incident-related congestion and delays by 50 to 60 percent.
- Electronic toll collection has increased throughput by 200 to 300 percent compared with traditional attended lanes.
- Automated traffic signal systems have shown the capability to decrease travel times by 14 percent, reduce delay by 37 percent, and increase travel speeds by 22 percent.

Preventing Accidents and Saving Lives. Today, ITS technologies are making it easier for emergency response teams to locate incidents and reach victims quickly, dramatically improving the chances of survival. Freeway management systems, such as ramp meters that help smooth traffic flow, have reduced accidents by 15 to 20 percent. New information technology for commercial vehicles is allowing more efficient and accurate safety inspections, increasing access to safety information for inspectors, and automating hazardous material incident response systems. NHTSA estimates that 1 .l million crashes-17 percent of the total 6.4 million nationwide-could be prevented each year if all vehicles were equipped with three ITS crash avoidance countermeasures currently under development: rear-end crash warning systems, roadway departure warning systems, and lane change/merge crash avoidance systems. This reduction in collisions corresponds to a $26 billion annual savings in crash-related economic costs.

Reducing the Cost of Government Operations and Services. In an October 1995 report, *High-Tech Highway: Intelligent Transportation Systems and Policy,* the Congressional Budget Office states, "ITS research may enable highway and transit authorities to provide better service at lower cost, possibly reducing the need for public subsidies." In an environment of limited budgets and cuts in public sector subsidies, the components of ITS infrastructure are dramatically reducing the costs of transit management, toll collecting, and truck safety inspections:

- Advanced public transportation management systems in 265 actual or planned deployments are estimated to save transit operators from $3.8 billion to $7.4 billion in operating costs (in 1996 dollars) over the next 10 years, without diminishing the quality of service.
- In Oklahoma, operating costs dropped from $176,000 to $16,000 per year per toll booth when booths were equipped with electronic debit systems, a cost reduction of 90 percent.
- Commercial vehicle administration programs have reduced compliance-related labor costs (obtaining licenses, permits, registrations, and credentials and reporting fuel-tax payments) by 9 to 18 per-

BENEFITS OF ITS

ITS is already providing benefits related to **improved efficiency** of the surface transportation system by helping operators monitor system performance, quickly identify and effectively respond to problems that develop, and provide timely, accurate information to travelers. Freeway management systems have increased throughput by up to 22 percent, while increasing travel speeds and reducing accidents. Electronic toll collection systems move 200 to 300 percent more vehicles per lane than conventional systems. Deployment of transit management systems is expected to yield approximately $5 billion in improved efficiency over the next 10 years. Research proposed for FY 1997 and I998 will continue to enhance and test advanced traffic control strategies on both freeways and arterial streets and develop and test effective transit management techniques. Technical assistance,guidance, and training will also be provided to public agencies on how to implement ITS infrastructure and services effectively.

ITS research into collision avoidance technologies, which will receive continuing emphasis in FY 1997 and I 998,promises to significantly reduce accidents and improve the safety of the surface transportation system. It is estimated that widespread deployment of three basic crash avoidance technologies-rear end crash-warning systems, roadway departure warning systems, and lane change/merge crash avoidance systems-beginning in the next 5 years, could ultimately reduce crashes by I7 percent, preventing I. t million accidents and saving $26 billion per year. The results of ITS research are also being applied to allow more efficient and accurate automated safety inspections of commercial vehicles, further enhancing safety.

ITS will also help reduce public agency costs associated with managing the transportation system. Implementation of electronic toll collection technology has already reduced administrative costs associated with collecting tolls by over 90 percent in some cases. States are also beginning to realize reductions in the cost of regulating motor carrier safety through the use of automated registration, fuel-tax-reporting, and weight-screening processes. The cost reductions are expected to grow as more States implement comprehensive commercial vehicle information systems and networks (CVISN), currently being tested in eight States. Such deployments can also significantly improve productivity for commercial carriers by reducing the time and effort needed to prepare necessary paperwork and undergo manual weight screenings and safety inspections.

ITS can also **enhance** the quality of life and environmental quality of our Nation. Because ITS technology can enhance capacity using the existing physical infrastructure, it can lessen the disruptions to wetlands, parks, open spaces, and neighborhoods that are caused by new construction. Also, ITS can increase mobility by giving people more information and greater control over their transportation choices.

cent through the use of advanced information technology.

Enhancing the Quality of Life. Because ITS technology can enhance capacity using the existing physical infrastructure, it can lessen disruptions caused by new construction to wetlands, parks, open spaces, and neighborhoods. Also, ITS services and the supporting infrastructure can increase mobility, giving people more information and greater control over their transportation choices. In greater Boston, for example, 30 to 40 percent of travelers change their routes, times of travel, or modes when they are given up-to-date information through advanced information services. National focus group research indicates high interest among all income groups in travel products that provide personal security and safety services, location assistance, advanced traffic notification, and alternative route advisories. Equally important as the Nation's baby-boomers age, in-vehicle safety and information technology could enhance the capabilities of older drivers.

ITS INFRASTRUCTURE IS READY FOR DEPLOYMENT.

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

Although market and user acceptance of individual components of intelligent transportation infrastructure is growing, local ITS deployment is narrowly focused and disconnected. For the most part, transportation officials and managers are electronically reinforcing the fragmentation of today's transportation systems and infrastructure (which ISTEA sought to change), instead of using the technology as a bridge to a new era of intermodalism. Although individual ITS products and services produce specific benefits, integrated

PUBLIC SECTOR INVESTMENT IN ITS IS GROWING

States and localities are investing in individual ITS technologies and components. Over $ l billion of Federal-aid funding was used for the deployment of core ITS services in FY 1995, a 280-percent increase over FY 1991 .The use of Federal funds represents only a fraction of total State and local spending on ITS products and services. Further, our reviews of ITS deployment decisionmaking revealed that when State and local officials have discretion over the use of funding to solve problems-air quality and congestion improvement problems, in particular-ITS solutions rate very favorably.

ITS infrastructure is expected to deliver multiple and synergistic benefits and provide more options for both system managers and travelers. The risk of continuing the current pattern of local deployment is electronic "hardening" of the fragmentation that will take decades and billions of dollars to overcome.

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

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

Creating Funding Incentives. ITS deployment is gaining momentum under existing surface transportation programs, but not consistently, optimally, or systematically. Temporary funding incentives are necessary to intervene in the current deployment process to foster integration and national interoperability. The power of small incentives was shown dramatically in the recent MD1 solicitation. The solicitation catalyzed institutional collaboration, even among sites that were not selected. Many of these sites are proceeding with their ITS deployment plans without direct U.S. DOT funding support.

Establishing Standards. Public sector officials are hesitant to buy new ITS products that might become obsolete under future standards. Private firms are reluctant to invest in technology that may not meet future performance requirements. The relationship between standards and ITS infrastructure deployment is like the classic chicken-and-the-egg: we will have difficulty integrating ITS without standards, yet setting standards will be difftcult without strong demand for integrated ITS services. The establishment of standards goes hand-in-hand with deployment incentives as priorities in the U.S. DOT's ITS Program and must be supported by the reauthorization of ISTEA.

Building Professional Capacity. Just as the interstate construction program required new skills in road building and civil engineering, ITS development requires skills in system integration, electronics, and communications. Because professionals with these skills currently do not exist in sufficient numbers to support the effective delivery of ITS, carrying out the U.S. DOT's 5-year plan for building professional capacity is crucial to establishing the infrastructure to realize the ISTEA vision.

WE MUST INVEST IN THE NEXT GENERATION OF ITS-PARTICULARLY SMART VEHICLES.

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

Research to develop and enhance this vehicle technology must be carried out in collaboration with the industry that will potentially manufacture it. The risk of not making this investment is threefold. First, the car of the future will largely be a "mobile computer." The economic block (Europe, the United States, or Japan) that develops the operating systems of this mobile computer will control the industry for a decade or longer. In addition, without accelerated developmental research, current evidence suggests that smart vehicles will be very late (perhaps decades) in arriving on the market, if they ever do. This represents a potential unnecessary loss of millions of lives and billions of dollars in accident-related costs. Finally, individually developed systems without proper human-centered integration could actually degrade safety.

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

WHAT'S NEXT? A REAUTHORIZATION AGENDA FOR ITS

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

RESEARCH AND TECHNOLOGY

Continued funding is required to maintain the momentum of the ITS Program's near- and long-term research and technology agenda. As provided by the initial authorization, the U.S. DOT would continue to pursue both high-priority and high-risk initiatives, such as collision avoidance systems, automated highway systems, advanced rural transportation concepts, and the next generation of advanced travel management and CVO systems. The research agenda would also support the development of standards and the execution of the 5-year program for building professional capacity, as well as field operational tests and evaluations.

INCENTIVES TO ACCELERATE ITS DEPLOYMENT

Based on numerous focus groups and listening sessions. two options have emerged for accelerating the deployment of ITS infrastructure. One option would provide small incentive awards to metropolitan areas, primarily to support the cost of system integration, after the demonstration of institutional willingness to adopt and finance an integrated system. A second option would create a more traditional program that directly apportions ITS deployment funds to State and local agencies. These funds would support both hardware procurement and system integration. Funding eligibility under either option would be contingent on conformance with the national ITS architecture and supporting standards and protocols.

MAINSTREAM DEPLOYMENT PROVISIONS

Existing Federal highway, transit, and motor carrier investment program policies and regulations have been refined over many decades, but have not accounted for improved system management or ITS. The successor to ISTEA must explicitly state the eligibility of ITS deployment for mainstream Federal surface transportation funding. It should also pave the way for expansion of the capital planning process to include operational planning, as well as ITS operations and maintenance. NEXTEA should also reconcile disparities between highway and transit programs regarding the eligibility of ITS operating costs. The National Highway System Designation Act of 1995, for example, allowed most highway funds to be used for ITS operations, yet corresponding provisions are lacking in the transit programs. In addition, the next surface transportation authorization must sanction innovative procurement and financing approaches, including public-private partnerships.

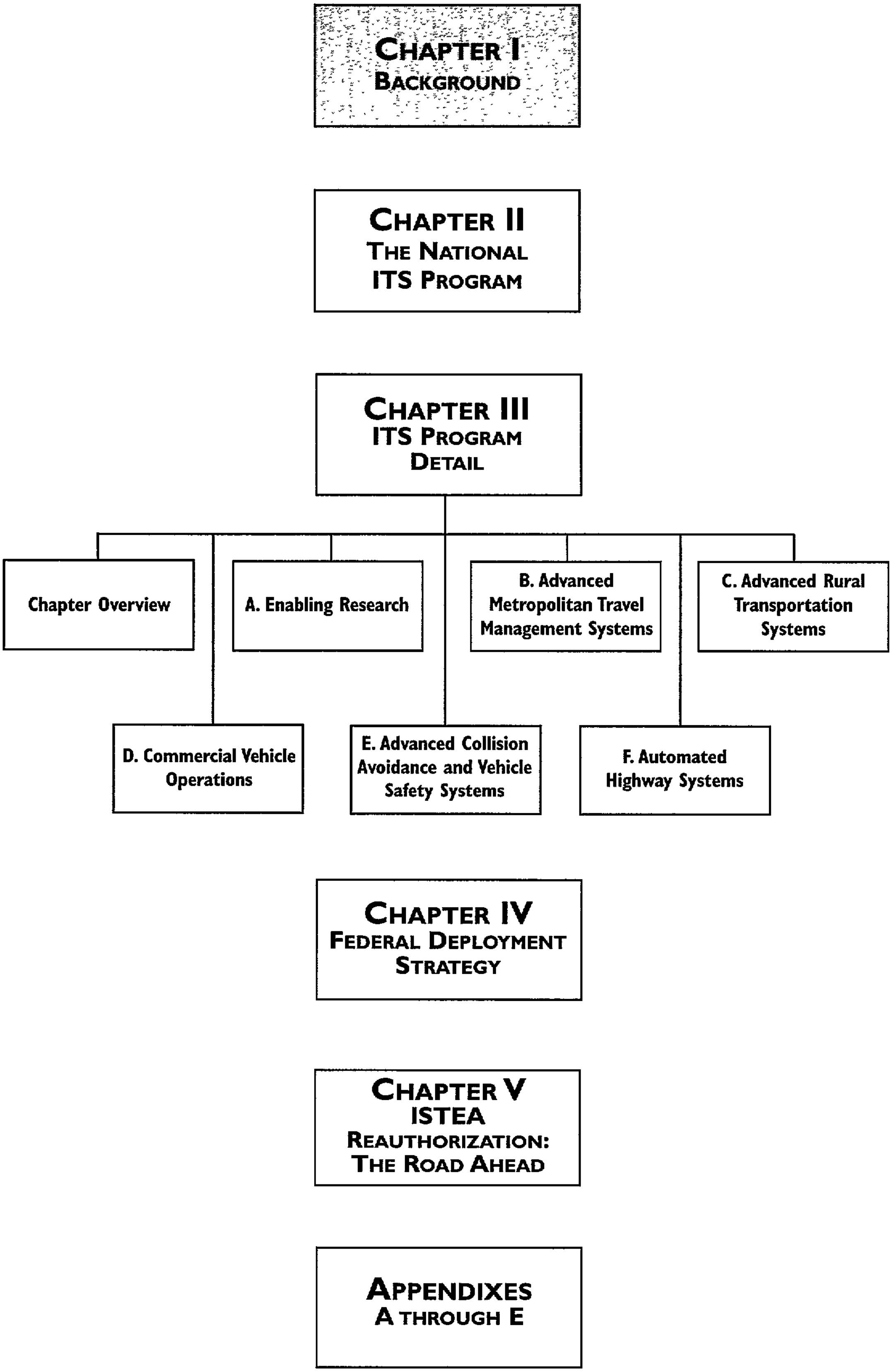
CONCLUSION

This telephone has too many shortcomings to be seriously considered as a means of communications. The device is inherently of no value to us.

WESTERN UNION INTERNAL MEMO, *1876*

Forty years ago, the Federal Government conceived a plan to build the interstate highway system, among the Nation's most ambitious public works projects. As it did in 1956, U.S. DOT is again serving as an agent to transform this Nation's surface transportation system-this time with the intelligent transportation infrastructure, which will serve as the foundation for managing the many individual systems as one seamless system. U.S. DOT does not propose to do this alone, but instead plans to encourage public sector agencies, with appropriate private sector support, to build this new infrastructure for the 2 1 st century. This new infrastructure will apply information technology to meet local needs within a framework that enables a national, interoperable system that will open up business opportunities much as the interstate highway system did four decades ago.

A historic opportunity is at hand for Congress to dramatically improve the future of surface transportation. Although the full potential of ITS has yet to be realized, enough has been learned in the past 5 years to verify the wisdom of forging ahead, nurturing the national ITS Program and allowing it to fulfill ISTEA's promise of a safer, more efficient and less costly intermodal transportation system.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I. BACKGROUND

Intelligent transportation systems provide the information and control needed to better manage surface transportation facilities-highways, roads, transit, and rail-and to help users of all modes make better decisions about travel. ITS applications take advantage of telecommunication, computer, sensing, and electronic technologies to collect and dispense information about transportation system performance, travel demand, impending collisions, and in some cases weather and environmental conditions. ITS concepts combine the insight provided by this information with the power of automation and other control technologies to improve the efficiency and safety of the Nation's transportation system and to significantly enhance the travel options and experiences of the American public.

ISTEA authorized the U.S. DOT to develop a national ITS program, building on decades of public and private research into individual ITS components and limited applications (such as basic traffic control and vehicle tracking). In the late 1980's, three events intensified interest in pursuing more aggressive research, testing, and deployment of ITS in the United States:

- Cost and performance breakthroughs were achieved in computer, sensor, and communication technologies.
- Traffic congestion, traffic safety, and air quality were issues of mounting concern.
- European and Japanese markets experienced aggressive development of ITS technologies.

These factors spurred ITS research efforts in the United States to shift from conducting isolated research projects to developing an integrated national program. The program's aim is to develop and deploy ITS user services to solve entrenched transportation problems and provide benefits to travelers, motor carriers, and businesses.

Congress passed ISTEA in 1991, promoting a transition from an era of system expansion through new construction to a new age of system management that more efficiently uses the existing highway and transit infrastructure.

ORIGINS OF THE NATIONAL ITS PROGRAM

Before ISTEA, advanced intelligent transportation technologies rarely made it outside the research laboratory to "real-world" testing and evaluation of their potential. Little ITS research extended beyond narrow technical concerns to investigate the societal impacts and institutional issues of broad-scale deployment. The research - climate changed in 1988, when senior DOT research officials, several universities, State transportation officials, and the private sector formed the Mobility 2000 group to identify the priorities and benefits of a national advanced transportation technology program. The group concluded that a "national policy [on ITS] should be formed using input from Federal, State, and local levels. From that policy, legislation and funding programs should be developed to guide needed research, conduct operational testing and evaluations, and deploy systems on a meaningful scale."

In response to a request for comments on a variety of ITS issues in May 1989, the Office of the Secretary of Transportation received more than 100 comments from both the public and private sectors that overwhelmingly supported the idea of a national ITS program.

Congress passed ISTEA in 1991, promoting a transition from an era of system expansion through new construction to a new age of system management that more efficiently uses the existing highway and transit infrastructure. In addition to its focus on better management of existing systems, ISTEA emphasized intermodalism: seamless integration of multiple travel modes.

In this spirit, the Intelligent Vehicle-Highway Systems Act, a component of ISTEA, established the IVHS Program (later renamed the Intelligent Transportation Systems Program) and authorized approximately $645 million in funding from 1992 through 1997. The Act called for the implementation of a "national system of travel support technology, smoothly coordinated among modes and jurisdictions to promote safe, expeditious, and economical movement of goods and people." Congress set forth ambitious goals for this new program, which included the following:

- Enhancing safe and efficient operation of the Nation's highway systems, particularly system aspects that will increase safety, and identifying system aspects that may degrade safety.
- Reducing societal, economic, and environmental costs associated with traffic congestion.
- Developing and promoting intelligent transportation systems and an ITS industry in the United States.
- Enhancing U.S. industrial and economic competitiveness and productivity.
- Enhancing, through more efficient use of the Federal-aid highway system, the efforts of several States to attain air quality goals established by the Clean Air Act.
- Developing a technology base for ITS and establishing the capability to perform demonstration experiments, using existing national laboratory capabilities where appropriate.
- Facilitating the transfer of transportation technology from national laboratories to the private sector.

To meet these goals, ISTEA required U.S. DOT, with the assistance of State and local governments and private partners, to undertake seven objectives:

- Promote widespread implementation of ITS to enhance the capacity, efficiency, and safety of the Federal-aid highway system and to serve as an alternative to additional physical capacity of the Federal-aid highway system.
- Promote standards and protocols to facilitate the widespread, compatible use of ITS technologies.
- Develop and evaluate ITS field operational tests.
- Establish an information clearinghouse.
- Establish an ITS Priority Corridors program to evaluate technologies under real-world conditions.
- Develop a prototype of an automated highway and vehicle system.
- Provide technical, planning, and operational test assistance to State and local governments to encourage widespread deployment of ITS.

ITS and the Challenges Facing Surface Transportation

ITS technology offers new and improved capabilities for addressing current and anticipated transportation issues and concerns. The ISTEA goal of widespread deployment of intelligent transportation technologies can enhance national transportation efficiency, safety, and productivity by: (1) meeting future transportation needs at a fraction of the cost of facility expansion or new facility construction, (2) improving highway safety through accident prevention and rapid emergency response, and (3) reducing transaction costs for the Government and transportation users. These benefits of ITS deployment are outlined in the following paragraphs.

Improving Efficiency of Physical Infrastructure

For the past 40 years, Federal surface transportation programs have focused on expanding and improving highway and transit systems, which has benefited the public and industry. Yet transportation demand is outpacing the capacity of new and expanded facilities. In 1993, 69 percent of the peak-hour travel on urban freeways occurred under congested conditions, and growing congestion continues to nullify the benefits of past transportation investments. Travel demand is also expected to grow by 30 percent during the next 10 years in the largest 50 metropolitan areas. As a result, improved highway management and transit facility enhancements are essential to sustaining safety and performance.

By implementing a combination of new ITS infrastructure along with new highway construction in these 50 major urban areas, the United States can add sufficient vehicle-handling capacity during the next 10 years to accommodate the projected increase in travel demand over that time period. This means that, in these 50 urban areas, congestion could be maintained at current levels over the IO-year period and would not get any worse. Deploying ITS could reduce the need for new roads, while saving taxpayers 35 percent of required investment in urban highways. Because ITS technology can enhance capacity and improve throughput of the existing physical infrastructure, it will also help preserve wetlands, parks, open spaces, and neighborhoods.

IMPROVING HIGHWAY SAFETY

More than 4 1,000 individuals die and 5.2 million are injured on the Nation's highways and roadways each year. In 1990, motor vehicle crashes and injuries cost $137 billion-a large portion of which was in property damage. Traditional Federal safety programs have focused on vehicle "crashworthiness" features, such as seat belts, child-safety seats, and air bags; roadside improvements; and behavioral factors, such as seat belt use and prevention/intervention of drunk driving to minimize traffic injuries and fatalities. All have contributed greatly to the impressive highway safety record enjoyed by the United States compared with other developed nations. These efforts are essential to holding the line in highway safety. Nevertheless, automobile accidents remain a leading cause of death for people ages 5 to 27. The U.S. must do more to improve safety on our highways.

Advanced collision avoidance and vehicle safety systems will add a powerful new weapon to the traffic safety arsenal, focusing on preventing accidents and on mitigating the consequences of crash injuries. The development of these technologies will ultimately strengthen the goal of NHTSA's overall motor vehicle safety program, which is to significantly reduce the number of collisions and associated deaths, injuries, and traffic congestion. A recent study by NHTSA estimates that three types of collision avoidance systems could potentially eliminate 1.1 million collisions per year-17 percent of all collisions. In addition, other ITS capabilities, such as incident management, emergency response, automatic highway-roadway warning, and automatic carrier safety inspection, are being advanced to make travel safer for drivers, passengers, and nonmotorists.

ITS will enable more efficient use of existing physical infrastructure. ITS, for example, will allow highway and traffic managers and operators to dynamically respond to changes in operations by providing information on alternative routes, detecting and clearing incidents, or adjusting traffic signals and ramp meters.

REDUCING TRANSACTION COSTS

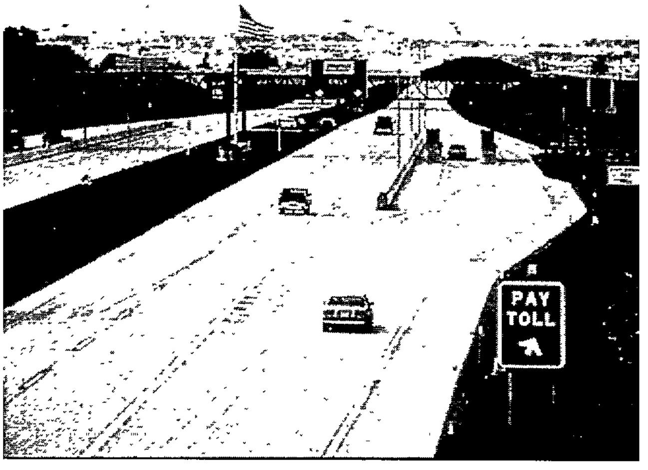
Many of the administrative systems supporting CVO require manual processes and redundant data entry. Most of these systems cannot share information among States. Furthermore, motor carriers spend between $500 and $900 per vehicle in labor costs to carry out various regulatory administrative activities, such as obtaining licenses and credentials and paying fuel taxes. The cost burden for public sector enforcement, inspection, and administrative activities is even greater because tracking and data management are labor intensive. Ultimately, the costs imposed by an inefficient transportation system hinder the competitiveness of businesses at home and abroad and raise the cost of government.

Creating an electronic nationwide network that would handle commercial vehicle regulatory and administrative functions would greatly reduce the paperwork associated with issuing credentials and conducting other transactions. A nationwide commercial vehicle information network would enable truckers to travel from coast to coast and border to border, making no more than one stop to verify compliance with interstate motor carrier regulations. A reduction in transaction costs would benefit taxpayers directly and consumers indirectly by lowering the cost of delivered goods. A 1995 study by the American Trucking Association's Foundation estimates that automated clearance and transaction services have a benefit-cost ratio of 20 to 1 for large motor carriers. Pilot tests have demonstrated that data collected on motor carriers' performance can be used to identify higher risk carriers that have poor safety records. This enables inspection and enforcement personnel to target carriers that need compliance reviews. making more efficient use of public sector staff while improving safety on the roadways.

In other venues. toll- and fare-collection activities often rely on antiquated, labor-intensive procedures for collecting fees, requiring vehicles to wait in long queues to pay tolls or cross borders. These procedures are costly and inconvenient for toll facility operators, as well as drivers. Deployment of ITS technologies for electronic toll collection and transit fare payment can speed collection of user fees and reduce the costs of cash transactions. In Oklahoma, for example, maintaining a single conventional toll booth costs $176,000 a year. Operating costs dropped to $16,000 per year per toll booth when booths were equipped with electronic debit systems, a cost reduction of 90 percent.

Beyond reducing government and user costs, ITS can also provide critical information to improve transportation system operations, planning, and investment decisions. The implementation of ITS technologies can enable better management of surface transportation in the same way that air traffic controllers have used advanced automation technologies to better manage the air system.

In addition, the availability of more accurate traffic and transit system data has fostered the development of a host of new traveler information services through a variety of media, resulting in more informed travelers. A Framingham, MA resident expressed how the SmarTraveler real-time information service. which



Oklahoma City saved $160,000 per year per toll booth when booths were equipped with electronic debit systems.

THE SKY'S THE LIMIT: THE ANALOGY OF ITS AND THE AIR TRAFFIC MANAGEMENT SYSTEM

Using real-time information to better manage traffic is not a new concept. Paralleling the application of ITS technologies to surface transportation, the FAA began using advanced information systems to better manage air space more than a decade ago,

Since the early 1970's, the number of aircraft handled by U.S. air traffic controllers has doubled. By 2010, traffic at the Nation's 100 busiest airports is expected to increase by another 30 percent.The FAA anticipated this massive growth more than 20 years ago when it reafized that the United States could not build enough new airports and runways to handle the demand. Instead of undertaking new construction, FAA and Congress made a commitment to increase air transportation throughput and to improve air traffic management by introducing advanced information, communication, and electronic technologies and systems. Known as the advanced traffic management system, these transportation technologies have enabled FAA to better manage air traffic growth by using improved air system data.

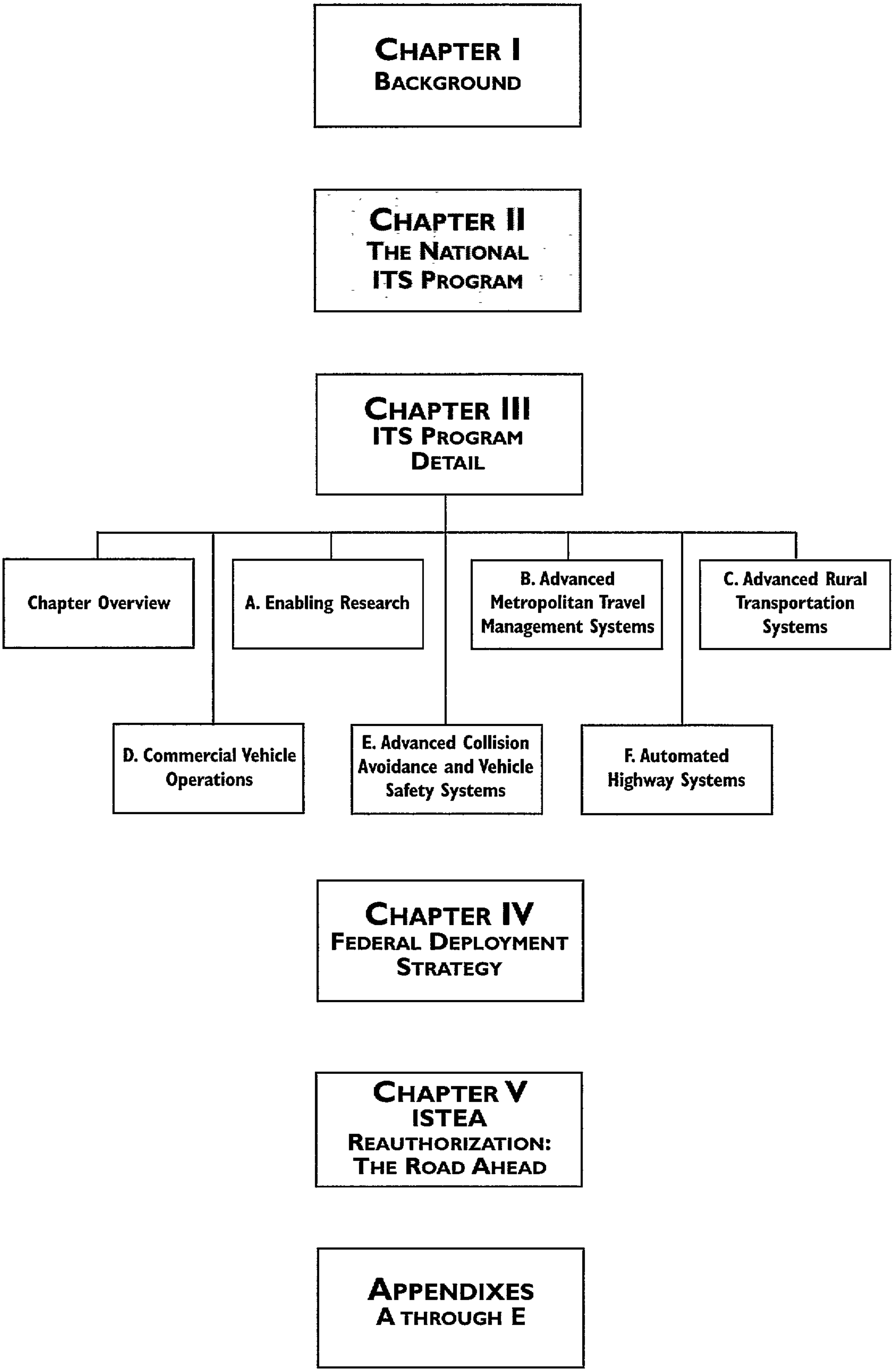
The air traffic management system has been developed and implemented in various phases, beginning with the aircraft situation display, which provides every traffic manager with a clear overview of the entire airspace.This overview provides controllers with accurate, real-time data and information, while allowing managers to consider variations in flow and direction to make better use of the crowded skies.The second phase of the system is a monitor-and-alert function that helps predict congestion, giving airspace operators the opportunity to adjust traffic patterns before potential problems develop.The third phase, stitt in development, will provide current and expected air traffic information to airlines, allowing them to modify their flight plans to help reduce problems.

The entire air system is managed more efficiently because traffic managers have access to information systems that allow data to be collected, displayed, and analyzed.The advanced air traffic management system has greatly enhanced FAA's ability to increase throughput, reduce delays, and more effectively use existing airport and en route airspace capacity-all without building new runways.

In addition, air traffic information has already enabled airlines to better manage their fleets, load factors, and crew assignments. It has saved carriers tens of millions of dollars white improving their on-time performance and customer satisfaction.Air carriers are now developing their own traffic management centers and creating new ways to use FAA's air traffic flow data. *The Wall Street Journal* recently reported that Delta Airlines built a new traffic operation control center, which is expected to save the company at least $35 million a year in prevented delays and schedule disruptions.

The Nation's surface transportation facilities share many of the challenges of the air traffic system: squeezing more efficiency from limited physical facilities, reducing delays, improving safety, and enhancing customer satisfaction. Like the advanced air traffic management system, ITS will enable more efficient use of existing physical infrastructure, provide valuable real-time information (such as information on delays, alternative routes, environmental conditions, and potential collisions) to managers and operators to improve system performance and safety, and allow managers to dynamically respond to changes in operations by altering routes or adjusting traffic flow. U.S. DOT expects to deliver similar benefits achieved by the advanced air traffic management system, except that this time the goal will be the advancement of more efficient surface transportation systems.

began as a U.S. DOT-sponsored field operational test, affected the quality of travel: “It used to be that the MBTA [the metropolitan transit authority] phone was always busy when it snowed, but the SmarTraveler line is never busy, and it also provides traffic information, so I know how bad the traffic really is . . . It makes it easier to make decisions.”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II.THE NATIONAL ITS PROGRAM

Leading transportation researchers and experts across the Nation have developed diverse visions for improving the performance of surface transportation systems through state-of-the-art technologies. The partners in the national ITS Program-U.S. DOT, ITS America, and others-have melded these visions into a cohesive strategy, charting a course for ITS in America that is guided by the unified, public-private, 20-year *IVHS Strategic Plan.* Supporting goals and objectives for ITS are set forth in the *National ITS Program Plan* and underscored by consensus development of a national ITS architecture, which serves as a blueprint to ensure that public sector and private industry deployments are compatible from State to State and city to city. The accomplishments of U.S. DOT's multifaceted program have advanced the state of technology and deployment and established the United States as an industrial and technological leader in key ITS areas.

Throughout its history, four principles have guided the vision of the ITS Program:

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

PROGRAM ACTIVITIES

Over the past 5 years, the national ITS program has grown, matured, and established a firm foundation for carrying out the goals set forth by ISTEA. The program addresses six broad categories of activities and systems related to ITS:

- **Enabling research** focuses particularly on the comprehensive system architecture and associated standards. Research lays the foundation for national compatibility among all ITS components. In addition this activity investigates human factors to ensure that ITS products are safe and user friendly. Research also attempts to improve the capabilities of technologies, such as communication and location-referencing systems, that enable ITS services to function effectively.
- **Advanced metropolitan travel management systems** include a great range of ITS services that address traffic management, traveler information, and transit management. Services include advanced traffic management systems (ATMS), advanced traveler information systems (ATIS), and advanced public transportation systems (APTS).
- **Advanced rural transportation systems (ARTS)** apply many of the ITS services in other categories to address the unique safety and mobility problems of diverse rural communities.
- **Commercial vehicle operations (CVO) can** be enhanced through advanced technologies and information networks to increase productivity and efficiency for both fleet operators and State motor carrier regulators. The Federal ITS/CVO program focuses particularly on ITS application to safety, inspection, and other regulatory processes associated with commercial vehicles.
- **Advanced collision avoidance and vehicle safety systems** aim to improve driver and pedestrian safety through human-centered vehicles equipped with technologies that can warn of or help the driver avoid impending crashes, monitor driver alertness, or automatically signal for help immediately after a collision.
- **Automated highway systems (AHS)** will take the potential of vehicles equipped with crash avoidance technology to a new level. Research in this area is centered on the potential benefits and feasibility of a smart vehicle that can communicate with

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

For each of these program areas, the ITS Program engages in two major categories of activities: research and technology development and foundational planning to support nationwide deployment in metropolitan areas, rural communities, and interstate corridors.

Research and Technology

Research and technology efforts have embraced both laboratory and field testing of ITS technologies and applications. In particular, initial laboratory and field testing has proven the technical feasibility and benefits of several first-generation ITS technologies and services, especially those aimed at metropolitan travel and CVO. As a result, the focus of new field testing is shifting away from nearly market-ready ITS services toward technologies that. until recently, were confined to the laboratory: advanced collision avoidance and vehicle safety systems and next-generation traffic and transit management systems. One of the most notable of these systems is the real-time traffic-adaptive signal control system (RT-TRACS), which advances the state of the art in demand-responsive traffic control. Field testing of advanced rural transportation applications will also intensify as the national program emphasizes the critical mobility and safety needs of rural communities. Long-term research will continue to focus on working with the private sector to develop marketable advanced crash avoidance technologies and to investigate their potential application to future automated highways. The next frontier in travel management will be automating numerous traffic and transit management functions and developing the traffic control center of the future.

Deployment Support

ITS deployment will require the support of innovative public-private partnerships. The U.S. DOT anticipates that the public sector will lead in building an ITS infrastructure-a communication and information backbone to support and integrate essential ITS services so that they are interoperable and intermodal. We expect that the private sector will lead in developing and introducing reliable, affordable ITS products and services to the market, reassured by consistent Federal support and guidance. The portions of the ITS Program that support near-term deployment include architecture, standards, model deployments, "mainstreaming" of ITS planning, technology transfer, and training efforts.

Five years after the passage of ISTEA, the U.S. DOT has fulfilled the objectives of Congress. U.S. DOT's research and field tests have proven that ITS can enhance capacity, reduce costs, and increase safety. But these efforts have also revealed that, without Federal leadership, intermodalism will likely be hindered by fragmented ITS deployment characterized by "electronic stovepipes," rather than integrated information networks. In light of these findings, U.S. DOT has established as its primary goal the creation of an intelligent transportation infrastructure "across the Country within a decade to save time and lives and improve the quality of life of all Americans." This deployment goal has three elements:

- Full implementation of a metropolitan intelligent transportation infrastructure, including advanced traffic management, traveler information, and public transportation system capabilities, in 75 of the Nation's largest metropolitan areas within 10 years. In January 1996, then Secretary Pena announced Operation Timesaver, an initiative designed to motivate metropolitan areas to build ITS infrastructure to reduce travel times for all modes by 15 percent.
- The implementation of Commercial Vehicle Information Systems and Networks (CVISN) that integrate multiple ITS/CVO services to achieve safe and efficient shipping operations and enable

electronic business transactions by the year 2005 in all interested States.

- The development of a rural ITS infrastructure to improve safety and mobility in 450 rural communities and small towns, with an eye toward linking rural ITS services with ITS infrastructure in adjacent metropolitan areas.

PROGRAM MANAGEMENT

The multifaceted ITS Program compelled U.S. DOT to reexamine its traditional way of doing business. In May 1994, the Department established the ITS Joint Program Office (JPO), which called for unprecedented interagency cooperation involving many of U.S. DOT's modal administrations, to manage the ITS Program. Housed at FHWA, the JPO has three primary objectives:

- Provide strategic leadership for ITS research, development, testing, and deployment.
- Guide and coordinate the development of policies.
- Ensure resource accountability.

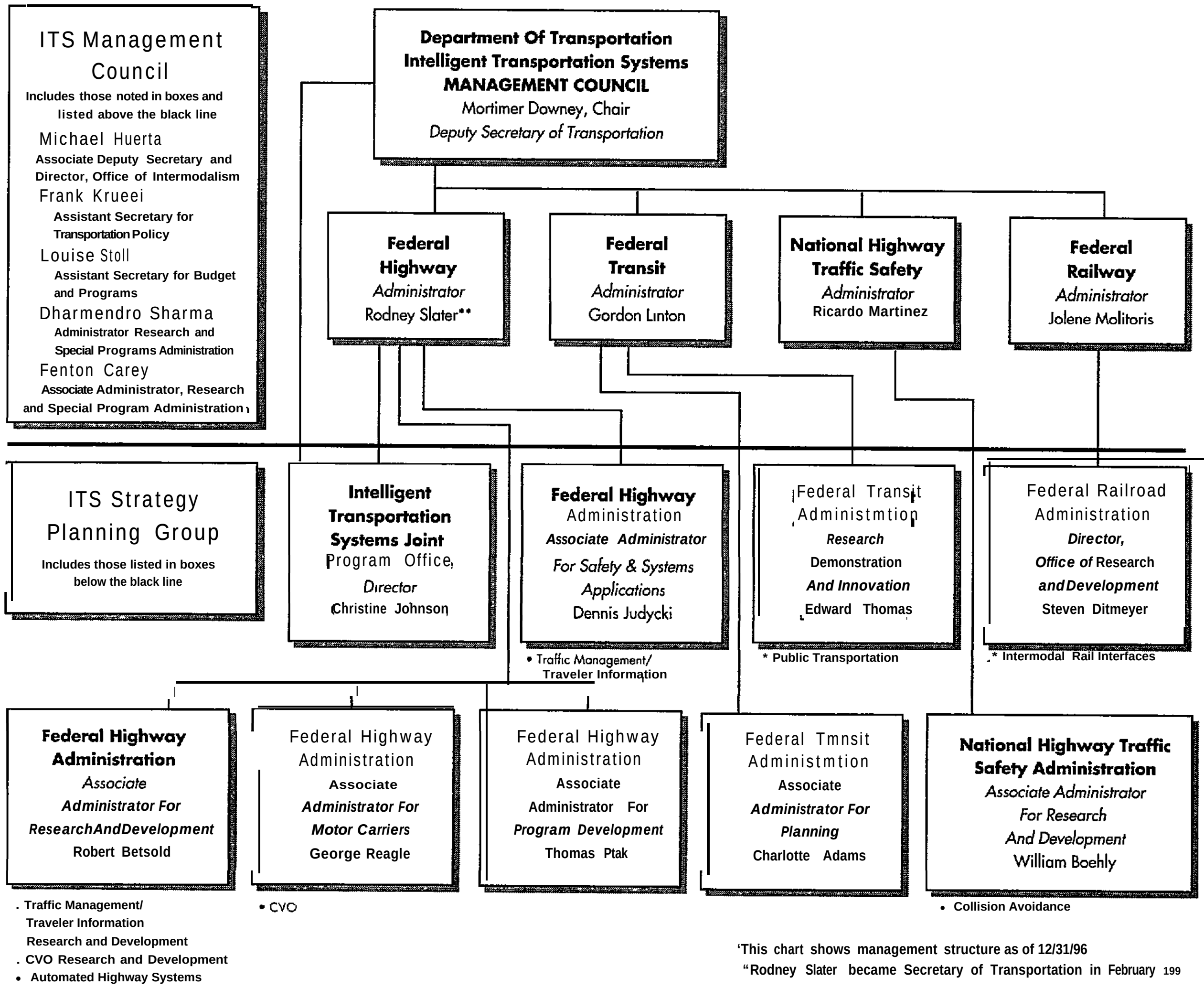
The JPO acts as a liaison among the modal administrations and receives policy guidance directly from the ITS Management Council, which is chaired by the Deputy Secretary of Transportation. A strategic planning group consisting of the JPO Director and office directors from all the program areas-the associate administrators from various modal administrations-also provides strategic planning, budgetary, and program guidance. Offices within the various program administrations (i.e., FHWA, NHTSA, FTA, FRA, and RSPA) are responsible for the actual implementation of ITS activities. Exhibit II-1 shows the JPO's management structure.

Since its inception, the JPO has undertaken a number of initiatives and responsibilities to improve oversight of ITS projects:

- In each of the program areas, the JPO developed road maps-detailed work plans that established milestones and critical paths for achieving program objectives.
- The office sharpened the project selection process, seeking proposals that feature firm agreements among partners and establish institutional relationships. It also formally selects operational tests based on the overall program goals, using defined and clear criteria.
- The office implemented a project-tracking data base.
- In 1996, the JPO created an integrated program spending plan that tracks committed and obligated funding and cost-sharing arrangements.
- All program leaders report progress on delivery of projects at quarterly program reviews. Changes to cost and schedule are also reported and discussed at these reviews.

The Federal Government is only one of many actors fostering the implementation of ITS technologies. The U.S. DOT consults with ITS America, which acts as a Federal advisory committee to U.S. DOT. ITS America is a nonprofit educational and scientific society charged with coordinating and accelerating the development and deployment of advanced technologies in surface transportation. A public-private partnership, its 1,500 organizational members include Federal, State, local, and foreign government agencies; national and international corporations; universities and research laboratories; and transportation-related associations, including affiliated State chapters. ITS America sponsors workshops, conferences, and symposiums to discuss research and testing, the results of which are published or posted on the Internet. It has also partnered with U.S. DOT to produce strategic plans, gain consensus on the national ITS architecture, and identify priorities for development of standards.

EXHIBIT II-1
ITS PROGRAM MANAGEMENT STRUCTURE FOR FY 1996*



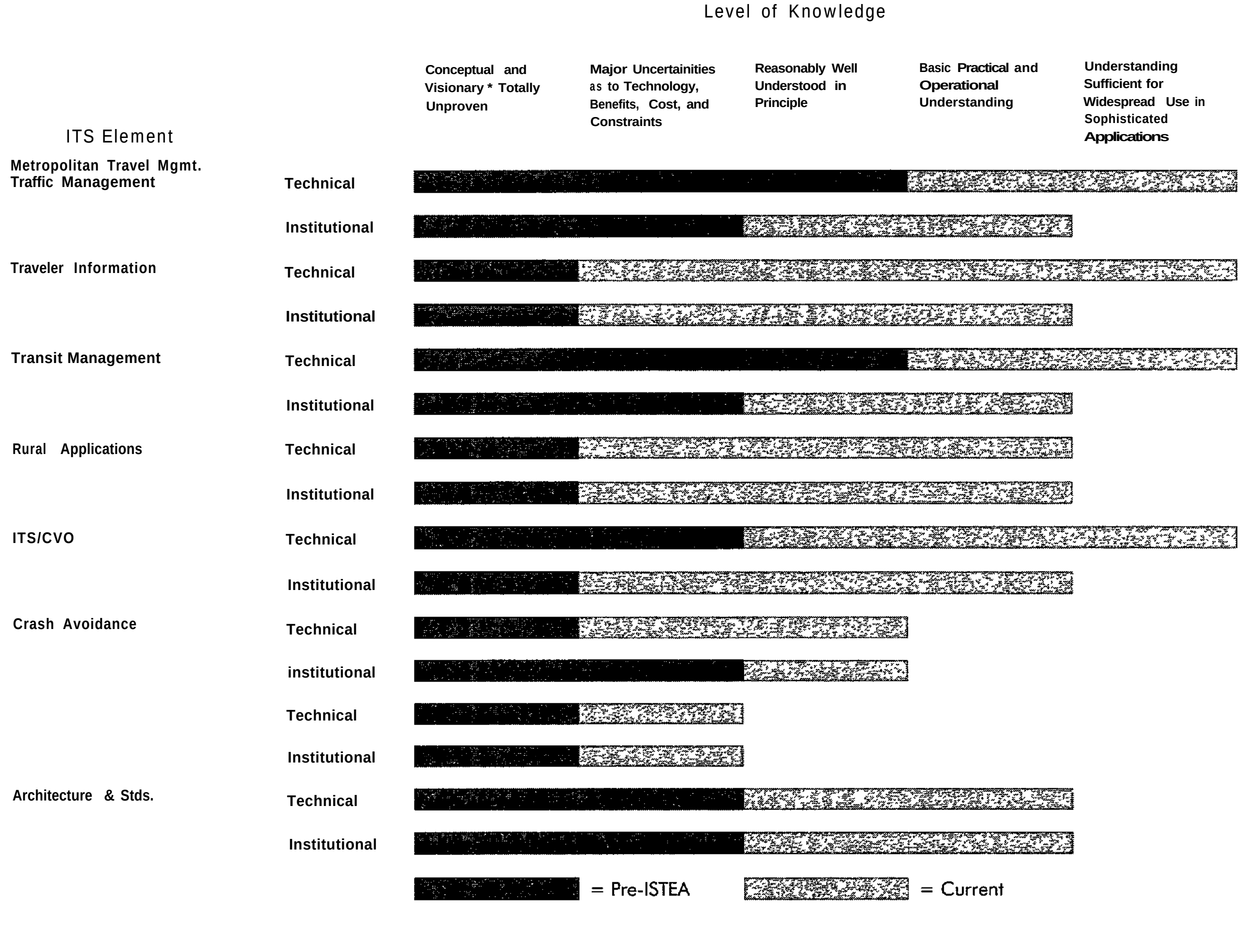
PROGRAM ACCOMPLISHMENTS

Since its creation by ISTEA, the national program has advanced the frontier of knowledge of technical and institutional issues related to ITS applications (see Exhibit 11-2). The program has accelerated development of promising technologies, created innovative applications to solve transportation problems and fulfill user needs, and helped spur ITS deployment in the Nation's metropolitan areas, rural communities, and interstate corridors.

In the decade before ISTEA, rapid technological advances in electronics and computing power, combined with their declining costs, spurred the development of innovative technologies aimed at surface transportation. By the time ISTEA was authorized in 1991, however, there was great uncertainty about the effectiveness of these ITS technologies and confusion over their real benefits and costs. For example, although the technical aspects of traffic and transit management technologies were reasonably understood in principle, the technologies were not widely used. The motor carrier industry and regulators were also familiar with technologies to better manage fleets and inventories, but were unclear about the potential of technologies that could improve safety and streamline regulatory processes. Little was known about how ITS technologies could work together and share information, because standards and technical and institutional frameworks had not been defined or developed.

Five short years after the ITS Program's creation, U.S. DOT possesses sufficient technical understanding to promote the widespread use of several intelligent transportation services and overcome institutional impediments to their acceptance. We have defined a national architecture-a blueprint for building compatible and interoperable ITS services-and identified critical standards. We have established the importance and value of integrated ITS services in place of frag-

EXHIBIT II-2
PREVIOUS AND CURRENT KNOWLEDGE OF ITS ELEMENTS



ITS Program Highlights for FY 1996

FY 1996 was a pivotal year in which the ITS Program established clear deployment goals for the Nation. The year also saw the fruition of R&D efforts as advanced crash avoidance technologies and next-generation dynamic traffic control technologies progressed from the laboratory to field testing. All these accomplishments rest on the foundation established by previous efforts. The Department's highlights for FY 1996 include the following:

- We identified a "core" public ITS infrastructure, called **the metropolitan intelligent transportation infrastructure,** to support the interoperability and integration of advanced metropolitan travel management systems.
- We unveiled **Operation Timesaver,** which establishes a clear deployment goal: to build the intelligent transportation infrastructure in 75 of the Nation's largest metropolitan areas within 10 years.
- We delineated the needs and strategies for building **CVISN,** a communication and information infrastructure that will facilitate the deployment and integration of ITS/CVO services that improve the productivity, safety, and efficiency of commercial operations.
- We launched the **MDI,** which will showcase an integrated metropolitan ITS infrastructure in four major metropolitan areas and demonstrate its advantages so that others can learn and benefit. We also selected pilot projects in seven regional trucksheds to build CVISN. We have successfully demonstrated the essential concepts of CVISN at two prototype sites in Virginia and Maryland.
- We finalized a **national ITS architecture** that will guide system design, integration, and interoperability of ITS user services and will help with the development of the ITS infrastructure.
- We signed **cooperative agreements with five SDOs** to advance critical standards that promote compatibility and interoperability of ITS technologies and guide design and development of ITS services.
- The PTA, in support of the ITS Program, developed a comprehensive **APTS program plan** that presents the goals and objectives of near- and long-term projects. FTA has also developed an advanced rural transit plan to identify how APTS technologies can support transit systems that serve rural communities.
- We drafted a **strategic plan for ARTS,** which identified seven critical program areas. This document will guide the development of a research and field-testing program to demonstrate a variety of rural ITS applications.
- We completed **preliminary performance guidelines** addressing the sensing, processing, and driver interface elements of several advanced crash avoidance and safety systems, and we began the first field tests of automated collision notification systems and intelligent cruise control.

ITS Program Highlights for FY 1996 (cont.)

- NHTSA completed its **strategic plan for the advanced collision avoidance and vehicle safety system program,** which outlines the causes and costs of motor vehicle crashes, appropriate ITS countermeasures, and research and testing plans.
- We developed **an advanced dynamic traffic control strategy, RT-TRACS,** that will advance state-of-the-art traffic signal control based on real-time demand.
- We completed a **strategic plan for building professional capacity** to educate transportation professionals about human resource and skill requirements for implementing, operating, and maintaining traffic, traveler, and transit ITS services. We are also developing course curricula to address training needs.
- We developed a **mainstreaming plan** to incorporate ITS within the traditional transportation planning processes used by MPOs, transit properties, cities, counties, and State DOTs. This plan allows ITS to be evaluated as competitive and viable transportation projects, rather than relegated to the sidelines as "exotic" luxuries.
- We demonstrated some of the **initial concepts for coordinating and integrating multiple ITS services** to millions who attended the Olympics in Atlanta, GA.
- As part of our CVO mainstreaming activities, we have encouraged 33 States to develop **seven regional forums** that are designed to improve motor carrier operations, build professional capacity, and explain the purposes, technologies, costs, and benefits of ITS/CVO to State legislatures, private industry, and the public.
- We held a kick-off ceremony at the site of the upcoming **AHS demonstration,** which will take place in San Diego, CA, in 1997.
- We developed a **Federal Communications Commission (FCC) strategy** that aims to secure a portion of the spectrum for specific ITS uses. This strategy identified the need for dedicated short-range communications to support a number of ITS applications, particularly those that provide the short-range communication links between vehicles on the roadway and equipment on the roadside.
- We developed an **augmented GPS strategy** that will enable ITS user services that use location-referencing technologies to more precisely identify locations of vehicles and travelers.
- We launched the **intelligent transportation infrastructure deployment monitoring system** to measure baseline investment in, and track development of, the intelligent transportation infrastructure in 75 large metropolitan areas.
- We incorporated the **highway-railroad intersection user service** within the national ITS architecture.

mented ITS deployment, as well as the need for an underlying information and communication infrastructure to enable integration. Although crash avoidance technologies and AHS must still overcome technical and market uncertainties, U.S. DOT's focused research and testing has steadily advanced these technologies from concept toward reality.

WHAT HAVE WE ACHIEVED?

The achievements of the ITS Program since 1991 are significant. In a 5-year period, we have built a solid foundation for national deployment of ITS and made breakthroughs in developing vehicle safety and information technology. The following paragraphs describe the major accomplishments to the ITS Program.

Defined a Vision for the ITS Program

In 1992, the U.S. DOT and ITS America published complementary ITS visions and strategic plans. In March 1995, the two organizations jointly published the *National ITS Program Plan,* written cooperatively to guide the development and deployment of ITS services. Acknowledging the key roles that local public and private sectors will play in ITS implementation, the plan was developed through a consensus-building process. More than 200 individuals and organizations commented and provided input on the plan, while more than 4,000 draft copies were distributed to ITS America members, U.S. DOT staff, and the general public through the *Federal Register.* The JPO's coordination of road maps, which mark milestones and critical paths for achieving key program objectives, builds on the plan's foundation.

Tested the Viability of Technologies and Applications

The U.S. DOT has stewarded 83 field operational tests that demonstrate the viability of first-generation ITS technologies and services; 28 tests have been completed. These tests have helped identify and resolve technical issues, created new models of institutional cooperation, and shown how several technologies can reduce congestion, improve emergency response time, increase transit system productivity and passenger convenience, and reduce the environmental impact of transportation. The results of these tests are documented in *Field Operational Tests: Lessons Learned* and *Analysis of ITS Operational Tests: Findings and Recommendations.* Appendix C describes the objectives of each of the 83 operational tests.

Evaluated Societal Benefits

Several studies conducted by U.S. DOT and others have shown how ITS technologies can have a favorable impact on transportation efficiency, productivity, safety, user satisfaction, and the environment. Exhibit II-3 shows the coverage of measured, predicted, and anecdotal results, which are continually updated and improved as U.S. DOT investigates and evaluates field operational tests and early deployments. The findings of 11 of the most recent major studies sponsored or performed by U.S. DOT are shown in Exhibit 11-4.

Research on the public benefits of ITS establishes a compelling national interest in launching the ITS infrastructure to both realize the vision and mission of ISTEA and engender a new array of private sector goods and services in much the same way that the Internet has.

Launched an Aggressive Research and Technology Program

The national ITS Program has helped ITS evolve from a relatively visionary concept to a viable and attractive solution for transportation problems. To a large degree, general concerns about the technological limitations of ITS have either been refined to specific questions or have been resolved. Among its many achievements, the program has refined real-time adaptive traffic control; improved vehicle tracking technologies used in public transportation, emergency response, and CVO; developed guidelines to help ensure that traffic management systems and in-vehicle navigation displays are user-friendly and safe; and promoted architecture and standards to ensure that ITS

EXHIBIT II-3
DOCUMENTATION OF PRIMARY ITS BENEFITS

ITS Technology	Types of Evidence Documenting ITS Benefits					
	Time Savings	Increased Throughput	cost Reduction	Reduction · Accidents	Reduction in Fatalities	Customer Satisfaction
ATMS	Measured Anecdotal Predicted	Measured Anecdotal Predicted	Measured	Measured Anecdotal Predicted	Measured Anecdotal	Measured
ATIS	Measured Anecdotal Predicted	Predicted	Evaluating	Anecdotal Predicted	Anecdotal	Measured Anecdotal
APTS	Measured Anecdotal Predicted		Measured Anecdotal Predicted			Anecdotal
ARTS	Evaluating		Evaluating	Measured Anecdotal Predicted	Predicted	Evaluating
ITS/CVO	Measured Anecdotal		Measured Anecdotal Predicted	Anecdotal Predicted	Predicted	Measured Anecdotal Predicted
Adv. Collision Avoidance & Safety Systems	Predicted			Measured Anecdotal Predicted	Evaluating	Evaluating
AHS	Evaluating	Predicted	Evaluating	Evaluating	Evaluating	Evaluating
Integrated Systems	Predicted	Predicted	Predicted	Anecdotal Predicted	Evaluating	Evaluating

Adapted from *Review of ITS Benefits: Emerging Successes.*

Notes:

- **Measured:** Outcome results from field measurement of desired quantities through engineering studies, which are the most compelling evidence.
- **Anecdotal:** Output measures or estimates made by people directly involved in fielded projects, which are also compelling, but less reliable than measured outcomes in terms of quantitative benefit estimates.
- **Predicted:** Results from analysis and simulation, which can be useful tools to estimate impact of an ITS deployment when field experience is not available or when projects are not of sufficient scope to determine system impact.
- **Evaluating:** Benefits are undocumented because they are currently being or will be evaluated.
- **Blank:** ITS technology is not expected to have a significant direct or indirect impact.

EXHIBIT II-4
DOCUMENTATION OF ITS BENEFITS

Document	Date	Description	Findings
*National Investment and Market Analysis **for** ITS*	January 1997, unpublished draft	This study. prepared by Apogee Research for ITS America and U.S. DOT (1) estimates public sector investment requirements to deploy basic ITS infrastructure nationwide by year 2005. (2) quantifies direct benefits, (3) estimates size of private sector market; and (4) identifies and evaluates national economic impact. The study is an analytical framework based on analyses conducted as part of the national ITS architecture efforts. The framework employs the best publicly available information on the costs and benefits of deploying ITS.	The deployment of the 9 elements of the metropolitan intelligent transportation infrastructure in the largest 297 metropolitan areas in the United States would have an overall benefit-cost ratio of 5.7:1. The deployment of these same elements in the 75 Operation Timesaver metropolitan areas would have a benefit-cost ratio of 8.8: 1. More than 80 percent of the benefits are from increased safety and reduced congestion.
An *Estimate **of** Transportation Cost Savings by Using Intelligent Transportation System (ITS) Infrastructure*	February 1997, latest version (unpublished)	This study, prepared by Mitretek for the ITS JPO. estimates the cost savings of metropolitan ITS infrastructure for 50 major urban areas to keep up with expected new travel demand over the next 10 years. The study employs a life-cycle analysis (10 years of investment, out to 20 years of operations) to compare two alternatives: (I) new highway construction (build-only) and (2) ITS plus limited road building. The results are discounted to 1996 using a 7 percent annual rate.	This study estimates that buying smarter by deploying ITS reduces the need for new roads, while saving taxpayers 35% of required investment in urban highways. The build-only alternative would require 44.000 new lane-miles to keep up with travel demand over the next 10 years in 50 major urban areas. The deployment of ITS would reduce required new lane-miles to 15,000.
*Preliminary Assessment **of** Crash Avoidance Systems Benefits*	October 1996	The study, performed by NHTSA, estimates the benefits of three types of advanced collision avoidance systems in terms of number of crashes avoided. The study uses probability analyses based on information from NHTSA's traffic accident data base and preliminary experimental data from NHTSA's advanced collision avoidance program.	The study predicts that three types of collision avoidance systems, rear-end collision avoidance, lane-change/merge crash avoidance, and road-departure warning systems, could eliminate 1.1 million vehicular collisions each year-17% of all vehicular crashes. This estimate presumes that all vehicles in the United States would be equipped with these collision avoidance systems. These predictions must be considered preliminary pending further research, refinement of estimates of potential countermeasure effectiveness, and field experience.

EXHIBIT II-4 (CONT.)
DOCUMENTATION OF ITS BENEFITS

Document	Date	Description	Findings
*Review **of** ITS Benefits: Emerging Successes*	September **1996**	This document, prepared by Mitretek for the lTS JPO, presents the findings of approximately 75 studies related to ITS impact on time savings, number of crashes, fatalities, throughput, cost reductions, and energy and the environment. The review distinguishes measured, predicted, and anecdotal results from evaluations of field operational tests and early deployments, and academic studies.	Highlights of the 75 studies reviewed in this report are provided throughout Chapter III.
*Benefits Assessment **of** Advanced Public Transportation Systems*	July 1996	The study, prepared byVolpe National Transportation Systems Center for PTA, considers the deployment of APTS technologies for a total of 200 motorbus, 212 demand-responsive transit, 16 light-rail, and 14 heavy-rail transit systems. For each of these systems. data representing the 1993 financial, operating, and performance characteristics (as reported by these transit systems under Section 15) were used to predict the benefits of APTS deployments for a IO-year period (1996-2005).	The analysis projects that total benefits over 10 years for 265 APTS system deployments would range from $3.8 billion to $7.4 billion. The annual APTS benefits, over the next 10 years, from these deployments are projected to range from $546.6 million to as high as $1.1 billion. Approximately 44% of the total benefits are accrued from fleet management system deployments, 34% from electronic fare payment system applications, 2 1% from traveler information system deployments, and the remaining 1% from demand-responsive transit systems.
*Assessment **of** intelligent Transportation Systems/ Commercial Vehicle Operations User Services: ITS/CVO Qualitative Benefit/Cost Analysis*	June **1996**	The study, performed by the American Trucking Association's Foundation for FHWA, evaluates the potential benefits and costs of ITS/CVO technologies for motor carriers that are classified as small (I-10 units), medium (11-99 units), and large (> 99 units). The calculated benefits are restricted to reduced labor expenses associated with regulatory compliance based on survey results from 700 motor carriers. The costs are based on actual 1995 product prices obtained from 170 vendors.	The study estimates the following benefit-cost ratios for three sizes of carriers: • *Commercial vehicle administrative processes:* small (1 .0: l), medium (4.2:1), and large 19.8:1) • *Electronic clearance* for motor carriers that pay drivers based on hours worked: small (3.3:1 to 6.5: l), medium (3.7: 1 to 7.4: I), and large (1.9:l to 3.8: 1). • *Automated roadside safety inspections* for motor carriers that pay drivers based on hours worked: small (1.3:1), medium (1.4:1), and large (1.4:1). • *Onboard safety monitoring:* small (0.18: 1 to 0.49: I), medium (0.06: 1 to 0.16:1), and large (0.02:1 to 0.05:1). • *Hazardous materials incident response:* small (0.3:1), medium (1.1:1), and large (2.5:1). • *Freight mobility:* Mobile communications can yield benefit/cost ratios ranging from 1.5: 1 to 5.0: 1.

EXHIBIT II-4 (CONT.)
DOCUMENTATION OF ITS BENEFITS

Document	Date	Description	Findings
Assessment of ITS Benefits: Results from the Field	April 1996	This study, performed by Mitretek for the ITS JPO, is a precursor to Review ***of ITS Benefits: Emerging Successes*** and presents the findings of estimated and measured effects of ITS field operational tests and early deployments.	Highlights of the studies reviewed in this report are provided throughout Chapter III.
Intelligent Transportation Infrastructure Benefits Expected and Experienced	January 1996	This document, prepared by ITS America for FHWA presents benefits of seven of the nine components of metropolitan intelligent transportation infrastructure. For each of these components, the document presents the range of reported effects on travel time, travel speed, freeway capacity, accident rate, fuel consumption, and vehicular emissions. The benefits results are based on a review of approximately 50 studies of the actual and predicted effects of ITS operational tests and field deployments.	The study predicts the following benefits: • ***Traffic*** signal ***control systems:*** travel time (decrease 8-15%), travel speed (increase 14-22%), vehicle stops (decrease O-35%), delay (decrease 17-37%), fuel consumption (decrease 6-12%), emissions (decrease CO by 5-13% and decrease HC by 4-10%). • ***Freeway management systems:*** travel time (decrease 20-48%), travel speed (increase 16-62%). freeway capacity (increase 17-25%), accident rate (decrease 15-50%), fuel consumption (decrease fuel used in congestion by 41%), emissions (decreases in CO, HC, and NOx). . ***Transit management:*** travel time (decrease 15-18%), service reliability (increase 12-23% in on-time performance), security (decrease incident response tim to as little as one minute), cost effectiveness (45% annual return on investment). • ***incident management:*** incident clearance time (decrease 8 minutes for stalls and decrease wrecker response time by 5-7 minutes), travel time (decrease 10-42%), and fatalities (decrease 10% in urban areas). • ***Electronic fare payment*** : patron popularity (up to 90% usage where available), fare collection (increase 3-30%) . and data collection costs (decreased $1.5 to $5 million). • ***Electronic toll collection:*** operating expenses (decrease up to 90%), effective capacity (increase 250%), fuel consumption (decrease 6-12%), emissions (decrease CO by 72%, decrease HC by 83%, and decrease NOx by 45% per affected mile). • ***Multimodal traveler information:*** travel time (decrease 20% in incident conditions and decrease 8-20% for vehicles equipped with in-vehicle navigation systems), fuel consumption (decrease 6-12%), and emissions (decrease HC by 33% from affected vehicles and decrease NOx by 1.5% from affected vehicles).

EXHIBIT II-4 (CONT.)
DOCUMENTATION OF ITS BENEFITS

Document	Date	Description	Findings
Assessment of ITS Benefits: Early Results	January 1996	This study, performed by Mitretek, is a precursor to Review ***of** ITS **Benefits:** Emerging* Successes and presents the findings of approximately 50 benefit studies.	Highlights of the studies reviewed in this report are provided throughout Chapter III.
Intelligent Transportation Systems Action Guide	1996	This document, prepared by ITS America, summarizes nine success stories illustrating how ITS solutions eased congestion, increased efficiency, improved safety, improved air quality, assisted elderly and disabled travelers, enhanced emergency response, and improved productivity. The areas in the action guide include Abilene, TX: Houston; Kansas City, MO; Montgomery County, MD; Oakland County, MI; the Oklahoma Turnpike Authority; Phoenix; Winston-Salem, NC; and the trucking corridor from Florida to Ontario.	Highlights of the studies reviewed in this report are provided throughout Chapter III.
Traveling With Success: How Local Governments Use Intelligent Transportation Systems	1995	This document, prepared by Public Technology, Inc., for FHWA, presents the stories of 3 1 successful local government ITS initiatives. These studies illustrate how ITS technologies have helped ease problems in eight categories of local transportation concerns: traffic management, parking solutions, mass transit, incident management, traveler information, traffic safety, toll collection, and public safety. The document also provides anecdotal benefits of integrated systems in Atlanta, Houston, and Oakland County, MI.	Highlights of the studies reviewed in this report are provided throughout Chapter III.

EXHIBIT II-5
ITS USER SERVICES

ITS user services are defined, not along lines of common technologies, but by how they meet the safety, mobility, comfort, and other needs of transportation users and providers. They represent essential, but not exclusive, ITS products and services.

Travel and Transportation Management
- **En *Route* Driver Information***
- **Route Guidance**
- **Travel Service Information**
- **Traffic Control**
- **Incident Management**
- **Emissions Testing and Mitigation**
- **Highway-Rail Intersection *Systems***

Travel Demand Management
- **Demand Management and Operations**
- **Pre-trip Travel Information**
- **Ride Matching and Reservations**

Public Transportation Operations
- **Public Transportation Management**
- **En *Route* Transit Information**
- **Personalized Public Transit**
- **Public Travel Security**

Electronic Payment
- **Electronic Payment Services**

Commercial Vehicle Operations
- **Commercial Vehicle Electronic Clearance**
- **Automated Roadside Safety Inspections**
- **Onboard Safety Monitoring**
- **Commercial Vehicle Administrative Processes**
- **Hazardous Material Incident Response**
- **Freight Mobility**

Emergency Management
- **Emergency Notification and Personal Security**
- **Emergency Vehicle Management**

Advanced Vehicle Control and Safety Systems
- **Longitudinal Collision Avoidance**
- **Lateral Collision Avoidance**
- **Intersection Collision Avoidance**
- **Vision Enhancement for Crash Avoidance**
- **Safety Readiness**
- **Pre-crash Restraint Deployment**
- **Automated Highway Systems**

*** Italicized services represent the basic capabilities of the metropolitan intelligent transportation infrastructure**

services are compatible and interoperable. The program's most significant accomplishment may well be the breakthroughs it has made in showing the value and, in several cases, the technical feasibility of the precursors of smart vehicles-systems that help drivers avoid collisions, provide route guidance information, and monitor driver alertness. The U.S. DOT is now poised to launch a major series of operational tests and begin integrating these individual ITS elements into a human-centered in-vehicle configuration. The smart vehicle initiative will build on the research undertaken by the advanced collision avoidance and vehicle safety system program, administered by NHTSA. The advanced collision avoidance research deepens our understanding of the causes of vehicular collisions, identifies and evaluates how these collisions can be avoided, and collaborates with industry to develop effective collision avoidance products. The research program also investigates the effectiveness and benefits of prototype systems and the factors that influence performance and safety, particularly for inexperienced and older drivers. A key result of the program will be the establishment of performance specifications to guide the design and manufacture of crash avoidance products.

A closely related research effort concerns the evolution of advanced collision avoidance and vehicle control systems into AHS. ISTEA specifically required U.S. DOT to develop an automated highway and vehicle prototype from which future fully automated ITS can be developed. The legislation further required U.S. DOT to demonstrate the technical feasibility of an automated highway concept by FY 1997. In August 1997, U.S. DOT and its partners will demonstrate this concept on an express lane of Interstate 15 near San Diego, CA, using contemporary cars, buses, and light trucks.

Other research targets "enabling" technologies, which are required to allow ITS to function effectively. Many of the combinations of technologies created for ITS applications are unique and innovative, and the application of these technologies in the transportation environment is also new. For example, the Global Positioning System (GPS) is a technology that is fundamental to ITS products and services that use or provide information about location. Launched and operated by the Department of Defense, GPS can currently determine the position of any object on the earth within 100 meters (300 feet). To help the navigation of ships on our coastal and inland waterways, the U.S. Coast Guard has deployed an augmentation system for GPS that provides accuracy ranges of less than 10 meters by broadcasting a signal that corrects errors in the basic GPS signal. This augmentation does not, however, serve the whole continental United States. Similar in principle to ship navigation applications, a number of GPS applications can track trucks, cars, buses, ambulances, police cars, and other land vehicles. This type of tracking. particularly in life-saving

Innovative Public-Private Partnership Creates Opportunities and Saves Money

In 1993, the Missouri Highway and Transportation Department (MoDOT) and the St. Louis metropolitan planning organization (MPO) jointly conducted an ITS early deployment planning study to determine how ITS could improve traffic flow air quality, safety, and energy efficiency in the bistate St. Louis area.The study identified a fiber optic network as the leading choice to allow the components of this system-video cameras, ramp meters, and changeable message signs-to communicate with each other. At the time of the study MoDOT and a council of Missouri devefopers were discussing the benefits of a fiber optic backbone along State highways.

Meeting with several telephone and cable companies already seeking to "wire" the St. Louis region for additional communication capacity, the State quickly learned that it had a window of opportunity to barter its highway right-of-way across the State in exchange for communication access. Using standard procurement procedures, MoDOT selected Digital Tefeport, Inc., to instaff a fiber optic backbone along the State's 1,250 miles of highways. In exchange, Digital Tefeport receives exclusive use of the location for its own fiber optic system, which will be less costly to install and have more security than if a shared utility right-of-way were used.

The partnership benefits everyone involved.The State will save the initial construction costs, conservatively estimated at $45 million. Digital Teleport will wholly own, operate, and maintain the network for 40 years, making the company a major player in the communication industry throughout Missouri and nearby States. The 1,250-mile backbone will enable Missouri to approach ITS deployment on a regional and statewide basis. During the 40-year contract with Ditigal Teleport the State is also expected to save an additional $100 million in operation and maintenance expenses.

Currently, installation is almost complete in the St. Louis area, as is the link to Kansas City across Interstate 70. The connection from Kansas City to the Springfield-Branson-Joplin area and back to St. Louis via Interstate 44 will be completed early next year. During the summer of 1997, the State anticipates accepting contracts to begin locating the envisioned ITS technology in St. Louis, including video cameras, ramp meters, and changeable message signs.

situations, requires much greater accuracy than is currently available. Departmental analysis has shown the value, cost, and technical feasibility of expanding the capability of the Coast Guard's augmentation system to benefit the traveling public in the greater continental United States.

Developed a National Architecture

In June 1996, the United States became the first country to develop a national ITS architecture, which was the result of an unprecedented effort to provide a flexible and expandable framework for the development and deployment of ITS. Instead of a single design, the architecture provides an inclusive setting within which different designs can be implemented, yet can operate compatibly. The architecture identifies how existing infrastructure can accommodate ITS additions and technological evolution. It also provides a framework for the development of national standards to ensure interoperability of conforming products from competing vendors. Exhibit II-5 lists the 30 ITS user services supported so far by the architecture.

Launched Development of Standards for Hardware and Software Compatibility

Standards allow communication, surveillance, monitoring, and computer processing systems to "speak" to each other; provide design guidance to manufacturers; and reassure purchasers that their systems will be compatible with other ITS elements. The national ITS architecture identified 45 critical interfaces needing to be standardized to ensure national compatibility and interoperability of ITS user services. In 1996, the U.S. DOT signed cooperative agreements with five standards development organizations (SDOs) to accelerate the development and acceptance of standards in five critical areas: in-vehicle and traveler information systems, traffic management and transportation planning systems, electronics and communication message sets and protocols, roadside infrastructure, and unique short-range communication strategies. Other standards have also been identified and are being pursued by national and international standards organizations. Two of the program's early achievements were adoption of the National Transportation Communications ITS Protocol (NTCIP), which facilitates data communications between traffic management centers and roadside equipment, and the "Smart Bus Bus" suite of standards, which allows integration of electronic functions on transit buses.

Identified Solutions to Remove Nontechnical Barriers to Implementing and Mainstreaming ITS

At the start of the program, many participants perceived that nontechnical barriers, rather than technical ones, would hinder widespread deployment of first-generation ITS products and services. To address this concern, the U.S. DOT initiated a major investigation into the institutional and legal issues associated with intergovernmental cooperation, public-private partnership, intellectual property rights, procurement, privacy, user acceptance, staffing and education, socioeconomic issues, and environmental issues. The results are documented in the 1994 report to congress, *Nontechnical Constraints and Barriers to Implementation of Intelligent Vehicle-Highway Systems,* and the required 1996 update, found in Appendix E of this report.

U.S. DOT has also conducted specific studies that address nontechnical impediments to ITS deployment in metropolitan areas and CVO. The studies include a review of seven metropolitan areas to assess the extent of ITS planning and deployment that was not directly funded by the national ITS Program. The results were published in the 1996 report entitled *Assessment of ITS Deployment: Review of Metropolitan Areas/ Discussions* of *Crosscutting* Issues. The results were based on interviews with a broad cross section of State, regional, and local transportation officials to assess the degree to which ITS are being planned and deployed, the interaction among agencies responsible for ITS, and their motivations for deployment. Another study of institutional issues is examining the processes used by transportation managers in 13 metropolitan areas to decide whether or not to purchase and deploy ITS products and services. Also, in 1995, FHWA completed 50 in-depth interviews with truck and motorcoach operators to ascertain their potential acceptance of ITS/CVO services. The results are published in User *Acceptance of Commercial Vehicle Operations (CVO) Services.*

We also continue to gain significant knowledge about institutional issues related to ITS from two other programs. First, the Early Deployment Planning Program helps local and regional agencies that are responsible for transportation to systematically plan ITS deployment, enabling them to resolve critical issues during the planning process instead of during implementation. We have also gained experience from the ITS Priority Corridors Program, which is building innovative institutional frameworks that allow multiple jurisdictions to deploy ITS services cooperatively.

Created New Models of Public-Private Partnerships

Because successful development and deployment of ITS technologies and services will rely on the efforts of both the public and private sectors, the U.S. DOT has made efforts to involve the private sector in all facets of the program, from research to testing to deployment initiatives.

NHTSA's crash avoidance program is a good illustration of how U.S. DOT is working to reassure and guide the development efforts of private industry and, in the process, creating new models of partnerships. To date, NHTSA has entered nine cooperative agreements with industry and academia to develop and test crash avoidance systems, including intelligent cruise control, lane-occupancy detection, and commercial vehicle applications.

In addition, the goals and activities of the AHS program are being realized through a cost-shared cooperative agreement with the National AHS Consortium (NAHSC). The NAHSC consists of almost 100 public and private stakeholders-automobile manufacturers, suppliers, universities, and State governments-who will specify, develop, and demonstrate a prototype AHS through consensus, aiming to ensure that the AHS is economically, technically, and socially viable.

Developed Plans to Meet Educational and Human Resource Needs

The transition to electronic management of surface transportation represents the same type of transition the FAA underwent as it moved from using a civil engineering staff to oversee construction of airports to better *management* of the air system, which required a very different set of technical skills. ITS concepts use information, communication, and navigation technologies that are unfamiliar to surface transportation professionals. ITS applications also emphasize system management, operations, and performance measurement, instead of construction and maintenance, and often require unprecedented cooperation within and between the public and private sectors. The U.S. DOT's national strategic plan and 5-year program for building professional capacity address the need to retool the skills of the Nation's professionals in the transit, highway, and CVO fields.

The program is currently developing training modules on all aspects of ITS deployment. The U.S. DOT has also provided for a continual exchange of information, creating awareness among members of the transportation community, public, media, and elected government about the potential of ITS to transform surface transportation and deliver significant public benefits.

Set National Goals for Widespread ITS Deployment

The U.S. DOT has established a national goal to have a comprehensive ITS infrastructure in place by 2005. Three specific "systems" of infrastructure have been specifically defined to date: the metropolitan intelligent transportation infrastructure, CVISN, and the infrastructure associated with rural applications. This goal has helped to create a positive environment within Federal, State, and local governments and has inspired confidence among private sector developers. The U.S. DOT is specifically monitoring progress on achieving this goal in 75 metropolitan areas and making plans to monitor deployment of CVISN.

Launched Model Deployments to Demonstrate the Benefits of ITS Infrastructure

In 1996, the U.S. DOT created the model deployment initiative (MDI) to showcase the benefits and cost effectiveness of ITS services integrated along the lines defined by the national ITS architecture. By 1998, four sites-the New York City tristate area, Phoenix, Seattle, and San Antonio-will showcase the benefits of the metropolitan ITS infrastructure. In the same time frame, eight States will demonstrate CVISN: California, Colorado, Connecticut, Kentucky, Michigan, Minnesota, and. in a joint project, Oregon and Washington.

What Have We Learned?

In the past 5 years, we have resolved deployment-related technical challenges, introduced methods to remove institutional impediments, and identified potential ITS benefits and user needs. The following paragraphs outline the level of knowledge we have achieved thus far in the program.

First-Generation Technologies are Ready for Deployment

ITS products and services are not technologies of the future. They are already being applied to solve problems for State and local transportation managers, enforcement officials, and other transportation service providers: improve the efficiency of commercial shippers and carriers; and provide travelers with better information to improve the quality and safety of their trips. Many ITS products and services are ready for, or are already on, the market. These products and services are or will shortly be available to travelers as either proprietary products for sale or subscription or as free public services.

Many inroads in the market have been made by traffic management and public transit management applications. For example, over the last 4 years, advanced vehicle location (AVL) use in U.S. transit systems for fleet management has increased more than 200 percent. Transit operators have also adopted innovative electronic data interchange technologies in their fare payment systems.

In addition, rudimentary ITS technologies developed for commercial shippers have been deployed and improved over the past several years. Both large national carriers and smaller local delivery fleets have garnered benefits from ITS products, including advanced vehicle location, identification, and communication technologies that track the location and condition of shipments, improve customer service, increase fleet productivity, and lower operating costs.

In the individual consumer market, a recent survey of trade magazines, automobile dealerships, and electronics stores indicates that 5 manufacturers now make approximately 10 different brands of in-vehicle navigation products available for sale in the United States. Both Hertz and Avis also offer an in-vehicle navigation product with mid-level and luxury rental cars. Similar navigational products designed for use on a portable computer can currently be purchased at computer-electronics stores. Updated, route-specific traffic information can be obtained by cellular telephone subscribers in most major metropolitan areas, and there are at least 14 World Wide Web pages dedicated to live traffic information.

By comparison, just 3 years ago, no domestic products were commercially available that provided any combination of location, navigation, or route guidance capabilities. The TravTek field test in Orlando, FL, had just ended. Zexel Corporation (a TravTek partner) was initiating a beta test of the in-vehicle navigation and route guidance product that would later be released under the brand name Guidestar. Siemens and Motorola were working with field tests in Michigan and Illinois, respectively, to explore the functionality of in-vehicle product prototypes. Access to traffic information was largely limited to 30-second broadcasts on commercial radio.

In addition to the increasing number and diversity of traffic information and route guidance products available, the first generation of in-vehicle personal safety and security services is showing great promise in the new car market. These products use the cellular telephone and GPS to reassure drivers that emergency medical services, police, or roadside automotive assistance will be dispatched immediately at the push of a button or with the deployment of an air bag. Variations of these security services include theft tracking/recovery and navigation assistance. Two products released this year, the RESCU system by Ford Motor Company and On Star by General Motors, are available on Lincoln and Cadillac cars for a base cost plus monthly service fee. Both manufacturers report that the products are selling at nearly twice the expected rate.

To effectively serve many diverse users, private ITS service providers depend on a public infrastructure that supports their communication and information needs. Although ITS products and services can be individually applied to ameliorate problems, such as congestion, safety, and productivity, more complete integration of ITS services by the public sector is required to support private sector product and service development. Uniting multiple sources of information will enhance and expand the availability of real-time information that the public will value and use in daily travel decision making.

ITS Offers Beneficial and Cost-Effective Solutions

ENHANCED USE OF EXISTING CAPACITY

Better management of transportation systems is central to achieving the efficiency envisioned by ISTEA; however, managing any part of the system-transit, highways, or streets-more efficiently is nearly impossible unless system managers have access to information, such as the locations of traffic incidents. This information does little good if there is no means to respond and make adjustments to the system or communicate with travelers. ITS field tests and deployments have shown that strategic application of information and control systems can significantly improve efficiency for system managers. The U.S. DOT estimates that deploying the intelligent transportation infrastructure in 50 of our largest metropolitan areas will reduce the need for new roads while saving taxpayers 35 percent of required investment in urban highways.[1] A preliminary study by ITS America and U.S. DOT estimates that ITS infrastructure in 75 of the largest metropolitan areas could have a benefit-cost ratio of 8.8 to 1.[2]

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1 Mitretek Systems, "An Estimate of Transportation Cost Savings by Using Intelligent Transportation System (ITS) Infrastructure," white paper prepared for FHWA, unpublished, February 1997. This life-cycle analysis covered 50 major urban areas and was performed according to the following OMB directives: total life-cycle analysis, discounted cash flows, discount at 7-percent rate. The needed road capacity without ITS was estimated from historical data from the Institute of Traffic Engineers and from FHWA High Performance Management System (HPMS) model output. The capacity that could be provided by ITS was obtained from a 1996 FHWA report that summarized recent intelligent transportation infrastructure benefit estimates. Road costs are current FHWA estimates, while ITS costs are estimates made in 1995 by FHWA for the intelligent transportation infrastructure in major metropolitan areas. Over the next 10 years, the discounted life-cycle cost for the build-only alternative is estimated to be nearly $87 billion. The discounted life-cycle costs for the ITS-plus-build alternative would be about $57 billion, giving an estimated savings of 35 percent. The lane-miles needed for the build-only alternative would be approximately 44,000. while only 15,000 would be needed for the ITS-plus-build alternative.

2 Apogee Research, ***NationalInvestment and Marker Analysis*** for ITS, prepared for ITS America and U.S. DOT, unpublished, 1997. This study estimates costs and benefits from deploying nine basic ITS infrastructure elements across the country by 2005. Data from the National ITS Architecture Study supported the cost estimates for both nonrecurring and recurring expenditures. Benefit estimates were based on empirical observations from field and operational tests across the country. Over 80 percent of the benefits are attributable to improved safety and reduced congestion. Overall, in present-value terms, the study projects total costs of $44 billion over the next 20 years with corresponding benefits of approximately $252 billion, resulting in a benefit-cost ratio of 5.7: 1 for all urban areas nationwide. For the top 75 metro areas, however, where congestion and safety-related problems are significantly greater, costs and benefits are projected to be $24 billion and $212 billion, respectively, resultmg in the 8.8: 1 benefit-cost ratio.

IMPROVED SAFETY

Today, ITS technologies are making it easier for emergency response teams to locate incidents and reach victims quickly, dramatically improving the chances of survival. Freeway management systems, such as ramp meters that help smooth traffic flow, have reduced accidents by 15 to 20 percent. New information technology for commercial vehicles is allowing more efficient and accurate safety inspections, increasing access to safety information for inspectors, and automating hazardous materials incident response systems. NHTSA estimates that 1.1 million crashes-17 percent of the total 6.4 million nationwide-could be prevented each year if all vehicles were equipped with three ITS crash avoidance countermeasures currently under development: rear-end crash warning systems, roadway departure warning systems, and lane change/merge crash avoidance systems. This reduction in collisions corresponds to an annual savings of $26 billion in crash-related economic costs.

PUBLIC SECTOR COST SAVINGS

In an environment of limited budgets and cuts in public sector subsidies, the components of ITS infrastructure can dramatically reduce the costs of transit management, toll collecting, and truck safety inspections. Nationally, ITS technologies are expected to save transit operations $4 to $7 billion in operating costs over the next decade. ITS has also improved transit productivity 20 to 25 percent in the State of Maryland and in San Diego County, resulting in hundreds of thousands of dollars in annual savings to transit operators. Several toll collection agencies have also reduced their operating costs while improving service. For example, the Tappan Zee Bridge Authority in New York State has found that each of its five electronic toll lanes can accommodate 1,000 vehicles per hour at peak times, compared with 350 to 400 in lanes served by conventional toll plazas. Commercial vehicle administrative programs have reduced compliance-related labor costs (for licenses, permits, registrations, and fuel-tax payments) by 9 to 18 percent through the use of advanced information technologies.

Market Acceptance of ITS is Growing

There are several distinct markets for ITS technologies: the general public is interested in comfortable, safe, and reliable transportation; public sector transportation managers want to provide safe, reliable, and economically sound services; and commercial shippers and common carriers seek strategies to minimize costs without undermining service. All three major market segments have shown increasing interest in and adoption of ITS technologies.

ITS acceptance has been highest among those groups with the most to gain economically. Large commercial shipping companies, including Schneider Trucking and H.J. Hunt. were early adopters of ITS technologies, such as vehicle-tracking and fleet management systems, because of the increased operating efficiencies and competitive advantage offered by the products. Other companies followed suit. Because the economic and efficiency advantages of ITS technologies were not so readily apparent to general travelers or public sector transportation managers, these two sectors have been slower to adopt ITS technologies. Nevertheless, certain segments of these markets are acquiring ITS technologies and demonstrating advantages that are influencing others to invest as well.

Market acceptance of ITS technologies by private individuals can be seen in the growing number of ITS products and services available for sale or in pre-commercial prototypes. ITS products and services for the general traveler include route guidance information services available by kiosk, telephone, pager, cable television, World Wide Web, computer software, in-vehicle computers. dedicated radio receivers, and wireless broadcast to personal digital assistants and laptop computers. Compelling evidence for the general traveler's acceptance of ITS products and services can also be found in a forecast from the University of Michigan's Office for the Study of Automotive Transportation: By the year 2005, 10 percent of all new cars sold in the United States, or 640,000 vehicles, will be equipped with an in-vehicle traveler information system. U.S. DOT studies of market acceptance indicate that private individuals are interested in and ready to use traveler information services to increase the predictability of travel times, improve personal safety, reduce the amount of time spent in traffic congestion, and improve the overall ability to schedule their time.

In the public sector, market acceptance is led by those agencies that quickly recognized the value of ITS to solve compelling transportation problems. Officials for the Dallas North Tollway quickly recognized the value of electronic toll-collection systems for easing the bottlenecks that formed at the facility's toll booths each day. In addition, building from an existing multistate traffic organization of State police and transportation managers, the greater New York City metropolitan area was an early adopter of a unified, multistate standard for electronic toll collection. When funds allow, transit authorities are investing in products and services that improve operating efficiencies, increase driver and passenger safety, and provide route and schedule information to the traveling public. Transit agencies are also exploring how ITS technologies can help enhance customer service. U.S. DOT studies show that greater awareness of ITS benefits, combined with ongoing technical assistance from U.S. DOT field offices, will encourage more metropolitan and rural areas to invest in ITS services.

Institutional Issues Pose the Greatest Challenges to ITS Deployment

A host of nontechnical issues challenges any large-scale endeavor requiring the cooperation of multiple jurisdictions and organizations, especially during the early stages of implementation. For ITS deployment, institutional concerns and issues will affect how information and communication systems, system expansions, and upgrades will be purchased and deployed. One of the targets of current U.S. DOT institutional research is to determine whether transportation managers purchase ITS components that are "smart replacements" and the degree to which they purchase ITS services that can work together.

Although institutional concerns do not present an insurmountable barrier to the deployment of ITS, they will influence whether purchases of ITS technology become the foundation for an integrated transportation system of the future or whether deployment devolves into randomly implemented technologies serving narrow modal or agency needs. The evolution of most ITS, therefore, will be heavily influenced by the incremental decisions made by transportation professionals as part of their daily routines.

Today, most county, city, and State budgets include expenditures for traffic signals. Most transit properties periodically upgrade their bus communication systems. Many States are investing in freeway control and incident response systems. However, most of the decision making is "stovepiped." Departments within a public jurisdiction and jurisdictions within a region often do not see the value of, or have the resources for, integrating their systems. We see this as one of our greatest institutional challenges-hanging transportation system planning and implementation processes. Federal and State procurement processes also need to be revamped to accommodate the design/build/operate requirements of system integration projects and to shift the current "build" mentality in transportation toward better operation and management. This shift can only be accomplished by fostering procedures that fully fund these large-scale system development projects from beginning to end. The model deployments, technical assistance, development of standards, and programs to build professional capacity provided by the national ITS Program will advance new paradigms and skills required to successfully deploy ITS infrastructure.

Program Expenditures

ISTEA authorized a net total of $645 million for the program's funding from FY 1992 to 1997. At the end of FY 1996, $53 1.8 million of these ISTEA funds had been authorized for expenditure. This amount was supplemented by $459.3 million in funds from the General Operating Expense budget (including $20 million in FY 199 l), for total funding of $99 1.1 million through FY 1996. All but approximately $12 million of the $991.1 million was obligated. Exhibit II-6 breaks down overall ITS funding obligations. Roughly 40 percent of total program funding has been directed by Congress.

U.S. DOT has worked diligently to build partnerships with State and local governments, academia, and the private sector to move state-of-the-art ITS concepts toward the state of the practice. The scope, mission, results, and future directions of each of the major funding categories shown in Exhibit II-6 are outlined below.

Field Operational Test and ITS Priority Corridor Expenditures

About 57 percent of obligated funds has supported field testing and demonstration projects as part of operational tests or the ITS Priority Corridors Program; 73 percent of this amount was congressionally directed. These efforts provide a crucial bridge between the laboratory and wide-scale deployment. The field tests have also forged new public-private partnerships and institutional arrangements. The tests have taught us much about the technical viability of ITS applications and how to resolve procurement and institutional problems.

I. Field Operational Tests

Scope: Operational tests are cooperative efforts between the U.S. DOT and a variety of public and private partners, including State and local governments, private companies, and universities, to field-test the viability of numerous and diverse ITS technologies and applications. As shown in Exhibit 11-7, the U.S. DOT has launched 83 operational tests across the country in six areas: traffic management (17 tests), traveler information (15 tests), public transportation (29 tests), rural applications (6 tests), ITS/CVO (12 tests), and advanced collision avoidance systems (4 tests). Of the 83 field tests, 28 have been completed.

The technologies being tested as part of the ITS field operational tests are very broad. For evaluation purposes, U.S. DOT has grouped technologies and ITS services into 16 areas: (1) traffic control/incident management, (2) traffic surveillance, (3) en route traveler information systems, (4) pre-trip planning, (5) electronic fare payment, (6) AVL and smart bus/paratransit/fleet scheduling systems, (7) ARTS, (8) emergency notification systems, (9) motorist safety, (10) commercial vehicle electronic screening, (11) commercial vehicle one-stop shopping, (12) out-of-service verification, (13) international border crossings, (14) hazardous materials response, (15) wireless communications, and (16) emissions testing.

Appendix C contains a table that describes the purpose, location, and cost of each operational test, as well as matrices showing the crosscutting analyses performed for each of the 16 technology categories.

Mission: Operational tests examine the technical viability of ITS services in real-world field environments. Beyond resolving technical issues, the program evaluates the public impact and benefits of ITS applications and identifies methods for removing institutional barriers to ITS deployment.

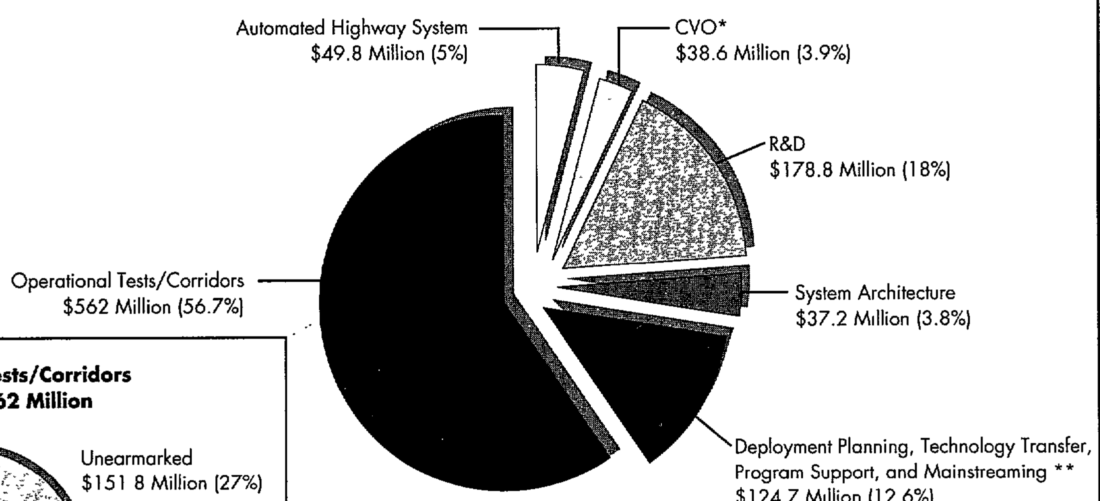
Program Results: The operational tests have provided rich opportunities to determine how individual and limited combinations of advanced transportation technologies can solve transportation problems. The tests have also resulted in myriad case studies to identify effective institutional arrangements, investigate private sector interests, and determine the implications of various legal issues. The findings from operational tests have been documented in several reports, most notably, *Analysis of ITS Operational Tests: Findings and Recommendations,* published in September 1995, and more recently, *Field Operational Tests: Lessons*

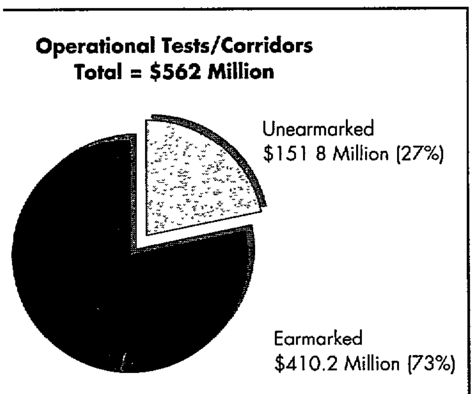
Learned, published in May 1996. The first report was prepared by the Volpe National Transportation Systems Center and presented findings and recommendations based on a review of 12 field operational tests. The second report was prepared by Booz-Allen & Hamilton, under a contract with FHWA to evaluate its operational tests. This report concluded that operational tests have created a climate of enthusiasm and expectation, capturing the interest of major technology firms and transportation operators across the United States. Some of the operational tests, such as TravTek in Orlando and SmarTraveler in Boston, have seen their products move from testbeds to become self-sustaining in the marketplace.

Future Directions: The operational test program will increasingly be oriented toward closing the gap between the laboratory and deployment. New tests will focus on establishing the viability of emerging and next-generation ITS services and enabling technologies. For example, the first field test of a new real-time traffic-adaptive control system, RT-TRACS, in

EXHIBIT II-6
WHAT HAS BEEN FUNDED?

FY 1991-1996
Total ITS Funding - $991.1 Million



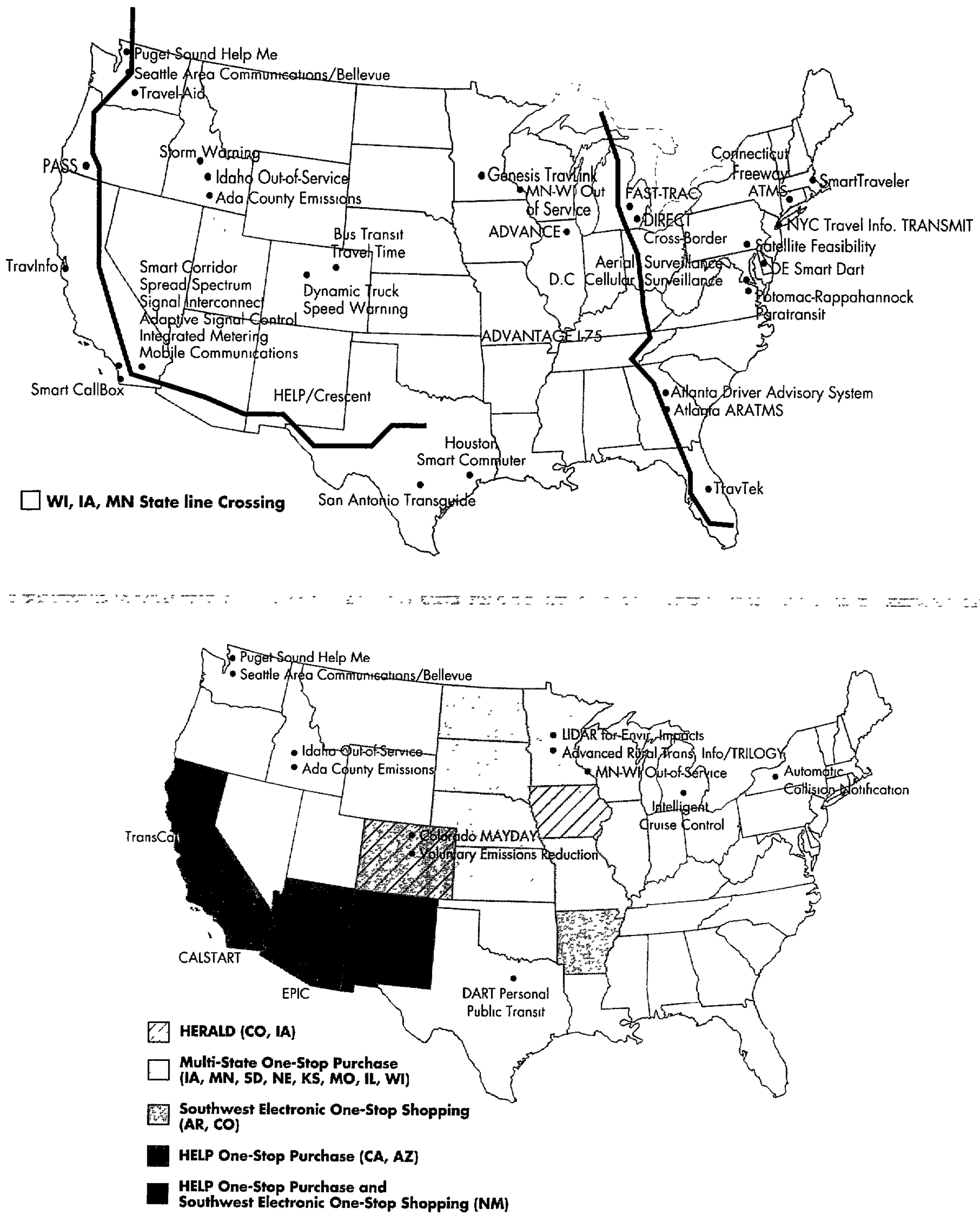


* CVO funds are also included in R&D, Operational Tests, and Deployment Planning

** $26.2 million for Deployment Planning, $22.3 million for Technology Transfer, $60.9 million for Program Support, and $15.3 million for Mainstreaming

Note: Of the $991.1 million made available to the FHWA for the ITS Program, $410.2 million (41.4%) has been earmarked by Congress, leaving $580.9 million (58.6%) to be expended at the discretion of the U.S. DOT. Also note that in addition to funding provided for FHWA, NHTSA, and FTA received $31.5 million and $13.2 million, respectively

EXHIBIT II-7
ITS FIELD OPERATIONAL TESTS



development at FHWA's Turner-Fairbank Highway Research Center, will begin in FY 1997. In 1996, NHTSA initiated operational tests of an automatic collision notification system (which automatically summons emergency help immediately on vehicular collision) and an intelligent cruise control system (which automatically adjusts cruise speed to maintain headway with a preceding vehicle). These will be followed by field tests of rear-end collision avoidance systems, lane-change collision avoidance systems, and systems that integrate collision avoidance with other ITS functions. Also in FY 1997, U.S. DOT expects to conduct two to three field operational tests to evaluate ITS applications in rural communities, including automated personal security systems (such as "Mayday" devices), warnings at rail-highway grade crossings, and demand-responsive paratransit.

Additional operational tests will focus on refining ITS/CVO systems, such as automated compliance review, emissions verifications, border-crossing technologies, and onboard safety diagnostics. Operational tests will also focus on improving the capabilities of APTS, creating universal, "contactless" fare payment cards that can pay for multiple services such as fares, parking, and tolls and automated vehicle diagnostic systems that can automatically dispatch information about mechanical problems to transit facilities.

2. ITS PRIORITY CORRIDORS

Scope: ISTEA created the ITS Priority Corridors Program to demonstrate ITS deployment in important travel corridors. In March 1993, U.S. DOT designated the four locations in the United States that met the ISTEA Section 6056(b) criteria as ITS priority corridors: the Northeast Corridor along Interstate 95, stretching through six States from Maryland to Connecticut; the Gary-Chicago-Milwaukee (GCM) Corridor centered around the Chicago metropolitan area and stretching from Gary, IN, to Milwaukee, WI; the Houston, TX metropolitan area; and the Southern California Corridor centered around Interstate 5 and Interstate 10 from Los Angeles to San Diego. These corridors have received approximately $70 million from all sources (Federal, State/local, and private) through 1996, of which approximately $22 million has been spent. Each corridor has launched some form of an early-start program to put new ITS projects "in the pipeline" to deployment. The Department is finalizing a report, *Policy Review of the ITS Priority Corridors,* that provides a specific inventory and discussion of priority corridor projects and overall program findings. The executive summary of the preliminary report is in Appendix D.

Mission: The purpose of the ITS Priority Corridors Program is to establish an ITS infrastructure and enduring institutional arrangements in the Nation's most congested areas that will support evolving deployment of ITS services. ISTEA identified six criteria for priority corridors:

- High traffic density above the national average.
- Severe or extreme nonattainment status for ozone under the Clean Air Act.
- A variety of types of transportation facilities, such as highways, bridges, tunnels, and toll and nontoll facilities.
- Inability to significantly expand capacity of existing surface transportation facilities.
- A significant mix of passenger, transit, and commercial motor carrier traffic.
- Complexity of traffic patterns.

Each of the four corridor regions has a unique geography and institutional setting. For example, the Houston Priority Corridor covers the Houston metropolitan area and has four major stakeholder-participants: the Texas DOT, the metropolitan transit authority, the city of Houston, and one county. The corridor emphasizes ITS services for traffic management, traveler information, and transit.

The Southern California Priority Corridor covers a much larger region within the State, including the urbanized areas of Los Angeles, San Bernardino, Riverside, San Diego, and Ventura Counties, as well as all of Orange County. The major participants include representatives from the California DOT and highway patrol, three associations of government, three cities, a city DOT, a transit authority, and an air quality management district. The major focus of this corridor is on traffic management, traveler information, and emergency response services.

The GCM Priority Corridor comprises portions of Northwest Indiana, Northeast Illinois, and Southeast Wisconsin and includes the Gary, Chicago, and Milwaukee metropolitan areas. The institutional partnership includes three State DOTs, three MPOs, a transit authority, a highway toll authority, and a commuter transportation district. It also has approximately 14 ex officio members representing cities and city DOTs, transit agencies, academia. and the private sector. The corridor members have emphasized commuter travel needs in the corridor region, including traffic management, traveler information, and scheduling bus-to-bus and bus-to-rail transfers.

The I-95 Priority Corridor extends from Connecticut to Maryland, although the I-95 Coalition includes the 12 States from Maine to Virginia and the District of Columbia. The executive board includes administrators from 42 agencies, and the steering committee includes technical and policy staff members of the same agencies. Efforts in this corridor are focused on communications and coordination, CVO, interregional travel and incident management, and traveler information.

Program Results: The ITS Priority Corridors Program was the only deployment program established by ISTEA and has served as a bridge to mainstreaming ITS technologies and services in traditional transportation arenas. Although the program originally set out to showcase technology and hardware, it has been more valuable in illustrating the challenges in creating interjurisdictional and interagency cooperative arrangements. In particular, the program has demonstrated the value of regional institution building, coordination, and integration. In some ways, the program's emphasis on corridors has allowed it to blaze new trails, because traditional transportation planning is often contained within a single MPO and a single State. The program has created communication channels and organizational frameworks among numerous agencies that will facilitate the U.S. DOT's long-term deployment goals, particularly the building of ITS infrastructure. The program has also helped to create inter-modal approaches to fulfill regional transportation needs.

Future Directions: Until recently, the ITS priority corridor participants focused on building institutional arrangements to facilitate ITS deployment, identifying the needs of the corridors, and designing systems to fulfill those needs. In 1997, au increased number of products and services will be installed in these corridors. For example, the Houston Corridor will expand its automatic vehicle identification (AVI) system and install a changeable lane-assignment system, real-time information kiosks, and a weather-monitoring and information system. The Southern California Corridor will launch a regional, multimodal traveler information system, a transit management and information system, and an advanced traffic management and information system for a sports complex. In the GCM Corridor, near-term projects include expansion of the corridor's traffic information center, integration of transit systems, and coordination of the three individual State incident management programs. The I-95 Corridor will establish an information exchange network and begin field tests of a freeway surveillance system, advanced ITS applications for CVO, traveler information systems, and electronic toll collection systems.

R&D EXPENDITURES

Since 1991, about 18 percent of ITS program funding has supported R&D efforts to advance the state of the art of ITS technology and ensure that the technology is effective, safe, and user-friendly. The program also provides the opportunity for individuals and small businesses to obtain seed funding for ITS research ideas through small-business research initiatives and the Innovations Deserving Exploratory Analysis Program administered by the Transportation Research Board. Five major R&D programs are summarized in the following paragraphs. (The research programs for architecture and standards, ITS/CVO and AHS are discussed later in this chapter.) Each of these programs is discussed in further detail in Chapter III of this report.

1. ADVANCED TRAFFIC MANAGEMENT SYSTEMS

Scope: The ATMS R&D program, administered by FHWA's Turner-Fairbank Highway Research Center, comprises six functional areas. The **surveillance and detection** program identifies the detection and surveillance needs of ITS, promotes the development of new sensors that have potential ATMS applications, field-tests the capabilities of new sensors, ensures that new sensors conform to ATMS compatibility standards, promotes the development of new algorithms for detection and surveillance, and investigates the integration of advanced surveillance and detection with ATMS real-time control strategies. The **real-time traffic management and control** program tests, evaluates, and refines advanced traffic management and control strategies. This broad program area identifies and develops control algorithms for demand-responsive control of surface streets and freeway ramp signals under normally varying traffic conditions and incident-related conditions. The **system integration** area investigates and analyzes how the functional elements required by ATMS applications (such as traffic management centers and detection and surveillance and control systems) can be integrated. Integrating various tools in the FHWA Traffic Research Laboratory (TReL) provides a controlled environment to allow researchers to test the effectiveness of ATMS elements before field trials. In particular, the TReL research allows investigators to examine how various functions, strategies, concepts, and configurations can be integrated and helps identify necessary standards and protocols. Over time, U.S. DOT's efforts will evaluate how new options can be integrated into existing transportation infrastructure.

The **advanced analysis methods** program develops and refines evaluation models and analysis tools to design and evaluate ITS strategies in corridors, freeways, and street networks. These strategies include real-time adaptive control systems, pre-trip planning, en route travel information, and en route guidance and diversion. The functional area of standards focuses on the development of communication standards, especially the National Transportation Communications for ITS Protocol (NTCIP), which is a standard to promote interoperability, interchangeability, and compatibility of ATMS components. By enabling components to communicate with each other, NTCIP facilitates system integration and allows easier and more cost-effective system upgrades and expansion. **Support and enabling studies** evaluate and assess the potential benefits and cost effectiveness of ATMS, including their impact on human performance and safety. These studies also specifically develop safety performance specifications for ATMS products, services, and traffic management centers.

Mission: The overall goals of the ATMS R&D program are to improve mobility, accessibility, and efficiency of freeways and surface streets. The specific program objectives are to advance the state of the art of ATMS technologies, particularly traffic signal control, freeway management, and incident management systems. The program also aims to ensure that ATMS services can function as part of a greater ITS infrastructure.

Program Results: The surveillance and detection program has completed a comprehensive review of traffic sensors and identified seven promising prototype sensors for field testing. The program has also developed functional and performance specifications for traffic detectors for ITS and ATMS and has evaluated current state-of-the-art detectors. The real-time traffic management and control program has developed RT-TRACS, which could improve traffic flow on arterial streets by up to 20 percent compared with traditional pre-timed traffic signal systems. The standards area has significantly advanced the development of the NTCIP, which enables traffic control devices to share data and messages with multiple sources. The advanced analysis methods program has developed the TReL to test and evaluate emerging ATMS strategies without costly field trials. In addition, the program has developed sophisticated traffic software that will allow better evaluation and comparison of ITS applications with traditional traffic designs and operations.

Future Directions: In the near term, the ATMS R&D program will focus on system integration within ATMS and the integration of ATMS with other ITS services as part of the intelligent transportation infrastructure. The focus will include the development of new traffic control algorithms that will allow signal timing plans to give preference to mass transit vehicles (to maximize the throughput of all travelers) and better manage traffic congestion while minimizing impact on air quality. The program will also field-test new traffic control strategies currently being developed, such as RT-TRACS.

2. Human Factors

Scope: Design, development, and adoption of new in-vehicle technologies are only acceptable and provide benefits when they are focused on the needs and limitations of the human operator. The human factors research program, administered jointly by NHTSA and FHWA Turner-Fairbank, addresses the user's ability to safely benefit from and cope with the information delivered by new technologies. The human factors program specifically addresses collision avoidance systems, ATIS/CVO, ATMS, and AHS. Collision avoidance research is focused on how best to convey critical safety information to the driver and how to avoid driver information overload when too much information is conveyed during challenging driving tasks. ATIS and ITS/CVO services addressed include in-vehicle route guidance and navigation, motorist services, and safety advisories and warning systems. The ATIS and ITS/CVO human factors research examines such issues as the information requirements of commercial and private vehicle drivers, display formats, accuracy of traffic information, and the transition between ATIS messages. The ATMS research focuses on the human factors requirements of operators in traffic management centers as they perform a variety of traffic management tasks, including traffic monitoring and incident detection. AHS human factors efforts focus on driver capabilities, particularly during the transition between "hands-on" and "hands-off' operation. The program also investigates the effects of age, spatial ability, and navigational information provided by in-vehicle devices on navigational performance, as well as design impediments to their acceptance and efficacy.

Mission: The effectiveness of ITS depends on user-oriented designs. The objectives of the human factors program are to improve the operational efficacy and safety of ITS products, services, and applications. With in-vehicle warnings and information services, drivers will have access to much more information than in the past. If this information is not presented in a user-centered format, information overload will diminish both efficiency and safety. In particular commercial drivers have extra requirements (e.g., cargo monitoring, scheduling of multiple stops, roadway restrictions, and adherence to commercial regulations) that could potentially divert drivers' attention from the primary task of driving safely. An objective of the ATMS research is to ensure that traffic management center operators can effectively manage traffic using real-time information and demand-responsive control strategies housed in state-of-the-art traffic management centers.

Program Results: Several major products are emerging from the human factors program, including design guidelines and handbooks for information system and traffic management center designers, a traffic management center research simulator, data bases that catalog knowledge obtained from human factors research, and analysis tools to allow researchers to evaluate effects on human performance. One such tool is the data acquisition system for collision avoidance research (DASCAR), which allows unobtrusive measurements of driving behavior and performance. The program has already completed an assessment of the effect of in-vehicle display systems on driver performance, helping to guide the design of initial in-vehicle display prototypes. The program is currently developing human factors design tools that will assist in the design of advanced traffic management centers.

Future Directions: The human factors research program will pursue more aggressive R&D efforts to fully realize the safety potential of ITS technologies that are almost on the market. Particular safety-related problems of inexperienced drivers and the aging population will be addressed by focusing on the ability of these groups to cope with and benefit from information delivery systems and technologies that will be found in the smart vehicles of the future. The program will continue to focus on the needs of commercial drivers and traffic management center operators to ensure optimal workloads for safety and efficiency. The program also plans to investigate more fully the human factors issues associated with AHS. Expanding from its current focus on the effects of singular technologies and systems, the program will also concentrate on how combinations of ITS applications operating within a greater infrastructure and in integrated smart vehicles will affect human performance and safety.

3. ADVANCED PUBLIC TRANSPORTATION SYSTEMS

Scope: The APTS R&D program, administered by FTA, focuses on three types of fundamental applications: transit fleet management, electronic fare payment, and traveler information. The APTS R&D efforts concentrate heavily on technology assessment and field testing. The U.S. DOT publishes a series of reports, *Advanced Public Transportation Systems: The State* of *the Art,* that investigates the extent of adoption of APTS technologies in North America. The reports focus on some of the most innovative or comprehensive implementations of four categories of services and technologies: fleet management, traveler information, electronic fare payment, and transportation demand management.

Mission: The purpose of the APTS R&D effort is to develop, test, and deploy ITS technologies and services that will improve the mobility, safety, and convenience of transit passengers and make operations more efficient and cost effective for transit providers.

Program Results: The program's research, information dissemination efforts, and technical assistance have helped catalyze roughly one-half of the actual or planned APTS deployments in the United States. As of the end of FY 1996, the results of 29 multiyear field operational tests have shown that: (1) automated traveler information systems increase the number of calls an agency can handle, (2) automatic vehicle location systems increase the on-time performance **of test** vehicles while decreasing passenger waiting times, and (3) agencies that use electronic fare payment systems have reduced both revenue loss from fare evasions and the cost of collecting fares. Deployment testing under the APTS program has helped to develop and demonstrate electronic fare systems that permit multiple transit operators to offer patrons a unified payment system. FTA is also coordinating with the FCC and others to ensure that communication frequencies for transit and ITS are not negatively affected by proposed radio frequency refarming legislation.

Future Directions: The program will continue to advance the state of the practice of APTS technology through technology assessment and by sharing knowledge. In particular, the program aims to develop new fleet management systems, including innovative automated system diagnostics, which would help diagnose

FIELD TEST SPURS BUSINESS EXPANSION AND CHANGES IN TRAVEL.

SmartRoute Systems, Inc., was founded in 1988 to provide innovative solutions for traffic congestion, accident management, and traffic-related air pollution. In May 1991, the company launched a real-time, on-demand, location-specific traveler information service called SmarTraveler in the Boston metropolitan area.The service was designed to assist car commuters, transit users, taxi drivers, salespeople, business travelers, and others with route-specific, up-to-the-minute traffic information that might affect their traveler behavior.

In 1992, U.S. DOT initiated the SmarTraveler field operational test to analyze user acceptance of and potential markets for advanced traveler information services.

During the field test, which received matching funds from the Massachusetts Highway Department., Boston residents received free telephone access to pre-recorded, regularly updated, route-specific information covering the area's highways, major roadways, and mass transit systems. Caller volume increased steadily over time, with significant increases during inclement weather. During three evaluation segments, callers using the service were randomly interviewed for additional information.The interviews indicated that travelers placed a high personal value on the traffic information, but they were reluctant to pay for it directly. The information was considered extremely valuable when it was included as part of other subscription services, such as those for cellular phones, Internet access, or cable television.

SmartRoute Systems used the field test information as the seed for developing a model public-private partnership that has expanded SmarTraveler into other cities.The partnership is designed so that the private sector incurs all startup, system development, and operating costs, and the public sector (usually a State DOT) pays for free telephone delivery of the travel information. SmartRoute also sells traveler data to private companies, which in turn deliver information to the public through on-line services, cellular phone networks,cable television,and traditional radio and television. Under a revenue-sharing agreement, public agencies receive a portion of the proceeds from these sales to private companies.

Public-private ventures will bring SmarTraveler to New York City, Philadelphia, and Washington, DC, by mid- t997. Cincinnati SmarTraveler was successfully launched in mid- 1995. Eventually, SmartRoute Systems (based in Cambridge, MA) plans to establish SmarTraveler in the Nation's 30 largest cities.

Now in its fifth year, Boston SmarTraveler receives approximately 5 million calls each year.Travelers use this powerful tool to make decisions about altering their routes, adjusting departure times, and changing modes of travel. In a recent survey of 2,000 Boston SmarTraveler users, nearly 50 percent reported that the information had a direct influence on travel decision making. In addition, 97 percent said that they planned to use the service again, 85 percent rated the service 8 or better on a scale of 10,63 percent reported an ability to avoid traffic problems, and 59 percent reported that they saved time. Over time, SmarTraveler has proven that people will change how, when, and where they travel if they have easy access to accurate and reliable traffic information.

SmarTraveler illustrates how federal incentives, in this case provided by the field operational test program, can help promising technologies deliver public benefits and become self-sustaining in the marketplace.

mechanical problems on buses and automatically transmit information on problems to the transit provider. Other efforts include developing the next-generation smart card that is "touchless" and is compatible with Master&d/Visa chip card standards. In addition, research will focus on improving the quality and supply of information available to enhance regional multimodal information services.

4. ADVANCED RURAL TRANSPORTATION SYSTEMS

Scope: The ARTS research program aims to advance the application of ITS technologies to rural transportation. Research areas include identifying specific user needs and assessing multiple technologies as they relate to the needs of diverse rural communities. The ARTS research program is also evaluating the usefulness of a prototype motor vehicle safety warning system that utilizes police radar frequency transmissions to alert drivers (in real-time) of hazardous road conditions.

Mission: Rural communities have different transportation priorities than metropolitan areas. ITS technologies can help to resolve many of the transportation problems in rural areas, but require unique deployment because of broad differences in geography and population density. The advanced rural transportation program will ensure that rural areas garner the safety, accessibility, productivity, and mobility benefits made possible by ITS services and products that target highway, transit, and emergency response services.

Program Results: The ARTS program is still relatively young. In early 1993, the program performed a comprehensive study of rural applications of advanced traveler information systems. Based on this and subsequent reviews, U.S. DOT identified seven fundamental "clusters" of ARTS applications:

- **Traveler safety and security technologies**, which can alert drivers to hazardous conditions and dangers.
- **Emergency service** technologies, which automatically notify emergency response services-ambulances, police, fire-of collisions and other emergencies.
- **Tourism and travel information services,** which provide information to assist travelers who are unfamiliar with the local rural area.
- **Public traveler services/public mobility services,** which improve the efficiency and accessibility of transit services to rural inhabitants.
- **Infrastructure operation and maintenance** technologies, which can improve the ability of transportation personnel to maintain and operate rural roads.
- **Fleet operation and maintenance** systems, which can improve the efficiency of the scheduling, routing, and maintenance of rural transit fleets.
- **CVO** systems, which manage the movement and logistics of commercial vehicles and include technologies developed specifically for rural areas that monitor vehicle and driver performance and locate vehicles during emergencies and breakdowns.

In addition, the ARTS program is field-testing the advanced rural transportation information and coordination (ARTIC) system in Minnesota, which will coordinate the communication systems of several public agencies (highway, State patrol, and transit) to improve response time to accidents and adverse road conditions and provide real-time transit status and schedule information. The ARTS research program is also field-testing advanced weather information systems and interregional traveler information systems in several States.

Future Directions: Future R&D activities of the ARTS program will identify and examine simple applications of ITS that rural transportation officials can implement immediately. A project on rural transit needs, which has already identified specific user concerns, will assess the applicability of existing and emerging technologies and systems. In FY 1997, the ARTS program will launch two **or** three field operational tests in rural areas. Long-term efforts will address how evolving ITS technologies, such as advanced collision avoidance safety systems, the next generation of traveler management techniques, and AHS, can be used to meet rural needs. The ARTS program will also pay particular attention to building a rural ITS infrastructure that can be integrated and is compatible with the ITS infrastructure in metropolitan areas and can support commercial freight and passenger transportation.

5. ADVANCED COLLISION AVOIDANCE AND SAFETY SYSTEMS

Scope: The advanced collision avoidance and safety system program (which is administered by NHTSA) evaluates and advances the development of systems that can prevent specific crash types (i.e., rear-end, intersection, road departure, lane change/merge, and heavy vehicle stability collisions), enhance driver performance (e.g., combat drowsiness and improve vision), and mitigate the consequences of crashes through automatic collision notification. Research activities include analysis of safety data, development of new research tools, field testing, and development of performance specifications.

Mission: The goal of the collision avoidance program is to significantly reduce the number of deaths and injuries that occur on the Nation's highways, primarily by preventing collisions. The overall objective of the program is to develop safety performance specifications for in-vehicle collision avoidance systems and other systems that enhance driving safety. These specifications will guide the design and manufacture of systems by the private sector.

Program Results: The collision avoidance program has made significant contributions during the past 5 years. Extensive analysis of accident data has identified opportunities for crash avoidance that are now guiding system development. The program continues to forge links between human factor considerations and system design. Preliminary performance specifications have been developed for sensing, processing, and driver interface elements for many of the collision avoidance systems now under development. Several joint efforts with motor vehicle industry partners to collect data and assess technologies have been completed or are well underway. New research tools are being developed to significantly enhance capabilities for analyzing and evaluating technical performance of crash avoidance countermeasures and estimating their real-world operational benefits. In addition, the program has moved key technologies, such as intelligent cruise control and automatic collision notification, out of the laboratory and into field testing.

Future Directions: The strategic goals for the next 5 to 10 years are to demonstrate the improved capability of collision avoidance systems, ensure that systems are both effective and user friendly, and provide a basis for understanding the benefits of the systems (i.e., the number of avoided collisions, injuries, and fatalities). The program also expects to strongly support AHS concepts that rely on vehicle-based intelligence. A major thrust of the program will focus on the larger issues of system capability, and usability and the benefits of smart vehicles that employ multiple technologies to avoid accidents, deliver information to drivers, and communicate with an intelligent transportation infrastructure.

DEPLOYMENT PLANNING, TECHNOLOGY TRANSFER, PROGRAM SUPPORT, AND MAINSTREAMING EXPENDITURES

About 13 percent of ITS funding helped create an institutional foundation for national deployment, which included the development of early deployment plans (EDPs), documentation of the benefits of deployment, assessment of institutional issues, and early awareness and training efforts. The thrust of these efforts has been to create a cultural shift in traditional transportation problem solving. Instead of focusing on "build/no build" scenarios, ISTEA encourages officials to think in terms of improved regional planning and intermodalism and better management of the transportation system to improve the efficiency of its operations. Four major deployment planning initiatives are discussed below: early deployment planning, the model deployment initiative, mainstreaming and technical assistance, and building professional capacity.

I. EARLY DEPLOYMENT PLANNING

Scope: Over the past 4 years, the national ITS Program has provided funding and technical assistance to government agencies in major cities, highway corridors, and rural communities to develop ITS EDPs (see Exhibit II-8). The early deployment planning process focused attention on ITS planning by giving agencies a framework within which to explore ITS strategies as potential solutions to an area's transportation problems and needs. There are currently 90 early deployment planning studies completed or underway. The majority of the participants in these planning studies are from agencies in metropolitan areas; however, 11 of the EDP studies cover intercity corridors and rural areas.

Mission: The primary mission of the EDP program is to encourage local transportation officials to begin

EXHIBIT II-8

ITS EARLY DEPLOYMENT PLANNING STUDIES

thinking about how ITS alternatives could be used to solve local transportation problems and meet the needs of diverse users. The EDPs emphasize a system engineering and integration approach, which differs from the single-mode orientation of most transportation planning agencies.

Program Results: Of the 90 studies initiated since the start of this program in 1992,40 have been completed. As a result of this effort, the U.S. DOT is beginning to see a significant number of ITS projects move through the regular transportation planning process toward implementation. We recently surveyed participants in 13 of the completed studies to determine how the EDPs are affecting project selection. According to officials surveyed in these areas, at least 29 projects valued at over $2 10 million have been initiated directly because of the EDPs.

Although the delivery of projects is important, the EDP studies also offer several less tangible benefits, among them the enhanced spirit of cooperation among the regional EDP participants. These studies have brought together regional transportation planners and decision makers in a unified, systematic approach to reducing congestion and solving transportation problems. The EDP process has helped to break down some of the jurisdictional barriers that have limited the existing regional planning process in the past. In addition, the EDP process has helped planners, transit officials, highway engineers, and local government officials better appreciate the potential benefits of ITS services. As a result, ITS projects have won a place at the table when critical decisions on alternative solutions and funding allocations are made.

Future Directions: Because the U.S. DOT is strongly encouraging the incorporation of ITS planning in the traditional metropolitan planning process, the FY 1996 solicitation that awarded 13 EDP study grants will be the last. The U.S. DOT will continue to provide guidance to transportation planners to mainstream ITS planning. Future work may also assess actual and planned ITS projects resulting from the EDP process.

2. Model Deployment Initiative

Scope: The 1996 MDI, which will demonstrate intelligent transportation infrastructure at approximately 12 locations across the Nation, aims to raise the awareness of the benefits of integrated ITS services and encourage public sector officials to build supporting infrastructure. The MD1 will showcase metropolitan infrastructure at four sites (Seattle, Phoenix, San Antonio, and the New York City tristate region), which were chosen from among 23 proposals received after a February 1996 request for participation. These areas will receive 50-50 match funding to deploy ITS infrastructure. Under the CVISN MDI, seven model deployment projects (in California, Colorado, Connecticut, Kentucky, Michigan, Minnesota, and Washington/Oregon) were chosen from 12 proposals received after a July 1996 request for applications. These projects will also receive 50-50 match funding to deploy CVISN components by the end of FY 1999. Before this selection, two States (Maryland and Virginia) were named to deploy prototype CVISN and to provide lessons learned. The prototype projects will be completed during FY 1997.

The Federal role includes shepherding ITS infrastructure deployment, evaluating the effects and benefits of deployment, and providing technical assistance. The national ITS architecture will serve as a framework for building ITS infrastructure at model deployments. The benefits of the products and services implemented at MDI sites will be assessed in terms of safety, efficiency, mobility, customer satisfaction, productivity, and environmental impact.

Mission: The mission of the MDI is to develop model sites to exhibit ITS infrastructure in metropolitan areas and commercial operations (as well as to showcase successful jurisdictional and organizational working relationships) for public and private sector decision-makers. The metropolitan MDI sites will demonstrate the benefits of integrated advanced travel management services that feature a strong regional, multimodal traveler information component. The CVISN projects will demonstrate the benefits of exchanging CVO safety and regulatory information and conducting compliance transactions electronically.

Program Results: The more exposure individuals have to useful products and services, the more likely they are to accept, purchase, and use them. By allowing the general public and local officials to experience first hand benefits from ITS infrastructure, the MDI will foster acceptance and more widespread deployment of intelligent transportation infrastructure. The MDI will also foster and strengthen institutional arrangements necessary for integrated and inter-modal ITS deployments. Even before the actual demonstrations, the MDI solicitation has catalyzed institutional collaboration, even among sites that were not selected. Many of these sites are proceeding with their ITS deployment plans without direct U.S. DOT funding support.

Future Directions: The U.S. DOT expects to complete evaluation plans for the MDI sites by February 1997, and project participants will complete detailed test plans in 1997. Evaluators will have at least 8 months to collect baseline data before each site deploys ITS infrastructure. These data will be compared with post-implementation data to measure the effectiveness of ITS infrastructure. The demonstrations will begin in FY 1998-99.

3. MAINSTREAMING AND TECHNICAL ASSISTANCE

Scope: Mainstreaming efforts and technical assistance to State and local officials encompass several activities. These activities include technical workshops; focus groups and formal surveys designed to ascertain how well State and local officials and transportation professionals understand and accept ITS technologies; case studies evaluating lessons learned from deployment; analysis of privacy issues and development of privacy principles; analysis of financial, legal, and institutional issues involved in procurement and contracting; development of local and State outreach programs; and strategies for encouraging public-private partnerships.

In particular, U.S. DOT is striving to incorporate ITS/CVO more fully into State and metropolitan transportation planning activities, help coordinate ITS/CVO activities among agencies and States, and explain the ITS/CVO program to key decision makers in the public and private sectors. The national ITS/CVO mainstreaming program is active in five major areas: (1) convening State and regional working groups made up of representatives of key public and private sector CVO stakeholders, (2) developing State and regional CVO business plans, (3) conducting benefit-cost analyses and other technical studies that provide supporting information for deployment planning, (4) identifying CVO "champions" in seven regions to work with the regional and State working groups and encourage CVO deployment, and (5) providing outreach services and education to State and industry stakeholders that will increase the awareness of and support for ITS/CVO activities.

Mission: Planning and technical assistance fulfill four objectives: determining needs for technical assistance and developing mechanisms for its delivery; bringing together public and private professionals to discuss solutions to challenges encountered by the deployment of ITS services; expanding the base of knowledge and creating awareness of ITS benefits for a wide range of public officials, transportation professionals, and the general public; and promoting ITS in the State and metropolitan planning processes by educating the ITS community about planning and regional planners about the potential of ITS.

Program Results: The success of the ITS Program hinges on enhancing awareness of the benefits generated from successfully deployed ITS technologies and also on offering innovative ways for State and local governments to mainstream ITS solutions into the traditional transportation planning process. U.S. DOT has developed a preliminary handbook, *Integrating*

ITS with the Transportation Planning Process, which describes how ITS can fit within ongoing planning. implementation, and operational activities for highways, transit systems, CVO, and other modes of travel. The material addressed in this handbook will be presented at workshops held during 1997.

In addition, 33 States have followed the U.S. DOT's recommendation and formed 7 regional forums to ensure that ITS/CVO services are delivered to areas that have the greatest trucking volumes and that services within these areas are uniformly provided (see Exhibit 11-9). The forums are based on seven major population and economic regional "trucksheds" (in New England, and the Southeast, Mid-Atlantic, Great Lakes, Mississippi Valley, West, and Northwest). The forums are designed to improve motor carrier operations, build capacity, and explain the purposes, technologies, costs, and benefits of ITS/CVO services to State legislatures, private industry, and the public.

Future Directions: The ITS program staff is making a concerted effort to become more actively involved with the transportation planning community. The U.S. DOT will continue to provide guidance to transportation planners to incorporate ITS into the traditional planning process.

Research is also underway to better understand impediments to deployment and post-deployment user satisfaction through interviews with local decision makers, including State and local public sector transportation managers in metropolitan areas. This effort will provide information on how to build ITS infrastructure and will produce a marketing plan to effectively target U.S. DOT outreach and training.

For ITS/CVO mainstreaming efforts, each State that has opted to become part of the regional forums will develop an ITS/CVO business plan that will outline the specifics of CVO and help States plan for ITS deployment. These plans are expected to be completed by December 1997, and regional plans will be completed by 1998. Regional "champions" are expected to be launched by spring 1997. These champions will provide dedicated, full-time support, guidance, and assistance to Federal and State decisionmakers in areas related to ITS deployment for CVO.

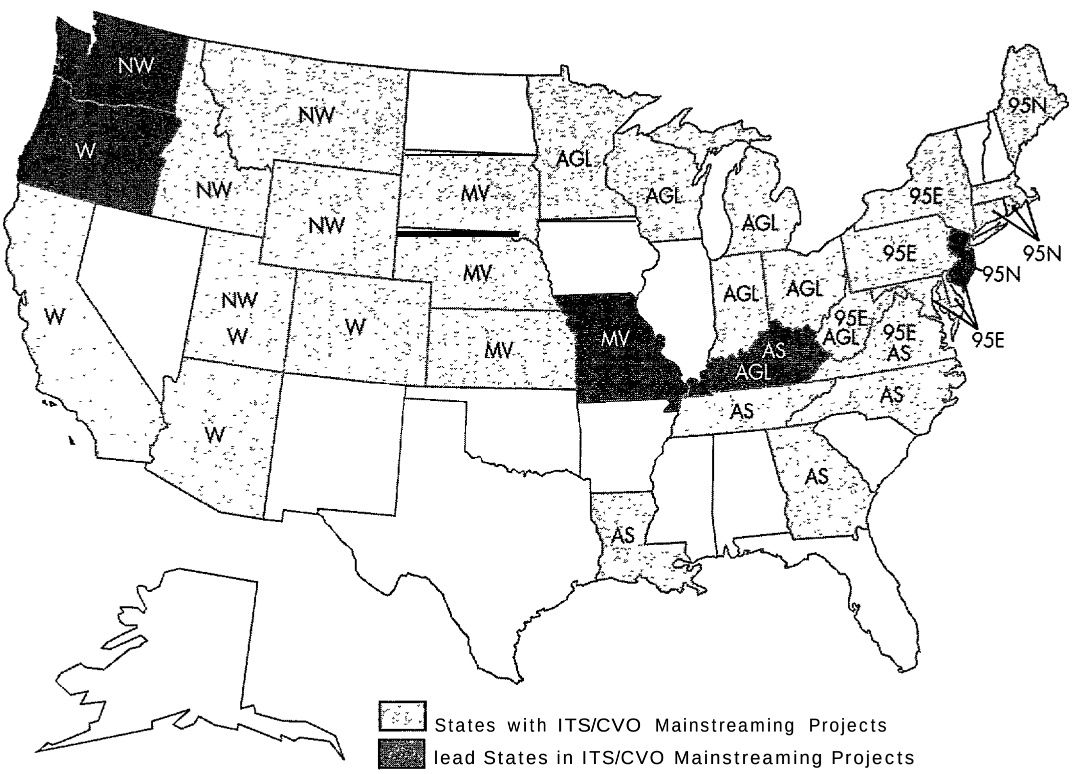
4. BUILDING PROFESSIONAL CAPACITY

Scope: In a 1995 survey and report conducted by the Institute of Transportation Engineers, 50 percent of State agency respondents rated their staffs' abilities to operate automated systems as fair or poor, and 66 percent rated their staffs' abilities to maintain such systems as fair or poor. Confronting these challenges, U.S. DOT developed a 5-year ITS Professional Capacity Building (PCB) strategic plan to train transportation professionals to plan, design, deploy, operate, and maintain ITS technologies, services, and applications.

The program focuses on a wide range of audiences, including Federal staff, elected officials, State and local practitioners and planners, university students, and the general public. At a public level, the program will raise awareness about ITS elements and their public benefits. At the more specialized and intensive levels, the program will develop and deliver training courses on technical and institutional issues related to critical ITS elements. The U.S. DOT will accomplish this task in cooperation with its partners, professional societies, colleges and universities, and representatives of the transportation industry. Training will be delivered via conventional means, as well as through new educational methods, such as computer-based and other distance-learning techniques.

Mission: In the short term (1 to 2 years), the U.S. DOT seeks to provide training and capacity building to its staff, State and local partners, and other transportation professionals. Short-term efforts include the development of six seminars on the following topics: benefits and costs of ITS deployment, public-private partnerships, innovative procurement strategies for deployment, ITS in the transportation planning process, system engineering and system architecture, and telecommunication technical and policy issues. In the longer term, the program will enhance the skills and abilities of transportation officials at all levels of government. The PCB program will also encourage the development of new courses and programs at universities and colleges to develop the next generation of transportation professionals, who will be fully cognizant of ITS technologies and trained to successfully develop, integrate, and deploy them.

EXHIBIT II-9
ITS/CVO MAINSTREAMING PROJECTS



States with ITS/CVO Mainstreaming Projects
lead States in ITS/CVO Mainstreaming Projects

95N	I-95 Coalition/Northern [Lead State, NJ]
95E	1-95 Coalition/Eastern (Lead State, NJ)
AS	Advantage CVO/Southeastern (Lead State, KY)
AGL	Advantage CVO/Great Lakes (Lead State, KY)
MV	Mississippi Valley (Lead State, MO]
NW	Northwestern [Lead State, WA)
W	Western (Lead State, OR]

Program Results: This program will ensure that sufficient numbers of trained Federal, State, and local ITS professionals will be available and that a sufficient number of trained professionals will enter the workforce through ITS graduate and undergraduate programs. Using a multidisciplinary and multilevel approach, the PCB program will provide its audience with knowledge of all aspects of the ITS program and the skills to handle technical and institutional impediments to deployment. The program will also provide training via new distance-learning methods to address the concern that many State and local officials do not have the resources to travel to centrally located training facilities.

Future Directions: During FY 1997, the PCB program will provide awareness and overview training to U.S. DOT personnel at headquarters and in the regional and division offices and at forums across the Nation to transportation officials and the general public. Overview short courses or seminars will be developed and delivered in six technical areas to Federal, State, and local practitioners to provide the general knowledge needed to help them consider and deploy ITS applications. In 1998 and beyond, specialized short and long courses will be delivered to transportation managers in the field, new course-delivery methods will be developed, and intensive training programs will be launched to educate the next generation of entry-level transportation practitioners.

SYSTEM ARCHITECTURE AND STANDARDS DEVELOPMENT EXPENDITURES

About 4 percent of ITS funding has supported development of the national ITS architecture and identified essential standards. These efforts establish a framework for integrated, interoperable, and intermodal ITS services and infrastructure. In particular, the architecture has provided the basis for an FCC strategy. promoted the need for augmented GPS, and otherwise emphasized the importance of the capability, accuracy, and security of enabling communication technologies. Both the architecture and standards programs are part of the U.S. DOT's enabling research program, which is described more fully in Chapter III.

I. ARCHITECTURE

Scope: The national ITS architecture, which addressed 29 of the 30 currently identified ITS user services (as of December 3 1, 1996) defines the information flows between system components and sets forth a set of requirements for the standards and protocols needed to achieve interoperability and compatibility. The full architecture documentation package is approximately 5,600 pages long, comprising 18 volumes. Much of the detail is for system designers and implementors developing detailed component specifications.

Mission: The architecture is a blueprint that defines the subsystems and data flows (i.e., information that must be shared between subsystems) to allow ITS services to work together within and across jurisdictions. The architecture is extensive and technically detailed and covers a broad range of technical and institutional topics. Most important, the architecture identifies the interfaces between subsystems for which standards must be developed.

Program Results: The national ITS architecture provides a unified framework within which public agencies and private firms alike can develop and deploy ITS with the confidence of national interoperability, as well as protection against the risk of technological obsolescence for early deployments. By addressing multiple ITS services, the architecture accommodates a high degree of intermodal integration. It also provides the flexibility for ITS components to be deployed to whatever extent and in whatever sequence make sense within a given jurisdiction or industry sector, with the assurance that they will be able to work with pre-existing ITS components and those yet to be deployed.

Future Directions: The system architecture activity essentially accomplished its goal of providing a practical framework to guide developers of ITS technologies and system integrators, and it identified areas that require standards. In addition, in FY 1997, the architecture's capabilities were extended to address the highway-rail crossing user service. The program is developing additional guidance and technical assistance documents to help practitioners adapt the national architecture to fit local needs. The effectiveness of the architecture will be evaluated and refined by the model deployments of ITS infrastructure.

2. STANDARDS

Scope: The standards program is focusing on interface standards resulting from the national architecture studies, which identified 45 specific interfaces (and associated message sets) necessary to achieve nationwide compatibility. In 1996, the U.S. DOT signed cooperative agreements with five SDOs-the American Association of State Highway and Transportation Officials (AASHTO), the American Society for Testing and Materials (ASTM), the Institute of Electrical and Electronics Engineers (IEEE), the Institute of Traffic Engineers (ITE), and the Society of Automotive Engineers (SAE)-to advance critical standards to support the building of intelligent transportation infrastructure and individual ITS applications. Other efforts include development of communication protocols and enabling/crosscutting standards (e.g., for location-referencing systems, spatial data transfer, and data dictionaries). The ITS standards program is being formulated by U.S. DOT and ITS America. Together, the two organizations have created a comprehensive plan for coordinating the various standards activities through such efforts as the working committees sponsored by ITS America.

Mission: ITS services must "speak the same language" to share data and work together effectively. ISTEA directed the Secretary of Transportation to "develop and implement standards and protocols to promote widespread use and evaluation of ITS technology" and to "promote compatibility among ITS technologies implemented throughout the States." Consistent with this mandate, the ITS program has adopted five standards goals: facilitating interoperability, providing an environment in which public sector agencies (and others) can choose ITS products and services from among multiple vendors, ensuring the safety of the traveling public, facilitating the deployment of ITS, and helping to create an ITS market.

Program Results: Standards will allow for the integration of hardware and software products manufactured by independent vendors for ITS applications. These standards will create and sustain a broad-based market for manufacturers, facilitate the retrofitting of systems that are already deployed, and allow interoperability and interchangeability of ITS products. The adoption of the NTCIP, which allows traffic management centers to obtain information from multiple sources, and the "Smart Bus Bus" suite of standards, which allows integration of electronic functions on transit buses, are two of the program's major achievements. (The first "bus" in "Smart Bus Bus" refers to transit vehicles, and the second refers to the devices that enable electronic networking.)

Future Directions: The U.S. DOT will continue to support development and acceptance of standards through ITS America and SDOs to address critical public interests. The U.S. DOT will ultimately make Federal funding for ITS components contingent on adherence to industry standards.

CVO EXPENDITURES

Approximately 4 percent of ITS funding has supported CVO projects. CVO activities have also been funded in the mainstreaming and R&D efforts. The CVO program is discussed in greater detail in Chapter III.

Scope: Total funding helped sponsor several activities, from strategic planning to field testing to deployment support. These activities include the design of the national carrier safety fitness system, which provides interstate carriers' safety histories to roadside inspection stations. Other projects include: establishment of a vehicle-roadside communication standard to enable commercial vehicles to travel nationwide using one transponder for multiple purposes, full-scale testing of electronic clearance services in the Advantage I-75 project (which is the longest ITS deployment in the world, with anticipated participation of 4,500 vehicles and the eventual capability for nonstop truck travel from Florida to Canada), implementation of the prototype CVISN Phase I system for roadside electronic verification in two States, completion of the evaluation of advanced brake-testing technology at the roadside to expedite the truck and bus inspection process and increase the number of annual inspections, and completion of the detailed system design for the carrier/vehicle-based safety and fitness electronic record (SAFER) system for vehicle screening and inspection.

Also as part of this program, 250 motor carrier safety assessment program (MCSAP) sites are being equipped with pen-based computer systems for easier inspections and automated selection that will allow unsafe carriers to be singled out for inspection.

FHWA is conducting operational tests to demonstrate commercial vehicle electronic clearance at international borders, including proper identification of Mexican and Canadian motor carriers at Otay Mesa, CA; Detroit, MI; Buffalo, NY, and Nogales, AZ. At these same four sites, as well as in El Paso and Laredo, TX, the U.S. Customs Service is testing the North American Trade Automation Prototype (NATAP), which is expected to be launched in September 1997. NATAP will enable data on goods, carriers, and drivers to be entered electronically only once, allowing for multiple use across 53 U.S. agencies and their counterparts in Mexico and Canada. FHWA is assisting with the NATAP testing as it relates to electronic clearance for motor carriers.

Mission: The CVO program's mission is to provide high-quality, efficient, safe, and legally compliant commercial vehicle shipping and busing services throughout North America. CVISN, which expands the vision of ITS/CVO is striving to establish a fully integrated collective of motor carrier information systems that supports safe and seamless commercial transportation by providing timely and easily accessible information to authorized users. The CVO program's three primary goals are to improve highway safety, increase motor carrier productivity, and streamline regulatory and enforcement procedures.

Program Results: The ITS/CVO program has helped change the business of regulating commercial freight by convincing multiple agencies to work together and by encouraging them to adopt the emerging trends in information and data management. In addition, field tests have helped promote de facto standards; several States have adopted the transponder used in the HELP, Inc., and Advantage I-75 projects. As of December 1996, U.S. DOT had also prepared 200 MCSAP sites for the initial phases of the SAFER program. A key element of the field testing of electronic clearance at the Detroit, Buffalo, Otay Mesa, and Nogales international border crossings is their eventual integration with NATAP, an initiative developed by the U.S. Customs Service. U.S. DOT has been coordinating its efforts at the Canadian and Mexican land borders with the NATAP efforts to ensure compliance with vehicle, driver, and carrier safety and credential requirements, while streamlining the flow of trade traffic.

Future Directions: Future activities are focused on deploying CVISN at seven pilot sites as part of the MDI, and supporting CVISN deployment in all interested States by 2005. Work will continue to deploy clearance and enforcement-related technologies at international border-crossing sites. The program will also emphasize compatibility of ITS/CVO services for road travel with cargo systems used in rail, air, and marine transportation throughout North America. Finally, the program will focus on achieving closer coordination with officials from Canada and Mexico to ensure that advanced ITS applications used at border crossings are compatible and reciprocal.

AHS EXPENDITURES

About 5 percent of ITS funding has been dedicated to the development of an AHS prototype. The AHS program also benefits by sharing results of research from the advanced collision avoidance program. The AHS program is discussed in greater detail in Chapter III.

Scope: The AHS program aims to create a prototype that can achieve automated "hands-off' operation of a vehicle. The first major milestone of the AHS program was the award of the cooperative agreement with the National AHS Consortium (NAHSC) on November 8, 1994. One hundred organizations have signed on as associate members-an unprecedented consortium of public, private, and academic interests. NAHSC core members include Bechtel, the California DOT, Carnegie Mellon University, Delco Electronics, General Motors, Hughes, Lockheed Martin, Parsons Brinckerhoff, and the University of California Partners for Advanced Transit Highways (PATH) Program.

The NAHSC work plan lays out a multiyear effort to develop and advance the critical technologies required to support the 1997 AHS demonstration, select and evaluate AHS concepts, and build and test an AHS prototype. The program is organized into three phases: analysis, system definition, and operational testing and evaluation.

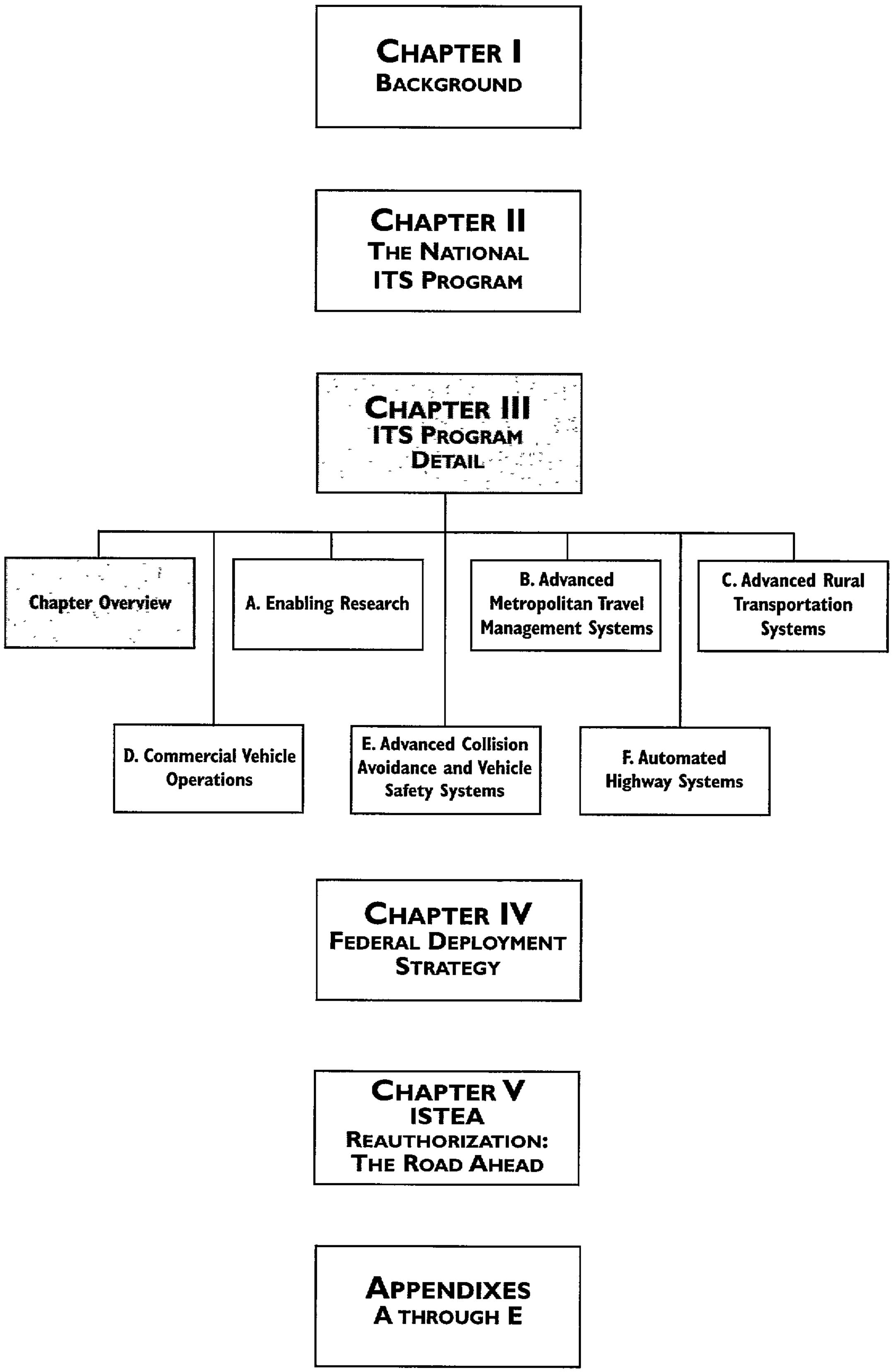
Most of the funding to date has supported research and engineering efforts to define and develop prototypes of the optimal AHS configuration and deployment approach. The program is also conducting case studies in selected cities, focused on commuter, trucking, and public transit users.

Mission: ISTEA mandated an AHS program by requiring U.S. DOT to: "develop an automated highway and vehicle prototype from which future fully automated intelligent vehicle-highway systems can be developed. Such development shall include research in human factors to ensure the success of the man-machine relationship. The goal of this program is to have the first fully automated roadway or test track in operation by mid- 1997."

Given this mandate, U.S. DOT's goals are to ensure that automated highways are designed to improve safety, increase efficiency, enhance mobility and access, and provide more convenient and comfortable highway traveling. The program focuses on gradual implementation of vehicle-highway automation capability, leading to eventual full automation.

Program Results: The AHS program has one of the greatest potentials for operational improvements in vehicle throughput and safety. In FY 1997, the demonstration of a preliminary AHS concept will be conducted on HOV lanes in the median of I-15 in San Diego, CA, and accompanied by displays and exhibits. The AHS demonstration will integrate basic collision avoidance capabilities with new capabilities in automated vehicle control; the vehicles and the highway will perform together as a unified system. In addition to the technology demonstrations, the 1997 event will include an exposition illustrating how an automated highway might become part of a region's transportation system through a gradual roll out of new capability.

Future Directions: Beyond the 1997 demonstration is the selection and prototype testing of the preferred AHS configuration. Upon completion of the system definition phase, in 2002, NAHSC will select a preferred system approach; operational tests will begin shortly thereafter. Opportunities to conduct operational testing of spinoff systems will be developed at the same time.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III. ITS PROGRAM DETAIL

Chapter Overview

The national ITS Program comprises six broad areas and is stewarded by the ITS JPO. As the ITS Program has evolved over the past 5 years, the framework found most useful for describing the overall effort identifies five bundles of functionality that address related users and effects on users, service providers, and shared physical and information infrastructure. Gathered within these bundles are ITS user services targeting specific needs; so far, the U.S. DOT has categorized 30 ITS services. The sixth program area is crosscutting research, which supports and enables all five functional areas.

PROGRAM AREAS

A. ENABLING RESEARCH

Enabling research, especially that for system architecture and standards, provides the framework for national interoperability among all ITS components. This program area particularly focuses on building and supporting the intelligent transportation infrastructure. The research program also refines the capabilities of enabling technologies for ITS applications (such as communication, sensing, and tracking technologies) and investigates human factors and institutional impediments to ITS deployment.

B. ADVANCED METROPOLITAN TRAVEL MANAGEMENT SYSTEMS

Most of the elements of ITS now being deployed across the Nation are advanced metropolitan travel management systems, which encompass a wide range of services for traffic, travelers, and transit. These systems include advanced traffic management systems (ATMS), advanced traveler information systems (ATIS), and advanced public transportation systems (APTS). The ATMS, ATIS, and APTS programs assess the technical viability of ITS user services and evaluate their benefits and impact on travelers and transportation operators. The U.S. DOT is currently facilitating the deployment of intelligent transportation infrastructure that would support and integrate nine essential ATMS, ATIS, and APTS services in metropolitan areas.

C. ADVANCED RURAL TRANSPORTATION SYSTEMS

Advanced rural transportation systems (ARTS) apply ITS services and technologies to address the unique safety and mobility problems of rural communities. The ARTS program assesses specific user needs of diverse communities, identifies applications of ITS technologies that can satisfy needs and deliver benefits, and develops a concept for a communication and information infrastructure that will support and integrate ARTS services and link them with metropolitan ITS infrastructure.

D. COMMERCIAL VEHICLE OPERATIONS

The ITS/CVO program focuses on the regulatory compliance processes and safe operation of commercial vehicles that carry freight and/or passengers. ITS/CVO systems apply technologies and information networks to increase productivity and efficiency for both fleet operators and State motor carrier regulators. They also enable States to more effectively target unsafe carriers, vehicles, and drivers. The program evaluates the potential benefits of individual ITS/CVO user services and develops an information and communication infrastructure, CVISN, which will support and integrate multiple ITS/CVO services.

E. ADVANCED COLLISION AVOIDANCE AND VEHICLE SAFETY SYSTEMS

Advanced collision avoidance and vehicle safety systems aim to enhance driver and nonmotorist safety through human-centered smart vehicles equipped with technologies that can sense objects, warn of and/or help drivers avoid impending collisions, automatically signal for help in the event of a collision, and monitor driver alertness. The advanced collision avoidance program is assessing the potential of these systems to reduce accidents and developing guidelines for system performance. The program focuses largely on basic and applied research; widespread deployment of the first advanced systems is expected in 4 to 5 years. The program also shares its research with the automated highway system (AHS) program because AHS concepts will probably rely in large part on vehicle-based intelligence provided by collision avoidance technologies.

F. Automated Highway System

The AHS permits automatic operation of vehicles along dedicated highway lanes to improve safety and capacity. The AHS program is closely coordinated with the collision avoidance research program because AHS concepts will share key subsystems (e.g., vehicle-based sensors, computational elements, and the driver interface) with collision avoidance systems. The AHS program defines system requirements for AHS prototypes. In 1997, the program will demonstrate a preliminary AHS concept, as required by ISTEA.

Chapter Overview

This chapter, "ITS Program Detail," presents the goals, activities, technical lessons learned, benefits, institutional issues, and future directions for each of the program areas discussed above.

Each section of the chapter first addresses a specific program area, describing the general problems and needs addressed by the program area, along with specific ITS applications that can resolve these problems and needs.

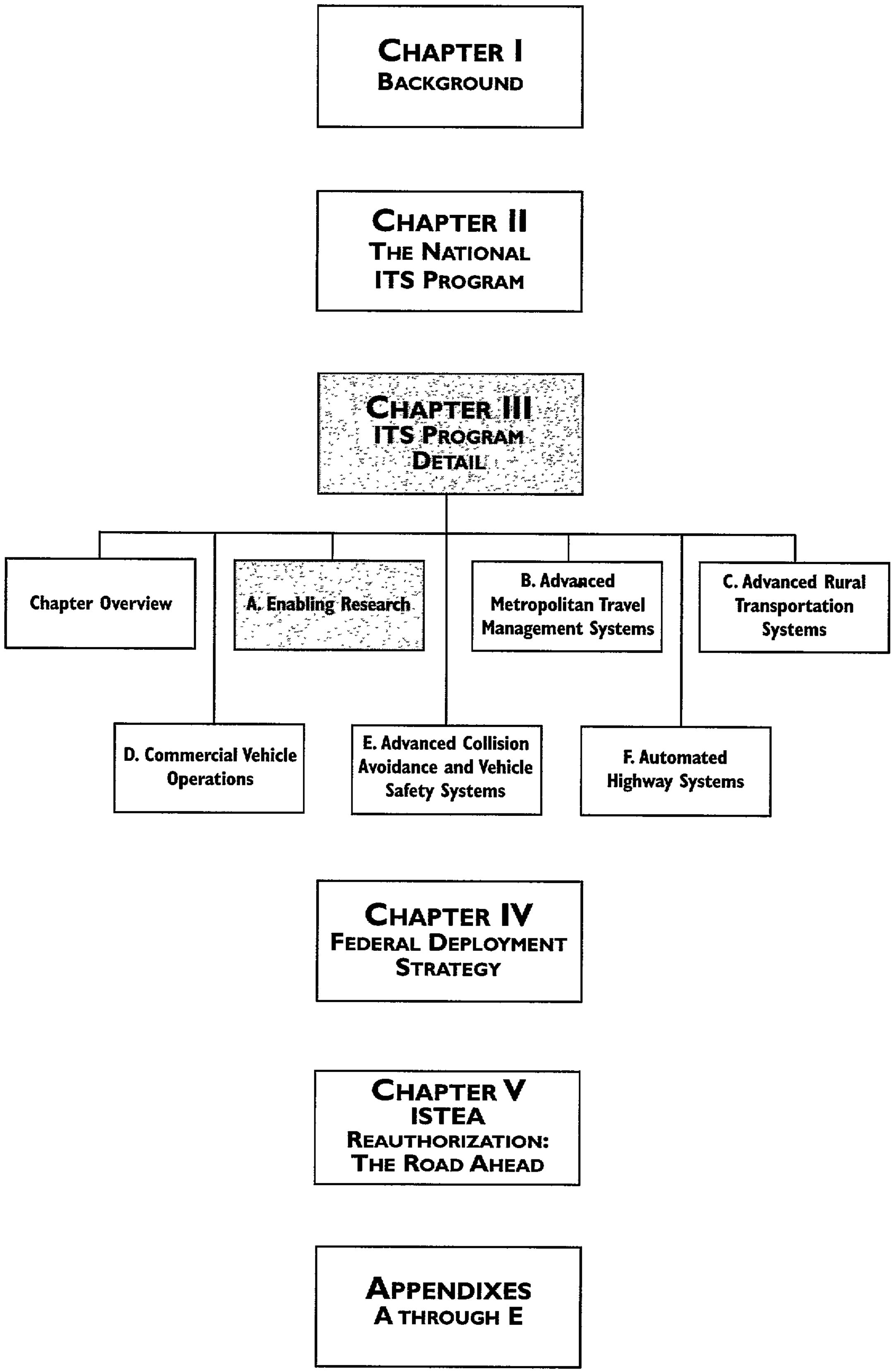
The next sections, on program goals and activities, describe the mission and objectives of each program area and identify accomplishments. These sections also highlight the tools and products developed by specific ITS programs to advance ITS applications.

The sections on technical lessons learned describe how various activities of specific ITS program areas have advanced state-of-the-art knowledge about the viability, feasibility, and impact of individual and integrated ITS services. These sections also summarize what has been learned about the effectiveness of the technology to perform required tasks and identify issues related to technology transfer for ITS applications.

The sections on benefits summarize what has been learned about the advantages and impacts of ITS services on travelers, system operators, and the private sector.

Institutional issues and user acceptance are also discussed for each program area. These paragraphs summarize what has been learned about institutional impediments, innovative partnerships resulting from ITS projects, and the responses of various users to new ITS services and products.

Finally, the sections on future directions identify the future activities and strategies of each program area, particularly as the activities relate to research, development, and deployment of individual ITS services and infrastructure.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III. ITS PROGRAM DETAIL

A. Enabling Research

How can ITS applications function and deliver services effectively and safely? This is the primary question asked by the U.S. DOT's research efforts to provide both a framework and a foundation to enable ITS services to perform at their maximum capabilities.

The enabling research program encompasses four broad areas of investigation. The first area targets the development of a comprehensive system architecture that establishes a framework for national compatibility of all ITS components. The second category pursues standards that allow the ITS services arrayed within this framework to share information and data using a consistent language and format. The third category of research addresses human factors that influence how the safety and performance of users are affected by ITS technology. The fourth category is directed toward improving the capabilities of elemental enabling technologies that allow ITS applications to function and provide services. The following sections describe these broad research categories and the program goals and activities, technical lessons learned, benefits, institutional and user issues, and future directions associated with each.

NATIONAL ITS ARCHITECTURE

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

In much the same way, the national ITS architecture is the master plan that defines major ITS components and describes how system elements can interact compatibly. It provides a comprehensive technical and institutional framework that allows individual ITS services and technologies to work together and share information. Because the architecture is policy neutral, it supports a broad range of modal and intermodal strategies and accommodates an extensive choice of starting points and implementation sequences.

The framework provided by the architecture is also inclusive, flexible, and expandable, delineating the optimal interrelations between functional components to enable 29 ITS user services. Its flexibility allows new user services to be added as required. Indeed, work incorporating the 30th user service, targeting improved safety at highway-railroad grade crossings, was completed in January 1997.

More specifically, the national ITS architecture defines the following aspects of ITS:

- Functions necessary to perform a given ITS user service.
- Subsystems that perform user service functions (i.e., roadside or vehicle equipment).
- Interfaces and information flows between subsysterns.
- Communication modes (wired or wireless) for transmitting ITS information.
- Requirements for development of standards to support national ITS interoperability.

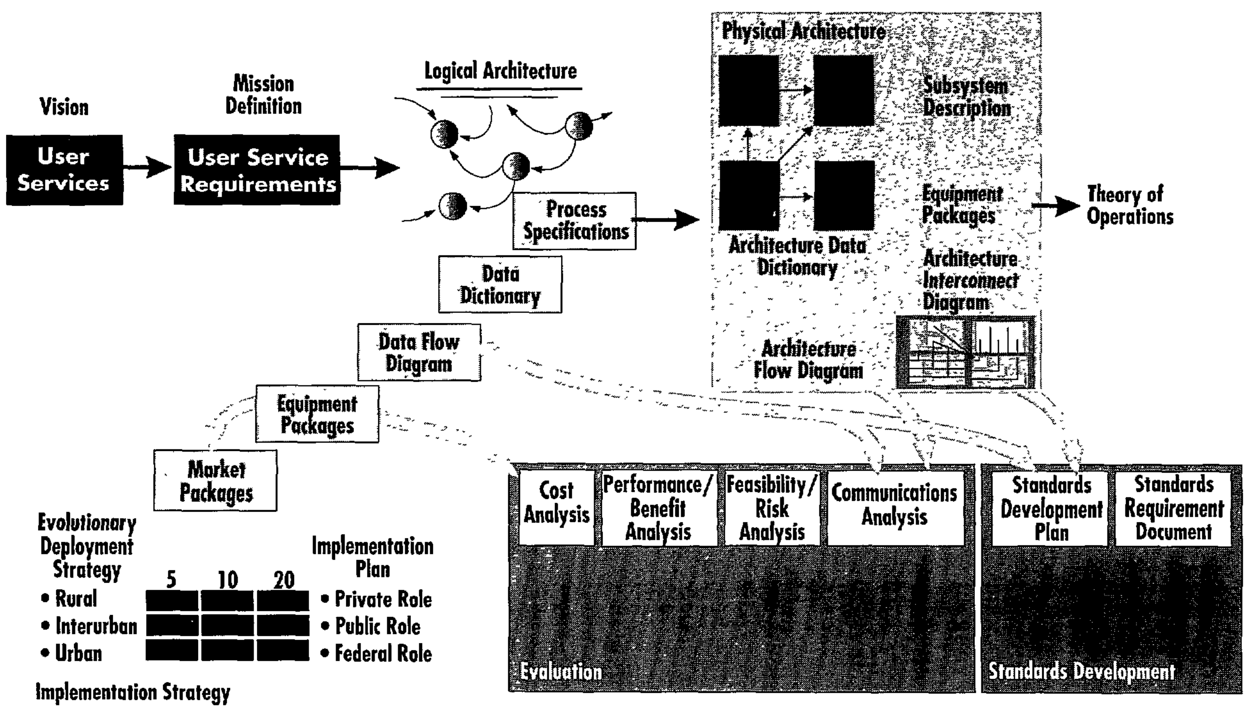
The ITS architecture consists of a logical architecture and a physical architecture. The logical architecture defines eight major processes and associated information flows, which are: (1) managing traffic, (2) managing commercial vehicles, (3) providing vehicle monitoring and control, (4) managing transit,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

The physical architecture allocates the processes of the logical architecture to 19 major physical subsystems, which are organized into four basic physical classes (i.e., transportation management centers, roadside equipment, vehicles, and travelers). The physical architecture has three major layers of infrastructure: transportation, communications, and institutional. The transportation layer deals with the transportation infrastructure and operations of ITS. The communication layer identifies how existing and developing commercial or dedicated communication systems and open protocols can support ITS services. The institutional layer outlines possible roles and relationships among public and private institutions—particularly how the Federal Government, State and local governments, vehicle manufacturers, and information and communication service providers could work together to implement ITS user services. Exhibit III-1 shows the development of the logical and physical architectures.

PROGRAM GOALS

The national ITS architecture effort seeks to provide a unified, technology-neutral, and policy-neutral framework that allows independent ITS designs and imple-

EXHIBIT III-1
ARCHITECTURE DEVELOPMENT ROAD MAP



mentations by public sector and private parties, but ensures that they are compatible. The objectives of the architecture program are as follows:

- Design a theoretical and practical structure in which different ITS functions can seamlessly operate with each other to provide various levels of service to travelers and system operators.
- Illustrate how ITS services can be incorporated in existing infrastructure and accommodate future technological advances.
- Support "open" standards that enable multiple public and private organizations to independently deploy ITS components that work together, regardless of who designed or manufactured the particular hardware or software.

Program Activities

The national ITS architecture, adopted by the U.S. DOT and ITS America in July 1996, is a cornerstone achievement of the ITS Program that paves the way for accelerated ITS development and integrated ITS deployment. The ITS architecture is designed to support the unique needs of urban, interurban, and rural areas throughout the United States. It has been honed and refined through some 50 public reviews and reflects input from a broad spectrum of stakeholders.

From September 1993 through 1994, four teams developed independent concepts for a national ITS architecture. A number of technical experts and stakeholders evaluated the resulting concepts. The U.S. DOT then selected two teams to work together to merge the best concepts from all four teams into the national ITS architecture. In June 1996, following extensive technical and public review, the two teams delivered more than 5,600 pages of documentation in 18 volumes, collectively titled The National *Architecture for ITS: A Framework for Integrated Transportation into the 21st Century.*

Technical Lessons

The national ITS architecture development process determined that many ITS user services, with the exception of advanced collision avoidance and AHS concepts, can be implemented using proven, commercially available technologies. In general, technological constraints pose less of a risk to ITS implementation than do market resistance, public sector budgetary constraints, and institutional impediments to public-private partnerships.

In developing the ITS architecture, the teams found that enhancing communication networks and services is particularly important to ensure that ITS components are widely operable, accessible, and integrated. The extent and characteristics of communication networks will affect the degree of ITS interoperability across the Nation. Communication networks will also influence how site-specific architectures will evolve in various locales because the national architecture does not rigidly mandate specific enabling technologies to implement ITS services.

Communication is one of the fundamental structural elements that makes up intelligent transportation infrastructure because it serves as the path ITS services use to gain access to and share information. Communication networks also link disparate ITS applications to each other and to centralized management centers, allowing for the key functions of data gathering, synthesis, delivery, and broadcast to occur in real time. Because of their importance to ITS, the architecture advocates five types of communication links:

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

- Vehicle-to-vehicle communications, which will someday provide vehicles with collision-warning and avoidance capabilities and play a critical role in AHS.
- Wireline communications, which include regular "phone line" devices, such as phone, fax, modem, video, and high-speed data networks.

In researching various options and technologies, U.S. DOT has learned that ITS communication needs can be met through a combination of owned facilities, leased services. or both, including emerging digital communication developments associated with the national information infrastructure initiative. For the most part, as noted by a member of the architecture development team, "the choice of which particular communications technology is used becomes a local design decision." The architecture did emphasize, however, that short-range communication spectrum is needed in the 5850 to 5925 MHz band to meet DSRC needs (such as vehicle to roadside transactions).

In addition to communication systems, development of standards for specific architecture elements is another area of importance for the national ITS architecture. The standards requirements derived in the architecture development effort were sorted into 12 groups to be addressed by appropriate SDOs. Subsequently, 45 potential standards development projects were identified. and 20 have already been initiated as high-priority development items for the next 1 to 2 years. Of particular concern is the absence of a common location reference standard because it is neither cost effective nor practical to accommodate the several methods that now exist for identifying a geographical location.

BENEFITS

The national ITS architecture provides a guiding structure based on open-system concepts and recommended nonproprietary standards. Significantly, the architecture also enables a degree of modal integration and system interoperability that would not otherwise

APPLYING THE NATIONAL ITS ARCHITECTURE IN MINNESOTA

In 1994, the Minnesota Department of Transportation (MnDOT) initiated a project called. Polaris to create an ITS architecture for the State of Minnesota. Polariswas a partnership between MnDOT and Loral Federal Systems, now Lockheed Martin.The goal of Polaris was to integrate ITS field trials and prepare for deployment on a larger scale.

Rather than starting from scratch, the Polaris team looked to the national ITS architecture as-a blueprint from which to develop Minnesota's own architecture Polaris derived its user services, requirements, and technological functions from the national ITS architecture. With these guideposts 'already in place, Minnesota's engineers and planners could focus their efforts on tailoring an architecture that would fit their State's needs.

To better understand these needs, extensive market research was conducted. The Polaris team held in-depth discussions with various transportation agencies throughout the State to learn about their preference; and requirements.These discussions highled of lack of coordination among- agencies, as well as a-lack of funding. In addition, the Polaris team conducted focus groups with travelers throughout the State and surveyed more than 1,000 individuals about their needs.

These discussions resulted in a traveler information model that is moving Minnesota toward a stronger private sector role in the delivery of traveler information. The creation of this model helped attract interested private sector parties by illustrating their potential roles in implementing ITS and demonstrating the rewards of investing in these new transportation technologies. At the same time, Polaris helped clearly define system specifications for all transportation agen-. cies.

Minnesota is now in the early stages of Orion, the State's deployment effort. Orion is a $26 million cooperative public-private ITS deployment based on Polaris and the national ITS architecture principles it embodies.

be possible to achieve. This integration results in several benefits, including lower costs, compatibility, flexibility, and synergy.

The architecture promotes production economies by allowing common ITS products and services to be assembled in a variety of ways to address a range of needs, saving money for consumers and reducing risks for producers. Conforming products from competing vendors will work together, and infrastructure implemented by one jurisdiction will be compatible and capable of working with systems in neighboring jurisdictions.

The architecture's open standards make it flexible enough to accommodate a wide range of designs and allow applications to evolve in step with new technologies and requirements. "Vendor lock-in," functional isolation, and obsolescence-all of which can be experienced with proprietary solutions-are less likely with adherence to a national framework. Access to a common communication and information infrastructure will make implementation more affordable compared with stand-alone systems. In short, the national ITS architecture results in a wider range of benefits by supporting a cross section of user services and facilitating their integration. The development of the national architecture is an important initial step toward achieving the vision of a nationwide, fully integrated ITS.

Institutional Issues and User Acceptance

A key advantage of the national ITS architecture is its acknowledgment of institutional realities and relationships. The architecture identifies approaches to institute new policies and ways of implementing transportation systems.

In addition, the national ITS architecture is being examined and considered carefully by ITS advocates in Europe, Asia, and other parts of the world. It is being used by U.S. firms to successfully market ITS development and engineering services internationally. U.S. DOT is particularly committed to achieving internationally consistent ITS architecture principles and standards, especially in North America, where implementation of compatible ITS user services between the United States and its neighbors to the north and south can facilitate trade.

Future Directions

Long-term stewardship of the architecture is an important goal of both the U.S. DOT and ITS America. The U.S. DOT has established the ITS Architecture Task Force to guide, promote, and facilitate effective, efficient, and rapid adoption of the national architecture. Key task force goals include the following:

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

A primary activity will be to facilitate adoption of the architecture's general concepts and approaches through technical assistance and awareness-building seminars aimed at professionals working for Federal, State, regional, and local transportation agencies. Efforts are also underway to include technical guidance on the architecture in the U.S. DOT's ITS educational initiatives and programs for building professional capacity.

Preliminary guidance has already been produced on how to use the architecture to integrate the components of a metropolitan ITS infrastructure, which is published in *Building the ITI: Putting the National Architecture into Action.* A draft guide to architecture implementation for transit applications has been finalized, and four similar guides covering other applications will be completed in 1997.

A critical next step is to validate the efficacy of the architecture through field implementation. The metropolitan and CVISN model deployments will help U.S. DOT to refine or expand the architecture as a comprehensive framework for building ITS infrastructure.

In addition, new user services or technologies will be incorporated in the architecture as the need arises. For example, in February 1996, U.S. DOT developed a national plan to investigate the potential application and benefits of ITS technologies at highway-railroad crossings. The ITS program has now incorporated this service in the national ITS architecture.

STANDARDS

Although the national ITS architecture defines how ITS components and subsystems can be linked together, development of standards is essential in achieving national compatibility and interoperability.

Standards and protocols establish a common vocabulary so that ITS elements can understand each other. Without them, systems conforming to the national architecture will have similar conceptual design and, perhaps, functionality but may be incapable of seamless information exchange. In addition, without standards for traffic controller interfaces, for example, local authorities might have to choose proprietary solutions that are not easily upgradeable or purchase expensive software customized for a particular equipment configuration. With appropriate standards, compatibility, interoperability, and expandability are much easier and more affordable.

The need for standards cuts across all areas of the ITS Program. U.S. DOT has identified four categories of critical ITS standards:

- **Data standards** provide uniform formats for data sharing across ITS applications. Examples include ITS data dictionaries, common data-formatting standards, location-referencing standards, and spatial data base interchange protocols.
- **Message** sets define message content and transmittal procedures among various ITS elements and subsystems.
- **Communication standards,** many of which already exist as industry standards, can be modified to provide additional functionality specifically for ITS applications. A need exists, however, to determine which of the available communication standards will be used for particular functions.
- **Performance standards** include performance guidelines that could be the basis for safety standards, including human factors guidelines for user interfaces.

PROGRAM GOALS

ISTEA directed the Secretary of Transportation to "develop and implement standards and protocols to promote widespread use and evaluation of ITS technology" and to "promote compatibility among ITS technologies implemented throughout the States." Consistent with this mandate, the ITS standards program has adopted the following five goals:

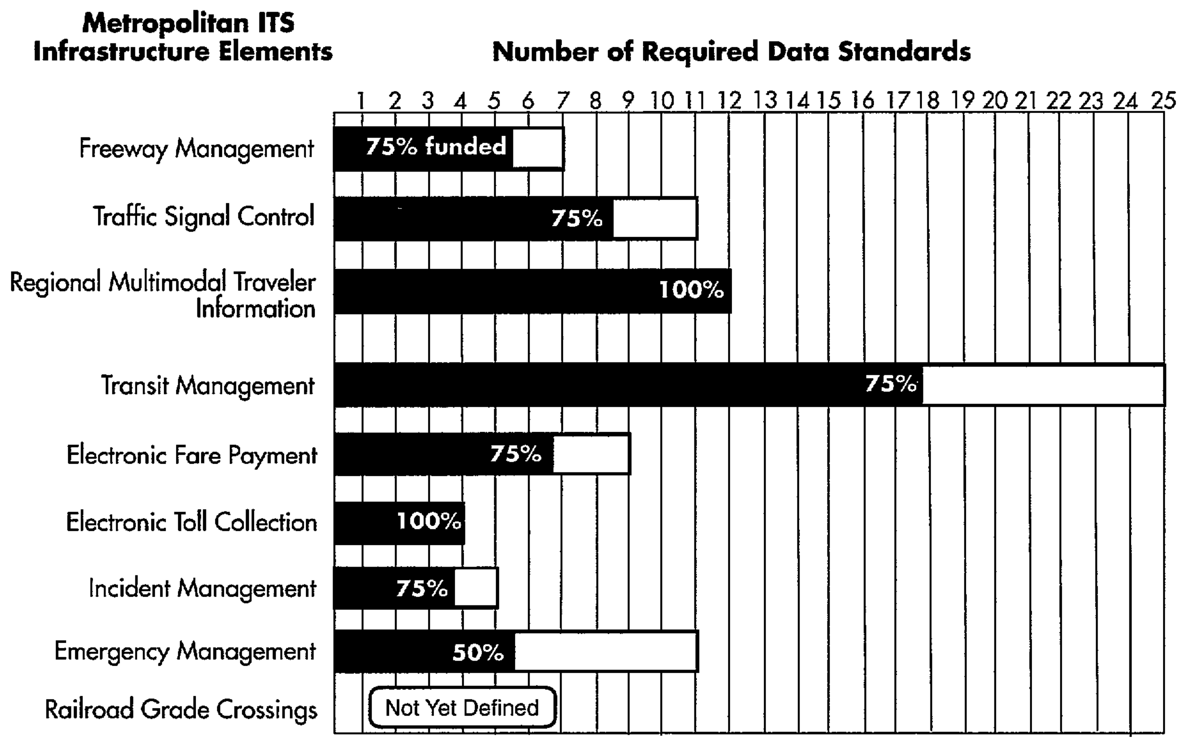
- Facilitate interoperability of ITS services at interagency, interjurisdictional, State, and national levels.
- Provide an environment in which public sector agencies (and others) have multiple vendors from which to choose when procuring ITS products and services.
- Ensure the safety of the traveling public.
- Facilitate the deployment of ITS.
- Provide an environment that will promote the creation of an ITS market.

The U.S. DOT's standards development efforts focus on critical areas of public interest, including safety, interstate commerce, and development of ITS infrastructure. The national ITS architecture development effort led to the identification of 45 interfaces to ensure national compatibility of 29 ITS user services by the end of 1996. Standards are also required for many of the remaining interfaces between ITS services and subsystems identified by the architecture. Consensus has already been secured on many standards, such as the National Transportation Communications ITS Protocol (NTCIP), which facilitates wireline communication between traffic management centers and field equipment.

PROGRAM ACTIVITIES

The ITS Program is currently concentrating on developing standards needed to effectively implement intelligent transportation infrastructure that supports metropolitan travel and CVO. These include key interface standards (including message sets and data dictionaries), communication standards (such as DSRC), location-referencing standards, and some safety standards. Exhibit III-2 shows the degree to which U.S. DOT has

EXHIBIT III-2
STATUS OF ITS ARCHITECTURE STANDARDS EFFORTS



funded standards required for metropolitan ITS infrastructure as of December 1996.

Although U.S. DOT hopes to secure ITS standards, it is also taking care not to stifle industry development or adoption of market-based standards. In 1996, U.S. DOT executed cooperative agreements with five SDOs to accelerate the nonproprietary development of standards for key ITS applications. These SDOs and their areas of concentration are as follows:

- The American Association of State Highway and Transportation Officials (AASHTO). focusing on State-level participation and roadside infrastructure.
- The American Society for Testing and Materials (ASTM), concentrating on DSRC systems.
- The Institute of Electrical and Electronics Engineers (IEEE), developing standards for electronics and communication message sets and protocols.
- The Institute of Traffic Engineers (ITE), working with traffic management and transportation planning systems.
- The Society of Automotive Engineers (SAE), focusing on in-vehicle and traveler information.

U.S. DOT selected five Standards Development Organizations to develop and gain consensus on standards. This 'bottom-up" approach allows the Department to leverage significant volunteer resources and, at the same time, foster public-private partnerships for ITS deployment.

U.S. DOT selected these five SDOs for their considerable expertise in developing standards. These professional organizations will ensure that their members and other stakeholders have an opportunity to participate in the process for setting standards. The SDOs will also provide technical support to expedite the adoption of ITS standards. Typically, the private sector participates in and supports the consensus-based SDOs, providing volunteer resources and, in some cases, field testing. This "bottom-up" approach allows the U.S. DOT to leverage significant volunteer resources and, at the same time, foster public-private partnerships for ITS deployment.

In anticipation of standards-setting activities, the U.S. DOT conducted surveys and forums to assess the needs of the ITS professional community. In 1996, ITS America and the U.S. DOT jointly surveyed ITS professionals, including members of SDOs, to establish priorities for standards. The survey revealed an immediate need for a traffic management data dictionary to standardize message sets required by advanced traffic management systems. The data dictionary allows data exchange between devices and systems and across jurisdictional boundaries. Based on the overall survey results, the ITS JPO began working with ITS America to establish a comprehensive plan for coordinating standards development efforts.

Also in 1996, the U.S. DOT held an interoperability summit to establish priorities for the development of standards for advanced traveler information systems. Summit participants reemphasized the need for standardized message sets and interoperability, commending the efforts to develop the traffic management data dictionary. The participants also concluded that interoperability is critical to the success of ATIS products and services because they will be used by the traveling public in a variety of ways and for various purposes. ATIS standards will be instrumental in facilitating this interoperability.

Technical Lessons

Some ITS standards will evolve quickly, while other, de facto, standards may need near-universal acceptance by users to stimulate adoption by manufacturers and providers. Technologies slated for near-term deployment-specifically, the metropolitan intelligent transportation infrastructure and advanced CVO-need immediate guidance on standards.

Benefits

Standards enable the integration of products by different vendors and create a broad-based market for retrofitting existing systems, thereby extending the useful life of existing system infrastructure and facilitating evolutionary technology enhancements. Interoperability and the interchangeability of basic components also decrease capital acquisition and life-cycle maintenance costs for consumers by encouraging price competition.

Institutional Issues and User Acceptance

The lack of ITS standards seriously inhibits widespread deployment. Ironically, without widespread deployment activity, there is little industry motivation to accelerate development of standards. The lack of clear and stable standards increases the risk to private firms that develop and market ITS products and services. Public agencies are also hesitant to invest in ITS infrastructure that newer, but incompatible, system technologies might render obsolete.

To ensure that developed standards have broad consensus support and benefit as much as possible from the accumulated knowledge of the ITS industry, the U.S. DOT is not imposing standards from above. Instead, U.S. DOT is supporting, guiding, and reinforcing the existing consensus standards development efforts in the United States by providing funding to five **SDOs.** These innovative cooperative agreements have created a new model of public-private partnership for accelerating the development and adoption of standards.

In addition, U.S. DOT has assimilated the American National Standards Institute (ANSI) standards development process and has worked to foster coordination among American standards-setting bodies, the Comite Europeen de Normalisation, and the International Standards Organization (ISO). ITS America represents U.S. interests in global standards development through participation in Technical Committee 204 of the ISO.

Future Directions

Agreed-upon national standards are crucial to realizing the vision of a nationwide intelligent transportation infrastructure in which ITS applications can deliver services wherever a traveler goes. Over the next several years, the standards program will continue to pursue standards for critical interfaces for ITS deployment. The formal adoption and implementation of the NTCIP suite of standards remain a top priority. Other priorities include determining a DSRC protocol for wireless vehicle-to-roadside transactions and promulgating standards and guidelines for the safety performance of in-vehicle ITS devices.

In support of these goals, U.S. DOT has formulated a strategic plan to target Federal funding toward specific standards development activities. Federal funding for ITS infrastructure will also be linked to adherence of system components to national standards. As a general rule, the ITS Program will give priority to standards activities that belong to the following two tiers:

Tier 1 (0 to 3 years)

- **Current activities of SDOs** that mesh with the Federal objectives of promoting national interoperability and facilitating deployment of ITS infrastructure, including development of message sets and special ITS communication standards.
- **Foundation standards,** which support the general ITS deployment and cover multiple interfaces in the national ITS architecture, such as data dictionaries, location referencing, and safety and human factors standards.
- **CVO standards,** primarily for DSRC and electronic data interchange.

- **Other standards requirements** as identified by the national architecture that supports ITS infrastructure, typically in the form of message set standards.

Tier 2 (3 to 5 years)

- **Requirements outside the intelligent transportation infrastructure** identified by the national architecture.
- **Continued collaboration** among the ITS JPO, SDOs, and ITS America to ensure timely development of standards and protocols. Partial funding will be provided when necessary to ensure that the process of funding does not supplant, weaken, or discourage the volunteer consensus process of the SDOs.

HUMAN FACTORS RESEARCH

The effectiveness of ITS depends on user-oriented designs. With in-vehicle information services, for example, drivers will have access to much more information than in the past. If this information is not presented with the user in mind, information overload will diminish both efficiency and safety. In particular, commercial drivers have extra requirements (e.g., cargo monitoring, scheduling of multiple stops, roadway restrictions, and adherence to commercial regulations) that could divert drivers' attention from the primary task of driving safely. System operators housed within state-of-the-art traffic management centers will also be charged with responding to increasing levels of real-time information provided by advanced traffic management systems. In the future, smart vehicles will deliver a multitude of information, from collision warnings to route guidance, that will only prove beneficial if drivers can respond to it efficiently and safely. Automated highways will also create a new mode of "hands-off" driving.

Human factors research aims to ensure that ITS applications are safe and user friendly This research investigates the effects of increasing levels of information on human performance and safety, specifically to ascertain the threshold between effective delivery of information and information overload.

Human factors research aims to ensure that these and other ITS applications are safe and user friendly. This research investigates the effects of increasing levels of information on human performance and safety, specifically to ascertain the threshold between effective delivery of information and information overload.

PROGRAM GOALS

The goals of the human factors program are to improve the operational efficiency and safety of ITS products, services, and applications. To meet these goals, the ultimate objective of the program is to provide design guidelines and specifications for ITS manufacturers and service providers.

PROGRAM ACTIVITIES

The human factors program specifically addresses collision avoidance systems, ATIS/CVO, ATMS, and AI-IS applications. In 1996, FHWA's Turner-Fairbank Highway Research Center and NHTSA completed a human factors strategic plan to guide current and future activities.

Collision Avoidance Systems: The human factors research program for collision avoidance systems, which is administered by NHTSA, investigates driver behavior and performance as they relate to collision avoidance, optimal methods to convey critical safety information to drivers, driver workload limitations, and the possible long-term effects of dependence on advanced technologies, such as over-reliance on automated systems and risk compensation.

ATIS/CVO Services: Human factors research into ATIS/CVO services includes investigation of in-vehicle route guidance and navigation, motorist services,

and safety advisories and warning systems. This research examines such issues as the information requirements of commercial and private vehicle drivers, display formats, accuracy of traffic information, and transition between ATIS functions. In particular, U.S. DOT investigates the effects of age, spatial ability, and navigational information provided by in-vehicle devices on navigational performance, as well as design impediments to their acceptance and efficacy. The aim of this research is to set priorities for information delivered to drivers, so that routine traveler information does not obscure or delay critical safety messages. In December 1995, FHWA published ***Preliminary Human Factors Design Guidelines for Driver Information Systems,*** which addresses in-vehicle driver interfaces.

ATMS Research: Research in this area focuses on the human factors requirements of operators in traffic management centers as they perform a variety of tasks, including traffic monitoring and incident detection. A comparative analysis of the design and operation of different kinds of advanced control centers (e.g., highway traffic, aviation, military) describes the critical input, data-processing, and output functions that influence optimal management of roadway traffic.

AHS Research: These human factors efforts focus on the limits of driver capabilities, particularly during the transition between "hands-on" and "hands-off" operation.

The integration of new information technologies supporting the needs of all drivers, including inexperienced and aging drivers, into the "human-centered" smart vehicle of the future will be a critical component of U.S. DOT's future research agenda. Coordination with other government agencies is already underway.

Technical Lessons

The human factors research program has resulted in the following important lessons learned:

- The most important design principle for **in-vehicle devices** is consistency between information displayed inside the vehicle and corresponding information displayed on road signs.
- Driver workload may be adversely affected by business or convenience devices in the vehicle, such as telephones, computers, or fax machines.
- For determining the safety of in-vehicle devices, performance measures include standard deviation of lane position, mean and standard deviation of speed, mean frequency of driver eye fixations to other locations, and the number of collision near-misses.
- Research with the ATMS human factors research simulator has identified some of the factors that affect operator performance in traffic management centers. For instance, results indicate that operators perform more effectively using automated incident detection and location systems than they do using manual detection systems.

Benefits

Several major products are emerging from the human factors program, including design guidelines and handbooks for ITS information system and traffic management center designers, a traffic management center research simulator, data bases that catalog knowledge obtained from human factors research, and analysis tools to allow researchers to evaluate effects on human performance. The program has already completed an assessment of the effect of in-vehicle display systems on driver performance, helping to guide the design of initial in-vehicle display prototypes. The program is currently developing human factors design tools that will assist in the design of advanced traffic management centers.

Future Directions

The human factors research program will pursue more aggressive R&D efforts to fully realize the safety potential of ITS technologies that are nearing the market. Particular safety-related problems of inexperienced drivers and the aging population will be addressed by focusing on the abilities of these groups to cope with and benefit from information delivery systems and technologies that will be found in the smart vehicles of the future. The program will continue to focus on the needs of commercial drivers and traffic management center operators to ensure optimal workloads to perform safely and efficiently. The program also plans to investigate more fully the human factors issues associated with AHS. Expanding from its current focus on the effects of singular technologies and systerns, the program will also concentrate on how combinations of ITS applications operating within a greater ITS infrastructure will affect human performance and safety.

"Enabling" technologies, such as sensing, surveillance, information-processing, communication, and automation technologies, are the eyes, brains, and brawn of ITS services.

ENABLING TECHNOLOGIES

In order for ITS applications to function and deliver services, they must be able to see, think. communicate, and respond to information. "Enabling" technologies, such as sensing, surveillance, information processing, communication, and automation technologies, are the eyes, brains, and brawn of ITS services. Often these technologies are off-the-shelf products developed for non-transportation applications. In some cases, enabling technologies, such as civilian GPS, have been modified from high-tech military functions for the commercial market. Direct off-the-shelf application of these technologies to surface transportation concerns is, however, complex and difficult and requires significant applied research. Highlights of the U.S. DOT's research to adapt and refine enabling technologies are outlined in the following paragraphs.

TELECOMMUNICATIONS

ITS applications have extensive wireline and wireless communication needs, and there is intense debate about how these needs can be fulfilled. Transportation managers desire availability, security, a high level of reliability and quality, and cost effectiveness. These needs can be met through various options of procuring (leasing) capacity from the existing telecommunication market, procuring capacity through innovative shared-resource agreements, building a dedicated network to meet transportation needs, or using a combination of lease/build options.

We have found that the lease/build decision is strongly influenced by local geographic and political conditions; the choice of telecommunication systems is unique to each State and local ITS implementation. The Federal role is to provide insight and policy support and to compile specific case information to share with transportation decisionmakers. In April 1996, the U.S. DOT published ***Shared Resources: Sharing Right-of- Way for Telecommunications,*** which identified legal and institutional issues of shared resources. Through these efforts, we have encouraged a number of actual network deployments and innovative procurements of network capacity and services in some of the more congested metropolitan areas and high-density States, such as the Baltimore-Washington, DC corridor; Detroit; San Francisco; Missouri; Ohio; and Maryland.

Continuing technological advances in digital communication technologies and the passage of the Telecommunications Reform Act of 1996 suggest that a wider array of communication options will emerge during the next several years. Ongoing research assesses technological advances, new commercial offerings, and opportunities for innovative public-private partnerships to enhance public sector ITS deployment strategies, policies, and practices.

SPECTRUM MANAGEMENT

Many existing and envisioned applications under the ITS umbrella require a short-range wireless communication link. Transfer of information between vehicles and the roadside infrastructure, such as the type required by electronic toll collection systems, is the most popular example of such an application. The ITS community has settled on the term "dedicated short-range radio communications" to describe this essential capability.

Because many ITS services rely on wireless communication technologies and because of revolutionary changes in both technology and spectrum management brought about by the Telecommunications Act, the U.S. DOT has become progressively more involved in issues affecting spectrum availability for ITS. The national ITS architecture, completed in June 1996, concluded that existing and emerging commercial communication services could meet the needs of most ITS user services, with one notable exception. Capability for DSRC must be found to support future expansion of 11 essential user services that require a link between a vehicle and the roadside.

As a result, the U.S. DOT has been supporting efforts to obtain dedicated spectrum for DSRC. In May 1996 the National Telecommunications and Information Administration of the Department of Commerce granted FHWA the use of 7.5 MHz at the 5850 MHz band to experiment with DSRC applications. The JPO has also been lending technical and policy support to ITS America's pursuit of a permanent FCC reallocation of this same band, which would allow public and private organizations to deploy DSRC services nationwide that could coexist with existing applications in the band.

The JPO has also been involved with FCC rulemaking that concerns public safety uses of spectrum, implementation of enhanced 911 services on cellular networks, and other spectrum issues that could affect delivery of ITS services. U.S. DOT coordination among its modal administrations, including the JPO, on spectrum issues has been steadily increasing to keep up with the constantly changing regulatory environment.

Another important issue is whether and to what degree this DSRC link should be standardized across the Nation. Many believe that there should be a continuous frequency band in which to locate these applications, but to date there is no such allocation for ITS services. The 5.8 GHz band, which consists of frequencies between 5850 and 5925 MHz, has been identified as potentially viable because it has a relatively sparse (and ITS-noninterfering) population and because of its expected imminent release from primarily government use to commercial use.

Surface transportation agencies are examining ways to cope with the impact of radio frequency spectrum allocations and refarming on ITS deployment strategies and plans. Transit agencies, for instance, are being called on by the FCC to upgrade existing radio communication systems (at considerable expense) to digital radio systems that operate in smaller channel spacings. Similarly, investments in wireless communication systems are subject to deferral until there is sufficient assurance that ITS uses will not have to move to another frequency before equipment investments can be recouped.

FM Subcarrier Technology

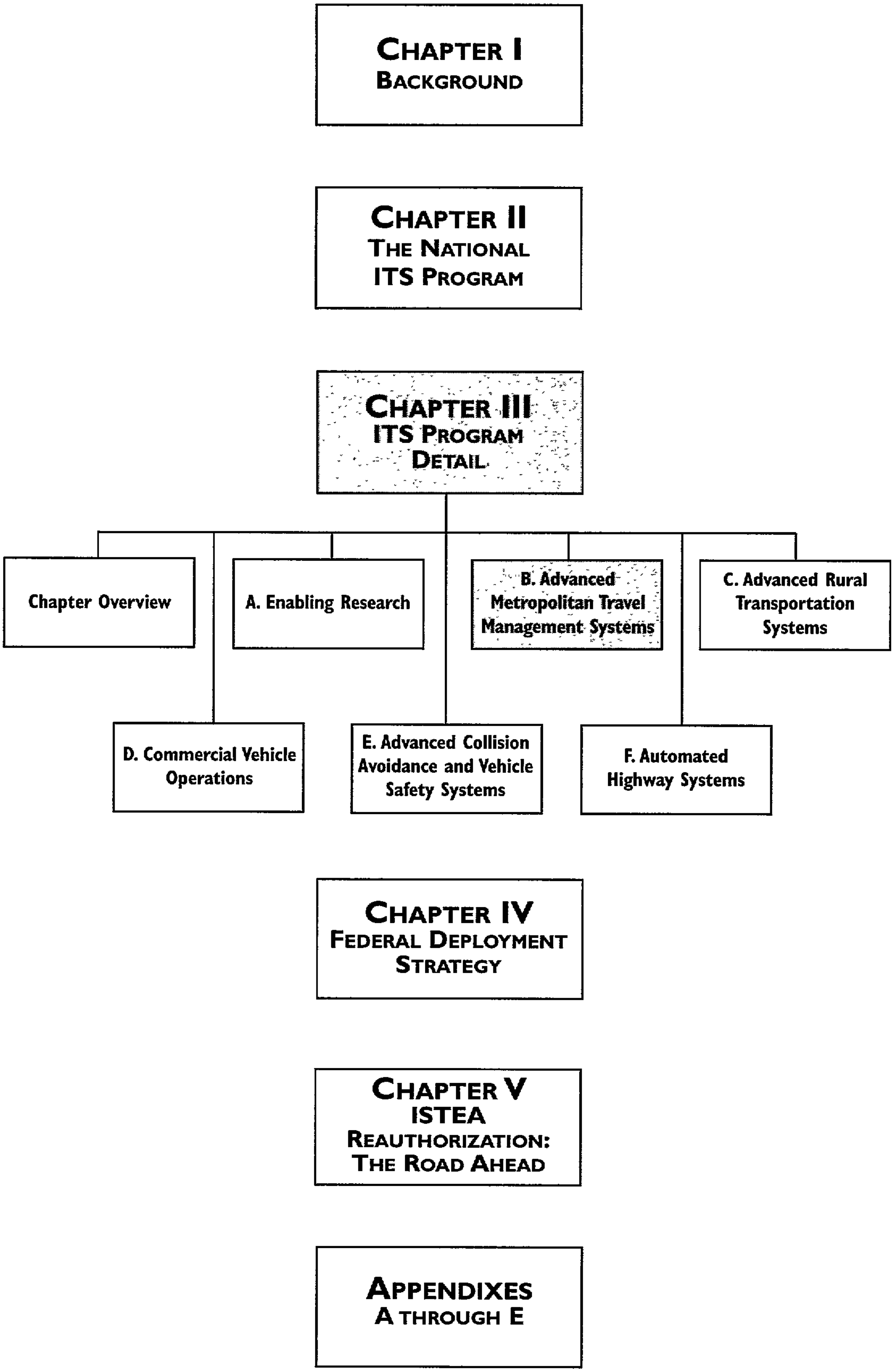
FM subcarrier systems that have high data rates and are compatible with commercial FM transmitters have demonstrated technical feasibility for use in a mobile environment. Higher data rates are needed because the radio broadcast data system standard, an alternative broadcast technique appropriate for reporting congestion and incidents, does not offer sufficient data throughput to meet anticipated needs for more detailed traveler information, such as travel time estimates. Testing and evaluation of specialized communication techniques, such as the subcarrier traffic information channel, are necessary to support the deployment of commercially viable traffic and traveler information systems.

AUGMENTED GPS

The U.S. Department of Defense applies GPS signal perturbations for security purposes, making civilian GPS service insufficient for most ITS applications. Although the accuracy degradation still allows locations to be determined within a few city blocks, ITS services that guide travelers or notify emergency response teams require augmented GPS to pinpoint more precise locations. This type of system is outlined in the recent U.S. DOT ***Technical Report to the Secretary of Transportation on a National Approach to Augmented GPS Services,*** which concludes that U.S. DOT, in coordination with the Department of Commerce, should plan, install, operate, and maintain a low-to-medium frequency beacon system to augment GPS. The U.S. DOT will determine the optimal system configuration and provide technical assistance to States and localities regarding the location of beacons.

NATIONAL SPATIAL DATA BASE AND LINK IDENTIFICATION

Several methods for identifying transportation network links are being examined to provide a technical basis for standardizing the format, content, and accuracy of spatial data. A method for denoting specific transportation links in any part of North America is being developed and will be tested using sophisticated techniques for location referencing.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III. ITS PROGRAM DETAIL

B. Advanced Metropolitan Travel Management Systems

Roughly 80 percent of Americans live in densely settled, but geographically dispersed, metropolitan areas, which include cities and their adjacent suburbs. The primary links between these metropolitan areas are their surface transportation systems-the networks of highways, roadways, bus routes, and rail lines-that allow residents to live and function by providing access to work, homes, schools, services, and each other. Without extensive and efficient transportation systems, the economic and social health of metropolitan areas would deteriorate.

Over the past 20 years, however, urban and suburban transportation systems have struggled to keep pace with the growing and changing travel needs of metropolitan areas. These areas have seen increases in population, especially in the suburbs, and rising numbers of single households and licensed drivers, both of which have led to more vehicles on the roads and escalating vehicle miles traveled. In the past decade alone, traffic has grown by 30 percent. The result of this growth has been chronic gridlock, which drains productivity, impedes economic growth, and wastes energy. Americans spend 2 billion hours each year stuck in traffic, and congestion costs businesses $48 billion annually. In addition, congestion increases the number of incidents and accidents, which constrict limited road capacity. Traffic congestion shows no signs of subsiding. In the next 10 years, the U.S. DOT expects that the number of cars on our roads and highways will increase by 50 percent.

Because economic and land development has migrated away from central cities to the outer suburbs, more Americans travel from suburb to suburb and from edge city to edge city than to a single central business district. In addition, the work commute has become an increasingly smaller proportion of travel. In 1969, for example, work and work-related travel accounted for more than 41 percent of all local travel, but by 1990, work-related travel accounted for only 26 percent of all trips. These changes in work and lifestyles prompt the metropolitan traveler to seek information on travel options more frequently; however, travelers typically receive little information on alternative driving routes to avoid congested roads or on alternatives to driving altogether. Most publicly available travel information is limited to static reports on traffic conditions affecting the morning and evening driving commute, but travelers often need information on multiple travel options and potential routes.

The struggle of State and local governments to meet the travel needs of metropolitan residents and businesses does not occur in a vacuum. Traffic volumes in most areas are growing at a time when transportation budgets are shrinking. In densely developed central cities and suburbs, it is not always possible or desirable to build more roads to alleviate congestion, because roads already fill the existing rights-of-way and road building is often costly and disruptive. Transit authorities also contend with slashed budgets while straining to meet greater expectations from customers for improved service.

In the midst of these budget constraints are the larger concerns of metropolitan areas across the United States: revitalizing cities, meeting clean air requirements that can improve the quality of life for residents, and providing essential services. Transportation plays a critical role in addressing these concerns, but it is readily apparent that traditional methods of providing transportation services, in particular building more road capacity, cannot resolve entrenched congestion. It is also apparent that no single mode of transportation can satisfy our growing and changing travel needs. Instead, officials at all levels of government-Federal, State and local-must ask themselves how multiple modes of existing transportation infrastructure can be managed creatively and how the demand for travel can be managed efficiently.

The ITS technologies and services generally categorized as advanced metropolitan travel management systems offer promising and responsive solutions. These systems include advanced traffic management systems (ATMS), advanced traveler information systems (ATIS), and advanced public transportation systems (APTS), which target the three major, interrelated components of metropolitan surface transportation systems: roads and highways, travelers, and public transit. These applications can be described as follows:

- **Advanced traffic management systems** include traffic signal control, freeway management, incident and emergency response management, electronic toll collection, and highway-railroad crossing protection systems. These systems use monitoring, information-gathering, and control (automation) strategies to improve traffic flow and allow more efficient response to emergencies and accidents.
- **Advanced traveler information systems** provide pre-trip and en route travel information through a variety of communication devices (e.g., broadcast radio, cellular phone, the Internet, cable television, kiosks). The users of this information include travelers, traffic managers, and transit operators.
- **Advanced public transportation systems** use advanced fleet management systems, multimodal traveler information, and electronic fare payment to improve the efficiency and quality of transit service.

Each of these three applications can improve the efficiency of specific modes of transportation, provide residents and businesses with better information on travel options, and help create a more efficient multimodal transportation network. When they are integrated, these components can create a truly seamless and responsive intermodal transportation system.

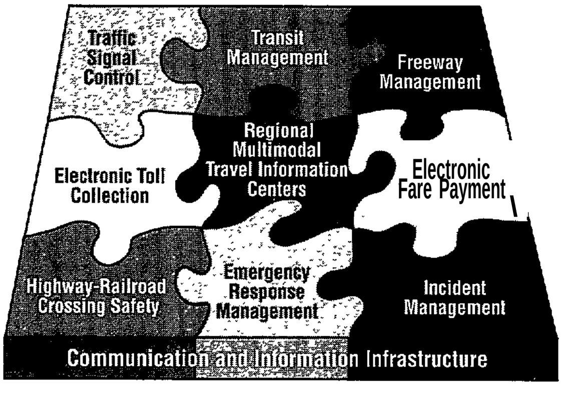
BUILDING A METROPOLITAN INTELLIGENT TRANSPORTATION INFRASTRUCTURE

The Department has proposed a common information and communication platform-an intelligent transportation infrastructure for metropolitan areas-to enable ITS user services to work together as parts of a finely tuned system. This metropolitan ITS infrastructure will be instrumental in advancing both multimodalism and intermodalism in metropolitan areas.

As shown in Exhibit 111-3, this infrastructure is the integrated set of nine basic elements needed to facilitate ITS deployment and lay a foundation for future services. These nine elements, which are primarily the responsibility of the public sector, are traffic signal control, freeway management, transit management, incident management, electronic toll collection, electronic fare payment, highway-railroad crossing safety, emergency response management, and regional multimodal traveler information.

The metropolitan intelligent transportation infrastructure, however, is a system, not just a collection of nine components. Its traffic detection and monitoring, communication, and control systems are necessary to support a variety of products and services in metropolitan

EXHIBIT III-3
METROPOLITAN ITS INFRASTRUCTURE



areas, and it allows these components to communicate with each other and work together. The metropolitan transportation infrastructure functions like the local- and wide-area networks used in most workplaces to allow electronic file sharing, mail, and other information exchanges within a single building or between geographically dispersed sites, even though employees may have different brands of computers and software of varying capabilities. Workers increase their productivity and utility, and so does the workplace as a whole.

Ultimately, the metropolitan intelligent transportation infrastructure will enable cities and towns across the Nation to link their traffic, transit, and emergency service systems to provide for more efficient and safer operations that are tailored to meet specific regional transportation needs. For example, metropolitan ITS infrastructure will allow transit buses equipped with automated vehicle location (AVL) devices to provide travel time and speed data that will support traffic signal control management and real-time scheduling. Freeway and incident management systems will provide information on traffic flow to emergency service providers, cutting response times and saving lives. Travelers will have an array of new information services at their fingertips; real time traffic and traveler data will be collected through ITS and made available by private service providers to homes, offices, public kiosks, and vehicles.

Benefits of Metropolitan ITS Infrastructure

Although each component of the metropolitan intelligent transportation infrastructure produces singular advantages, the integrated whole is expected to produce multiple, synergistic benefits, which the U.S. DOT is evaluating along with expected capital and operating costs. The benefits of the individual components are well documented in this and other reports, most notably, ***Intelligent Transportation Infrastructure***

Implement the Intelligent Transportation Infrastructure across the United States within a decade to save time and lives and to improve the quality of life.

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Benefits: Expected and Experienced. To date, no community in the Nation has all nine components in place. Atlanta has come the closest to building metropolitan intelligent transportation infrastructure as a result of preparing its transportation system for the 1996 summer Olympics. Based on its findings from operational tests, the priority corridors, and early deployment planning activities, the U.S. DOT expects that metropolitan infrastructure will contribute to an expanded trasportation network that will benefit traffic managers, transit operators, commercial vehicle operators, and the traveling public.

Enhancing Use of Existing Capacity

The U.S. DOT estimates that road capacity will have to increase by about 30 percent to accommodate the current level of highway congestion in 50 large metropolitan areas over the next decade. Creative use of ITS technologies can, however, increase the productivity (throughput) of existing transportation facilities. The U.S. DOT estimates that by deploying ITS infrastructure over this same time period, taxpayers could save 35 percent of required investment in urban highways. As an integrated system, metropolitan intelligent transportation infrastructure would offer shorter commuting times, more travel options, improved safety, and a cleaner environment.

Field tests of individual ITS user services have demonstrated that components of ITS infrastructure can improve the efficiency of existing transportation infrastructure. As a dramatic example, when two sections of the Santa Monica Freeway collapsed during

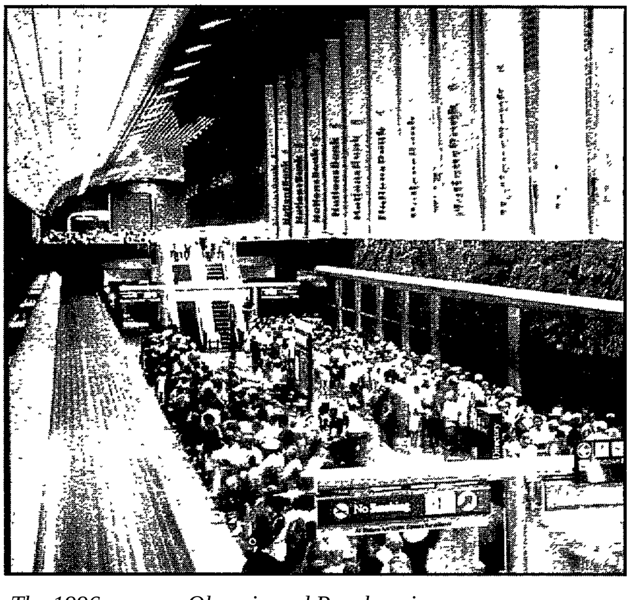
ATLANTA ITS GOES FOR THE GOLD

During the summer of 1996, Atlanta hosted one of the biggest events in history, which called for unprecedented coordination of transportation services. More tickets were available for the Olympic games in Atlanta than for the Barcelona and Los Angeles games combined. More than 10,700 athletes participated in the games, and more than 2 million people went to Atlanta to see the historic event.The Metropolitan Atlanta Rapid Transit Authority (MARTA) used 750 buses and 200 rail cars around the clock to transport 17.8 million passengers in I7 days, including 1.3 million in a single day. And that was just the spectators! A total of 2,000 buses and 4,000 drivers was used throughout the Olympics to transport athletes, Olympic dignitaries, the media, and spectators.

Atlanta, already one of the Nation's most congested areas, enlisted the support of dozens of partners to prepare for the event using an integrated approach to intelligent transportation. Not only did the city achieve its transportation vision for the Olympics, but it now serves as a model for a highly integrated, intelligent transportation system.

During the Olympics, five ITS projects were in operation: the Atlanta Regional Transportation Management System; the Atlanta Traveler Information Showcase, an ATIS project that delivered traveler information via cable television, the World Wide Web, and other services; an APTS service known as ITS MARTA '96; high-occupancy vehicle (HOV) lanes; and a field operational test consisting of 130 kiosks that offered information ranging from real-time traffic conditions and route planning to ride sharing and weather forecasts. The regional transportation management and ATIS elements linked eight agencies, which tracked freeway, surface street, and transit operations in what is perhaps the most complex and comprehensive ITS deployment ever attempted in the United States.

At the core of the Atlanta ITS effort was the $ 140 million Atlanta Regional Transportation Management Center (TMC), which provided surveillance and communication through sensors, video, and fiber optic lines on all interstates inside Interstate 285 at Atlanta' s perimeter. TheTMC served as the central clearinghouse for all transportation information in the area. In addition, six transportation control centers in surrounding counties fed information into and retrieved it from the TMC. TheTMC also received information from MARTA's Transportation Information Center, the MARTA bus fleet, a public cellular phone-in line, and various airborne and ground-based traffic spotters. During the Olympics, all this information was used collectively to manage transportation and mobility.



The 1996 summer Olympic and Paralympic games. held in Atlanta, created the focus for one of the most ambitious ITS deployments in the United States.

Partners in the ITS integration effort included the U.S. DOT, FHWA, FTA, Georgia DOT, MARTA, the City of Atlanta, and nearly two dozen private companies. Additional coordination took place with Atlanta International Airport, the Atlanta Committee on the Olympic games, Cobb (County) Community Transit, and the five counties surrounding Atlanta.

While visitors to the Olympic games directly benefited from Atlanta's cutting-edge transportation technologies, the real success story is the level of cooperation and system integration that still endures.

the 1994 earthquake, the Smart Corridor field test was put to an early trial. Using video surveillance, changeable message signs, and adjustment of traffic lights, the system was able to divert the equivalent of 20 lanes of additional traffic through the parallel surface street network with no resulting gridlock. In addition, the smart interactive kiosks were deployed to inform travelers of highway conditions and help them plan trips via transit. Originally, two kiosks were scheduled to be deployed as part of a test of this technology. After the earthquake, 78 were installed at major gathering points (e.g., Union Station, malls) to enable people to consider their travel alternatives more effectively.

Promoting Data Sharing

ITS is mostly focused on collecting, analyzing, and distributing information. The intelligent transportation infrastructure allows data from a variety of sources to be shared and compiled, so that the combined data base is more complete and more cost effective to update. This broad data base allows jurisdictions to better implement congestion management systems and other types of management programs. In Atlanta, for example, the major transportation agencies shared the same information through a central clearinghouse using a client-server architecture. The architecture allowed jurisdictions to operate their transportation facilities autonomously and gain access to data from other jurisdictions in a format that was uniform, consistent, and current for all systems. The central system, which handled all compatibility issues, can also expand to accommodate data requirements. In an era of constrained resources, a common infrastructure saves redundant spending.

Creating "Virtual" Management Teams

Metropolitan areas generally consist of multiple local jurisdictions and State agencies, each responsible for providing some level of traffic and transit surveillance, management, and control. These agencies have different responsibilities and motivations, which makes it difficult to create truly intermodal surface transportation systems. The ITS Program, through its field operational tests, ITS priority corridors program, and EDP activities, has promoted sharing of ideas, tasks, and responsibilities among diverse jurisdictions and cooperation between public and private partners. In Atlanta, for example, the ITS effort created de facto management teams that included several Federal, State, and local traffic and transit agencies. Because intelligent transportation infrastructure will result in cost savings by allowing agencies to share infratructure, it will provide the impetus for different agencies to forge alliances.

Fostering Intermodalism

Intermodalism is accomplished by increasing transportation options, providing seamless connections between modes, and coordinating the activities of public agencies. The metropolitan intelligent transportation infrastructure accomplishes all three tasks by addressing the three interrelated elements of metropolitan transportation systems-roads and highways, travelers, and transit-and by providing better information on travel options and coordinating the activities of multiple travel modes. At the core of the Atlanta ITS effort, for example, was the Atlanta Regional Transportation Management Center, which provided surveillance and communication on all Interstate highways using road sensors, video, and fiber optic lines. Other information on the network was provided by six transportation management and control centers in the counties surrounding Atlanta, which integrated local traffic signal systems with freeway operations for those counties. In addition, the Metropolitan Area Rapid Transit Agency (MARTA) gathered information on road conditions from its buses, 239 of which were equipped with tracking and communication equipment that relayed data to the agency's transportation information center. Information also came from airborne and ground-based traffic spotters, a public cellular phone-in line, and a variety of other sources. All this information was used collectively to better manage traffic signals, freeways, and transit facilities and was strategically provided to travelers through a variety of media.

A Story of Shared Infrastructure: The Courtland Street Off-Ramp

The old adage, "A picture is worth a thousand words," held true during the 1996 Olympic games, when a single image not only told a story, but spurred agencies into coordinated action.

The "picture" was a view of the Courtland Street ramp in Atlanta. The story it conveyed was that traffic backups were causing severe delays. The action it spurred was a multilayered response to solving traffic problems, accomplished as a result of Atlanta's integrated approach to intelligent transportation.

Courtland Street ramp is an off-ramp from the downtown "connector" section of Interstate 75/85. A heavily used exit ramp, it served key downtown Atlanta hotels and other access points during the Olympics. Despite light traffic during the early days of the games, the Courtland Street ramp suffered heavy congestion that stretched onto the interstate and blocked the downstream entrance ramp serving athlete buses. Full camera coverage of I-75/85 and the integrated design of Atlanta's ITS infrastructure enabled effective and efficient handling of the Courtland Street problem.

Atlanta's ITS was designed with traffic "centers" distributed at the city traffic department, city police, Georgia Emergency Management Authority, several counties, the transit authority (MARTA), and the Georgia DOT (GDOT). All centers share the same information and similar capabilities. When managers at each center viewed the traffic backups on Courtland Street, they could assess the situation and coordinate a response with managers from other centers.

By sharing information infrastructure, public agencies in Atlanta were able to work together to prevent backups at the Courtland Street off-ramp.

During a debriefing, traffic managers discovered that they were literally looking at the same camera view and acting to resolve the situation based on their unique responsibilities. GDOT used the image to manage its response on the freeway, while the City of Atlanta was reviewing the effectiveness of its signal timing modifications. At the same time, MARTA used the information to determine the impact on the spectator fleet, Georgia State patrol used it to manage the athlete fleet, and the Atlanta Committee for the Olympic Games used it to coordinate various aspects of its transportation program.

Sharing the same capabilities-indeed the same camera view-enabled multiple agencies at numerous locations to develop a coordinated response. Clearly, this type of efficient response would not be possible without the capabilities provided by ITS technologies and an integrated approach to ITS deployment.

Increasing Customer Access to Information and Options

Customers are the impetus for addressing concerns about regional traffic congestion. In an age of expanding regional boundaries, multiple jurisdictions, and local transportation systems, individual travelers need up-to-date information about how they can reach their destinations safely and quickly. ATIS services are the cornerstone of a renewed customer orientation in delivering transportation services. ATIS can transfer data gathered by other ITS technologies-on traffic flows, incidents, and road and weather conditions-into information programs on alternative routes, travel times, route guidance, and the comparable performance of other modes for the same trip. This information can be transmitted via a variety of media. In Atlanta, cable television, cellular phones, handheld personal computer devices, and public kiosks were deployed throughout the city to help visitors and residents navigate the transportation system during the Olympics. For example, public kiosks at Atlanta Hartsfield Airport gave travelers an overview of their ground transportation options and the estimated departure times of bus, rail, and van services; weather and tourism information; and regional driving conditions.

Fostering Private Sector Involvement in Developing ITS Services

Local relationships determine whether infrastructure is deployed by the public sector, the private sector, or a combination of the two. In any case, ITS products developed by the private sector are of little value to consumers without information and communication structures in place to make them work. The presence of an ITS infrastructure inspires confidence that products will be able to "plug" into the system and provide intended services to consumers. For example, the development of the national information infrastructure, originally funded as a Federal research project, has spurred a proliferation of public and private software developments and applications directed toward private and public consumers.

Program Activities-Supporting Advanced Metropolitan Travel Management Systems and Infrastructure

The Federal ITS Program has undertaken several activities to help communities understand the benefits of advanced metropolitan travel management systems and the metropolitan intelligent transportation infrastructure. The ITS Program will also help these communities plan and "buy smart" to connect future technologies with existing components to form an integrated transportation system.

Leadership Activities

The U.S. DOT has been the leader in setting goals and developing strategies for deploying ATMS, ATIS, and APTS user services and for building ITS infrastructure in metropolitan areas. In particular, Operation Timesaver is the first national directive to articulate the goals and benefits of metropolitan intelligent transportation infrastructure (ITI). The U.S. DOT formed the IT1 Deployment Initiatives Coordinating Group in January 1996 to provide "coordination, guidance and leadership for U.S. DOT actions" in helping public and private sectors to build ITS infrastructure. This group (originally composed of FHWA, FTA, and ITS JPO) facilitates outreach and communications, mainstreaming, training, and progress measurement and reporting.

R&D

The program's R&D efforts to date have focused largely on creating integrated systems of advanced techniques for traffic control and surveillance, refining analytical tools for evaluating new technologies, and developing enabling technologies to support transit fleet and traffic management. In addition, efforts have helped to establish and demonstrate the technical feasibility and practicality of technologies and services, identify institutional impediments to deployment, and evaluate potential benefits and costs. In the past, R&D was limited to testing and evaluation of isolated components; now, the integrated system approach allows for the assessment of large-scale deployments and system requirements.

Operational Tests, ITS Priority Corridors, and EDPs

The U.S. DOT has conducted 17 field tests of ATMS, 15 tests of ATIS user services, and 29 field tests of APTS applications in cities and suburbs across the Nation; altogether 24 field tests have been completed. Although some field tests have focused on resolving technical problems and understanding the impact of ITS technology on users and the system, the ITS

Priority Corridors Program has concentrated on institutional arrangements needed for interjurisdictional and multimodal transportation systems at the metropolitan and regional levels. The EDP program, which was carried out in 75 metropolitan areas, focused on how ITS user services, particularly ATMS, APTS, and ATIS, could be incorporated into existing transportation infrastructures to solve local problems. As a result, EDP activities have helped move metropolitan transportation planning from single-mode thinking to a more comprehensive system integration approach. The specific scope, mission, and accomplishments of these three programs are detailed in Chapter II of this report.

> ***If we're going to enable initiatives like traveler information and traffic management systems to work, we have to establish strong institutional connections among various jurisdictions, government agencies, and the private sector.***
>
> MORTIMER DOWNEY
> DEPUTY SECRETARY OF TRANSPORTATION

NATIONAL ITS ARCHITECTURE

In 1996, the U.S. DOT finalized the national ITS architecture, which addresses advanced metropolitan travel management system services. The architecture defines the subsystems and data flows (i.e., information that must be shared between subsystems) required to make ITS work. The system architecture is not a design. but the first step toward establishing standards and implementation guidelines for building ITS in local areas. The architecture defines major processes, input, and output for ITS. The processes include traffic management, commercial vehicle management, vehicle monitoring and control, transit management, emergency services management, driver and traveler services, electronic payment services, and planning of system deployment and implementation. The architecture also outlines how the transportation infrastructure should operate and offers approaches to leveraging existing commercial communication systems and protocols. Finally, the architecture highlights socioeconomic issues, such as barriers that must be removed and partnerships yet to be established. The scope and benefits of this activity are discussed more specifically in the "Enabling Research" section of this chapter and in Chapter II.

STANDARDS

Standards provide the means to achieve compatibility between systems. The standards program, as it relates to advanced metropolitan travel management systems and metropolitan ITS infrastructure, is addressed in discussions of ATMS, ATIS, and APTS that follow this overview and, more generally, in the "Enabling Research" section of this chapter.

BUILDING PROFESSIONAL CAPACITY

To help train future transportation professionals, the U.S. DOT has developed a 5-year strategic plan. The training will provide technical and managerial courses on traffic control equipment and software, advanced corridor management technologies, use of incident management systems to relieve traffic congestion. and integrated transportation information systems and applications of decision support technologies. The scope, mission, and benefits of the program for building professional capacity are detailed in Chapter II.

TECHNICAL GUIDANCE AND OUTREACH

Offering outreach services and education for local elected and appointed officials and senior transportation managers is a critical component of the ITS Program. Using information from a series of focus groups with elected and appointed city and county officials, the U.S. DOT is developing detailed technical guidance on deploying ITS infrastructure components. Guidance documents will provide information needed to ensure future compatibility with newer systems and will allow local governments to tailor the ITS infrastructure to meet specific needs. These documents will also help local governments better understand and use the national architecture and move forward with system design and procurement.

Outreach and educational activities include ITS scanning tours, in which a region's officials and transportation managers are brought to meet and view other regions' ITS deployments. For example, Public Technologies, Inc., a nonprofit organization based in Washington, DC, fields an outreach program that matches transportation managers and officials from a region that is considering ITS infrastructure deployment with experienced counterparts from across the Nation in small two-day workshops. ITS America's State chapter program also helps cities, counties, and State DOTS work together to implement metropolitan intelligent transportation infrastructure. Follow up surveys with managers and officials who have participated in these outreach activities affirm their positive impact on advancing ITS deployment.

MDI and Deployment Tracking

In the past, the ITS Program assessed individual ATMS, ATIS, and APTS user services; now it focuses on integrated services represented by the ITS infrastructure. The MD1 is a step toward achieving the goals of Operation Timesaver. In Phoenix, San Antonio, Seattle, and the New York-New Jersey-Connecticut metropolitan area, model deployments will showcase the benefits of large-scale, high-tech intelligent transportation infrastructures in real-world settings. Also, in a Phase I project, Oak Ridge National Laboratory (ORNL) developed a data base to inventory infrastructure-related hardware in 75 metropolitan areas. In Phase II of this project, which was initiated in June 1996, ORNL began work on a system for tracking infrastructure deployments. Future studies are addressing the cost effectiveness of metropolitan intelligent transportation infrastructure. The specific scope, mission, and benefits of the MDI program are discussed in greater detail in Chapter II.

Mainstreaming

ISTEA established an ambitious planning process at both the metropolitan and State levels to fulfill a variety of social, economic, and environmental goals and to shift the planning perspective from capacity and construction to better management and operations. In this planning process, MPOs and State DOTS are primarily responsible for metropolitan and regional transportation planning. The Transportation Improvement Program (TIP), supported by ISTEA, is a multiyear listing of surface transportation projects proposed for funding by Federal, State, and local sources in the metropolitan areas. The Statewide Transportation Improvement Programs perform the same function for the States. The projects listed in these programs must conform to the goals of long-range planning; project selection is competitive. The transportation plan is the foundation for the basic policies and visions of the region or State. The plan is the comprehensive package of projects and program initiatives that spans a 20- to 25-year horizon, providing a vision of an area's transportation future, as it supports priority economic development, community, and environmental goals. As a result, it is important that ITS is fully incorporated in both the State or regional plan and the metropolitan and State TIPs.

Despite the role that ITS plays as the enabling infrastructure for comprehensive system management, ITS projects have often been relegated to the sidelines as an exotic collection of support technologies. In addition, much of the early interest in the ITS Program was stimulated by Federal funding, rather than through a systematic bottom-up planning process. The U.S. DOT's goal is to mainstream ITS into the traditional transportation planning process through extensive workshops and guidance documents. In particular, in FY 1996, U.S. DOT began developing a planning model, the ITS Deployment Analysis Package, which will be available over the next 18 months, to enable MPOs and States to assess the benefits of ITS in relation to other candidate projects in the State or regional Plan and TIP. Other mainstreaming activities are discussed in greater detail in Chapter II.

User Acceptance

Under the ITS Program, several studies were conducted on institutional issues related to traffic management systems. Most recently, a research project was initiated to better understand local and State transportation managers' decisions to purchase and deploy components of metropolitan intelligent transportation infrastructure. Using a case-study approach, DOT analysts interviewed 130 officials in 7 metropolitan areas from core and suburban cities, counties, MPOs, transit authorities, port authorities, State transportation departments, and State police. The results are published in *Assessment of ITS Deployment: Review of Metropolitan Areas/Discussions of Crosscutting Issues.*

The Federal program is attempting to move metropolitan areas along an evolutionary path, from wise replacement of conventional management technologies to installation and integration of foundational ITS infrastructure components in metropolitan areas. The program has looked at the practical ITS applications for specific modes and is currently focusing on how to integrate these systems into a metropolitan intelligent transportation infrastructure to better serve users and managers of all modes.

The following sections describe each of the three programs of the advanced metropolitan travel management systems: ATMS, ATIS, and APTS.

Advanced Traffic Management Systems

The public, elected officials, and transportation managers perceive traffic congestion as one of the most serious transportation problems affecting our communities. Demand for our roadways is increasing, accidents and other highway incidents exacerbate gridlock, and traffic from special events held at large facilities burdens our transportation systems. Applying traditional solutions to congestion is becoming increasingly difficult. Physical, financial, and environmental constraints now prevent us from "building our way out" of such problems. New methods must be found and implemented to address the estimated $100 billion per year in lost productivity caused by traffic congestion.

Until recently, available technology for traffic signals, incident detection, and emergency response has not helped traffic engineers eliminate congestion. Unreliable equipment required many on-site service calls to keep it operating properly. Traffic signal systems, most of them using fixed-time cycles that are not updated on a regular basis, often relied on historical information obtained from manual traffic counts. Incompatible technologies tied engineers to using traffic signals and controllers from only one vendor. Even after the development of standards, proprietary communication protocols limited the use of multiple vendors. If an area was able to use equipment from different manufacturers, maintenance staff was taxed because of the different service requirements of each brand.

In addition, municipal engineers could not identify equipment failures from remote locations and instead depended on citizens' complaints, random observations by staff, reports by travelers, and police notification to detect problems and incidents. All of these methods had shortcomings. Accident locations provided by travelers were often inaccurate, and information from law enforcement officers, who could not directly communicate with the highway agency, was often not timely.

These approaches to managing traffic on streets and freeways are no longer practical, efficient, or sufficient. ATMS services can now help transportation managers to better monitor traffic patterns, collect and manage traffic data, adjust traffic control devices, and coordinate with police and emergency services. These capabilities allow more timely responses to traffic patterns influenced by accidents, peak-period traffic, and special events.

ATMS can consist of one or more components that, when integrated, provide part of the intelligent transportation infrastructure for a metropolitan area. These components include:

- **Adaptive traffic control systems,** which can maximize traffic flows on arterials by modifying signal timing to adapt quickly to travel demand.
- **Freeway management systems, i**ncluding technologies that monitor highway and environmental conditions on the interstate highway system and other freeway and expressway systems; manage traffic congestion through such devices as ramp meters and lane control signals; and provide traffic information through infrastructure media, such as variable message signs and highway advisory radio.
- **Incident management and emergency management systems,** which often work with freeway management systems to help transportation and law enforcement officials detect, verify, locate, respond to, manage, and clear highway incidents promptly, thereby decreasing congestion and preventing secondary accidents.
- **Electronic toll collection systems,** which alleviate bottlenecks at toll plazas using transponders that identify vehicles and collect fares electronically. These systems can use prepaid fare cards or bill drivers later. Electronic toll collection systems can also be integrated with other payment systems for transit or public parking to create a regional electronic fare payment system.
- **Highway-railroad crossing safety systems,** which use in-vehicle and roadside devices to coordinate train movements with traffic control devices at highway-railroad intersections, and warn drivers of approaching trains. Future technologies may automatically activate barrier protections to eliminate collisions at crossings.

Physical, financial, and environmental constraints now prevent us from "building our way out" of congestion. ATMS components improve the efficiency and safety of existing infrastructure.

When implemented on a national scale, these ATMS services will dramatically change how our Nation's streets and highways are managed. ATMS technologies will automatically notify- traffic engineers of equipment failures and allow them to correct problems from a central location. Surveillance cameras will allow managers to view traffic conditions at intersections throughout the day. Sensor technology will continuously report traffic flow data. Advanced traffic signal control systems will use this information to adjust signal timing for changing traffic flows and, if needed, divert traffic to other routes to improve overall system performance. Emergency and transit vehicles could be given priority at signalized intersections. Eventually, computer software algorithms will predict traffic flows and modify signal timing in anticipation of changing traffic patterns.

Highway engineers will be able to view the freeway system via pictures from closed-circuit television cameras or through digital images made possible by the automatic collection and reporting of traffic data. Highway engineers will also be able to predict traffic flows with computer software algorithms to identify conditions leading to congestion and recommend proactive traffic management strategies.

ATMS technologies will also automatically detect accidents and other incidents. Decision support systems will advise the traffic operation staff about resources needed for incident response, traffic control actions, and information that should be conveyed to travelers.

The efficacy of ATMS technologies will increase as advanced traffic signal and freeway management systems are integrated and both systems share information with a regional multimodal traveler information system to help travelers make informed decisions.

PROGRAM GOALS

The primary goals of the ATMS program are to create a safe and efficient intelligent transportation system that can anticipate when and where traffic will be moving, automatically identify problems affecting this movement, and rapidly modify the transportation system to adjust for these problems and enhance system capacity.

PROGRAM ACTIVITIES

To achieve these goals, the ATMS program engages in R&D, field testing and planning, and standards development. Many of these activities are supported by other programs within the national ITS Program.

R&D: In response to a workshop held by the Mobility 2000 group in 1990, the U.S. DOT developed the ATMS R&D program to bridge the gap from the "here and now" (the first generation of ATMS) to the future (second-generation ATMS services). The original program identified five areas of concentration for R&D activities:

- Surveillance and detection.
- Real-time traffic management and control.
- Support systems.
- Modeling simulation.
- General studies.

The complexity of ATMS and the transition into an expanded vision of intelligent transportation infrastructure prompted U.S. DOT to modify the program plan to better categorize activities and describe the ATMS R&D efforts. ATMS R&D now includes the following:

- Surveillance and detection.
- Real-time traffic management and control.
- System integration, including development of the Traffic Research Laboratory (TReL).
- Standards.
- Advanced analysis methods.
- Support and enabling studies.

The following paragraphs describe current and future activities using the latest program area categories.

Surveillance and Detection: As the backbone of ATMS, the surveillance and detection program has pursued development of functional and performance specifications for ITS, as well as evaluation of state-of-the-art detectors. First, a study on detection technology for ITS established sensor performance requirements and examined sensors currently on the market for their applicability to ITS. Second, under the traffic surveillance and detection technology development initiative, seven subcontracts were awarded to sensor developers for the adaptation of technologies to ITS. Third, a project called Incident Detection Issues, Part I (Freeways), developed a system that compensates for equipment malfunctions, assesses real-time traffic conditions, and detects incidents.

The surveillance and detection program will continue to monitor the evolving surveillance and detection needs of ITS, promote the development of new sensors that have potential ATMS applications, and field-test new sensors. Efforts will also ensure that new sensors conform to ATMS compatibility standards. In addition the program will focus on developing surveillance and detection software and methods to provide feedback to ATMS real-time control strategies. A study titled *Deployment Issues of Surveillance Systems* will identify guidelines needed to help State and local transportation professionals select appropriate surveillance designs for their ATMS applications. These guidelines will be written in FY 1997.

Real-Time Traffic Management and Control: This area of the R&D program developed an expert system to aid in the design of traffic signals for isolated inter-

MARYLAND USES TEAMWORK AND TECHNOLOGY TO CHART A NEW COURSE

In the State of Maryland, highway travel increased 60 percent between 1980 and 1995. Heavy volumes of traffic,stop-and-go commuter peaks, and lack of comprehensive information regarding conditions on avaifable alternatives contributed to and compounded the effects of unexpected incidents, such as traffic accidents.

To improve highway travel and safety, the Maryland Department of Transportation and the Maryland State Police, in cooperation with other Federal, State, and local agencies, implemented CHART (Chesapeake Highway Advisories RoutingTrafflc), the Nation's first statewide traffic management system. CHART serves a region that is nearly 100 miles long by about 50 miles and contains roughly 400 lane-miles of principal arterials.

CHART's mission is to improve real-time operations of the highway system through teamwork and technology. CHART is composed of four basic components: I) surveillance (continuous detection of what is occurring on major segments of the highway system); 2) incident response (working with law enforcement, fire and other emergency response agencies to remove blockages quickly and safely); 3) traveler information (alerting users to disruptions in the flow of traffic); and 4) traffic management (managing to cope with incidents through message signs, signals, and other traffic control measures). CHART uses a mix of high and low technology, from TV cameras to tow trucks. As acknowledged by Maryland DOT, however, the key is teamwork "teamwork among agencies, teamwork within agencies, and teamwork among individuals. Without extraordinary teamwork, CHART could not work."

CHART gathers its traffic information from a variety of sources. Information is received from the Maryland State Police, CHART communication vehicles and other State Highway Administration field personnel, cellular phones, CB radios and observation aircraft sponsored by the broadcast media and public agencies. [Three of CHART's surveillance technologies are pictured here.] The Statewide Operations Center compiles all of this information for use in responding to incidents, as well as in providing traveler information that is timely and accurate.

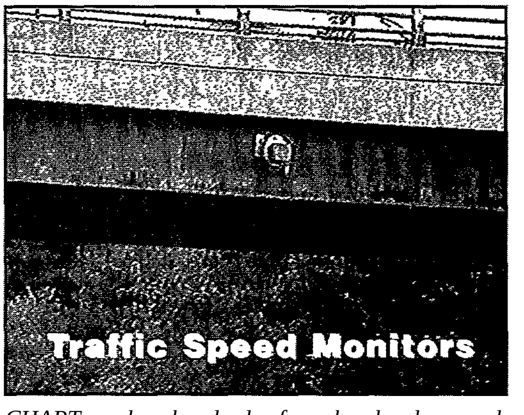
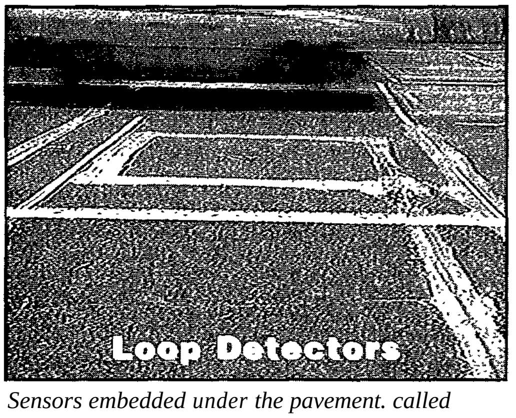
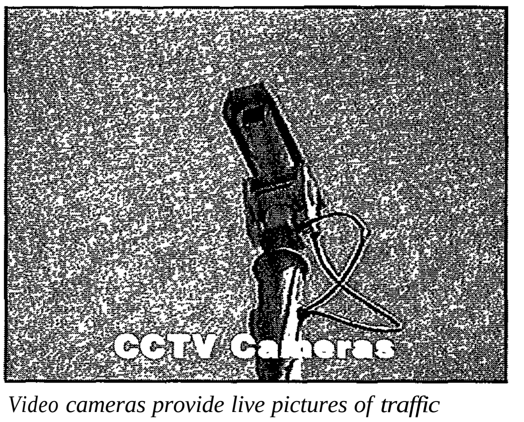


CHART employs hundreds of overhead radar speed detectors, which monitor vehicle speeds and transmit traffic volume data to Statewide Operations Center computers.



Sensors embedded under the pavement. called loop detectors, measure traffic volumes as vehicles drive by.



Video cameras provide live pictures of traffic conditions to spot bottlenecks and incidents.

sections, produced adaptive traffic control algorithm prototypes, and developed a communication standard protocol for traffic devices. The real-time traffic adaptive control system (RT-TRACS) project is developing a software platform that can dynamically adapt to traffic demand in a street network using a suite of traffic control strategies. Preliminary RT-TRACS control strategies are being tested in FHWA's TReL using a microscopic traffic simulation model, CORSIM. In 1997, FHWA will field-test the RT-TRACS platform and three prototypes of adaptive traffic control strategies.

In addition, the program will investigate algorithms used to control ramp meters, particularly at entrance ramps, that can adjust to manage upstream and downstream freeway conditions. Other studies include the development of a dynamic traffic control and route guidance system, which will establish the integration of RT-TRACS and dynamic traffic assessment to provide forecasting capabilities and proactive management of signal systems in anticipation of expected traffic.

System Integration: ATMS functions, such as surveillance and adaptive signal control, must be part of a cohesive architecture to work together effectively as part of a transportation management system. The essence of the system integration effort is to identify how ATMS functions can be integrated with each other and with other ITS elements within the frameworks of the NTCIP and the national ITS architecture. NTCIP has developed protocols that support the data flows and interfaces of ATMS components, such as those between a traffic management center and roadside equipment. The national ITS architecture effort has defined the data flows and interfaces between ITS subsystems, such as those between ATMS and ATIS. An important part of this effort is to determine how multiple ATMS elements can be optimally configured within a traffic management center. The traffic management center integration and testing study, which started in FY 1996, examines how ATMS can be integrated within a broader array of ITS services. Of particular interest in the traffic management center integration effort is the identification of system configurations that allow jurisdictions autonomy, but also facilitate interjurisdictional cooperation.

Efforts in this R&D area have produced: ATMS functional requirements and specifications, a prototype of integrated ATMS that describes information management in advanced traffic management systems and a configuration for traffic management centers, and a series of workshops in which potential users commented on the draft functional requirements and specifications.

A major accomplishment of the program has been the creation of the TReL, which tests new ATMS technologies and products. TReL emulates real-world conditions in a simulated environment. It not only tests individual technologies, but also evaluates the impact of integrated systems. TReL also allows researchers to evaluate current and proposed standards of ATMS elements.

The next phase of the system integration efforts will focus on advancing the primary interface requirements, pursuing national standardization for each area of functionality, and investigating the compatibility and integration of ATMS functions with other ITS functions.

ATMS Standards: In May 1993, the U.S. DOT sponsored a symposium to identify barriers to deploying ATMS technologies. One significant issue raised by participants was the lack of compatible communication protocols used by numerous traffic management devices. As a result, the U.S. DOT is supporting the continued development of the NTCIP, initiated by the National Electrical Manufacturers Association, to provide for interoperability and interchangeability of traffic management devices in the same communication infrastructure. ATMS standards are currently supported by the broader standards development effort of the national ITS Program.

Advanced Analysis Methods: Work in this area has produced enhanced traffic simulation models for use in designing and evaluating ATMS applications, as well as improvements in the ITS modeling capabilities of existing traffic models. Specific accomplishments include: modification of two models (NETSIM and FRESIM) to analyze freeways, interchanges, and intersections; seamless integration of traffic models that optimize signal controls and ramp metering, as part of a "network-wide optimization of models;" development of a graphic user interface for CORSIM, the network traffic simulation model, to allow data entry and output using graphic representations: and development of a powerful integrated system of traffic software, an open architecture package allowing for the integration and use of numerous public and private software. Other efforts in this program area include development of an encoding scheme for ATMS/ATIS data fusion, development of a data base for validating traffic models, and technical support for ATMS R&D.

Work will also incorporate ITS impact analysis capabilities in both regional planning models and traffic operation models. An effort has already been launched to develop a tool to enable transportation professionals to effectively and efficiently include ITS alternatives in current planning analyses. ATMS R&D will also continue to develop models that analyze conventional traffic management strategies.

Support and Enabling Studies: Other research activities cover human factors and environmental issues. Accomplishments in this area include: completion of the final report in the responsive multimodal transportation study project; production of the *Human Factors Handbook for ATMS Design*, which aids in the design of operator-friendly transportation management centers; expansion and modernization of the vehicle fleet used in the CORSIM traffic model to better evaluate environmental impact; and sponsorship of symposiums, ATMS technical design reviews, and workshops. In FY 1997, the program will conduct a study on the energy and environmental impact of ATMS and evaluate the potential ATMS impact on unsignalized intersections and roundabouts.

Future activities will also focus on incorporating human factors into the development and design of ATMS products; developing methods to investigate the impact of surface transportation on the environment; and collecting data to validate and calibrate ATMS functions. This program will also enhance procedures for assessing ATMS impact on highway capacity.

Field Testing and Planning: The U.S. DOT has sponsored 17 ATMS-related field operational tests; 6 are completed. These tests have addressed the technical viability and performance of incident detection on freeways, portable detection and surveillance systems, adaptive traffic signal systems, integration of signal systems across jurisdictional boundaries and with ramp meters, and advanced traveler information systems. Future field tests will focus on assessing the efficacy of next-generation ATMS applications, and will include the first field test of RT-TRACS, scheduled for FY 1997.

Technical Lessons

Most of the technology used in first-generation ITS products and services is not new, but the combination of technology is, as is the environment for implementation. Exhibit III-4 highlights technical lessons learned in the ATMS program.

Methods and procedures have been developed to assist State and local jurisdictions to effectively use surveillance systems for traffic management. An operational test, which evaluated the feasibility of measuring traffic flow using vehicle probes equipped with cellular phone technology, found that a high degree of cellular phone market penetration was required to produce effective information. In two other locations, transponders for electronic toll collection systems were used to measure traffic flows on roadways other than the toll facilities, a technique that proved to be feasible and

EXHIBIT III-4

SYNOPSIS OF ATMS TECHNICAL LESSONS LEARNED

Traffic management centers coordinate the information and control functions of ATMS elements. Through field tests and laboratory research, we have learned much about ATMS technical issues including:

- Basic R&D has led to better methods for monitoring, controlling, and evaluating real-time dynamic traffic flow.
- Operational tests are resolving the technical challenges of surveillance technologies, such as loop detectors and video.
- Research is underway to develop a flexible platform, called RT-TRACS, to accommodate multiple demand-responsive control strategies for an entire traffic network.
- The program is developing open architecture interface standards, in particular the NTCIP, to ensure compatibility of ATMS elements.
- Probe vehicles that gather traffic data can significantly increase the effectiveness of a monitoring system.
- Research is guiding the design of traffic management centers to enhance operator performance and incorporate more sophisticated automation.

cost effective. Tests of GPS-based vehicle tracking demonstrate that these systems also provide location information that is more than adequate.

Study of traffic flow theory has helped create control algorithms and refine traffic simulation models that are sensitive to changes in travel demand. Transportation engineers and planners outside the Federal Government have been given newly developed traffic models to help design ATMS applications and have experienced significant time and cost savings. Software algorithms have been developed to improve incident detection, reducing the rate of false alarms and decreasing the time needed to validate an accident.

Research into human factors in traffic management centers indicates that automated detection and location systems improve operator performance over manual detection and that cameras with pre-set views improve operator performance in monitoring roadways for incidents. Research has also compared the effects of different control center designs and human-machine interfaces on operator performance.

BENEFITS

ATMS benefits, which were once theoretical, have begun to be measurably demonstrated. Several ATMS field tests and implementations across the Nation, many sponsored with Federal funds, have demonstrated significant improvement in traffic flow, reduction in travel time, reduced congestion, increased throughput, reduction in accidents, and reductions in labor, operating, and maintenance costs. Examples of these benefits are listed in Exhibit 111-5.

INSTITUTIONAL ISSUES AND USER ACCEPTANCE

Creating and maintaining a work force that is capable of designing, constructing, operating, and maintaining ATMS technologies is critical. The introduction of new technologies also necessitates changes in the existing work force and requires that employees acquire new skills, particularly in shifting from expertise in civil engineering to system engineering, electronics, and information systems.

FUTURE DIRECTIONS

In the short term, the ATMS program hopes to achieve acceptance by elected officials, transportation managers, and the traveling public of ATMS products and services as viable solutions to their transportation problems. The program also emphasizes integrated application of these products and services. These short-term goals involve incorporating ATMS into the traditional metropolitan planning process; breaking down jurisdictional and modal boundaries; developing interchangeable software systems, equipment, and communication protocols; and creating transportation professionals and tools for effective planning, design, and implementation of ATMS solutions. A longer range vision for ATMS is to increase the extent to which automation is used to monitor the transportation system, detect and respond to problems, and disseminate data collected during the management process. Achieving this goal will involve developing and testing advanced decision support systems. Later, the ATMS program expects to develop expert systems that can be used in regional traffic management centers.

ADVANCED TRAVELER INFORMATION SYSTEMS

Over the past 20 years, all major U.S. metropolitan areas have been forced to deal with increased traffic and congestion, rush hours that last much of the working day, and incident-related traffic jams. Advanced traveler information systems (ATIS) can return a measure of sanity, control, and predictability to the transportation system and improve traveler safety by providing personalized multimodal information on traffic conditions, recommending alternative routes, and offering directions to transit and ridesharing opportunities.

EXHIBIT III-5
BENEFITS OF ATMS

ATMS Element	Benefits	Source
Traffic Signal Control	• In Los Angeles, the automated traffic surveillance and control program, which includes a computerized signal control system, reduced travel time by 18% increased average speed by 16% and reduced delay by 44%. • The Abilene, TX. automated signal system decreased travel times by 14%. reduced delay by 37% and increased travel speeds by 22%. • The State of Texas expects its automated traffic signal control program, traffic light synchronization, to have a benefit/cost ratio of 6: 1. mostly from reduced travel time. • The bus priority system in Portland, OR, which uses an integrated traffic signal system and allows buses to extend green time or shorten red time by only a few seconds, reduced bus travel times by 5 to 8%.	Mitretek Systems, *Assessment of ITS Benefits: Emerging* Successes, prepared for FHWA, September 1996.
Freeway Management	• Freeway management systems, primarily through ramp metering, have reduced accidents by 15 to 62% while handling 8 to 22% more traffic at speeds that are 16 to 62% faster compared to pre-existing congested conditions. • Seattle's ramp-metering system has allowed freeway volume to increase by 10 to 100% along various segments of I-5. Speeds have increased by up to 20%.	Ibid.
Incident Management	. Incident management programs can reduce delay associated with congestion caused by incidents by 50 to 60%. . The Maryland automated surveillance program, which has lane sensors and video cameras, has an estimated benefit/cost ratio of 5.6: 1, mostly from a 5% decrease in congestion caused by incidents. • Minnesota's Highway Helper Program has reduced the duration of stalled vehicles by 8 minutes.	Ibid.
Electronic Toll Collection	• Electronic toll collection increases capacity by 200 to 300% compared to attended lanes.	Ibid
Emergency Management	• Accidents in freeway systems under freeway management were reduced between 15% and 50%. • Speed enforcement cameras in London have reduced speeding by approximately 10%, accidents by 20% to 80%, and serious injuries and fatalities by about 50%.	Ibid
Advanced Highway-Railroad Grade Crossings	. Active railroad grade crossings have reduced the number of accidents at intersections by 64% from 1978 to 1993. Advanced warning systems are expected to equal or exceed these benefits.	Volpe National Transportation Systems Center, *Safety of Highway Railroad Grade Crossings: Research Needs Workshop,* Vol. I, January 1996.

ATIS include an array of public and proprietary multi-modal traveler information products and services that use advanced telecommunications and electronics, digitized "smart" maps, GPS, and other technologies to disseminate timely and accurate traffic, transit, and other travel-related information. ATIS also include a set of mobile personal security and safety services, commonly referred to as "Mayday" products.

ATIS, the traveler information broadcast function of the advanced metropolitan travel management system, processes two types of information: *dynamic*, which describes current traffic conditions (including weather advisories) and transit schedules, and *static*, which is provided to the traveler using digital maps, routing algorithms, and electronic data bases and consists of detailed route guidance according to the range of modes available.

System performance information is collected through the ATMS, APTS, and other transportation management systems to meet agencies' individual and shared needs for transportation network information. This information on traffic and transit conditions can be disseminated to the public through public or private sector service providers to support more informed travel decisions. The Mayday services will allow travelers to contact a service center for roadside vehicle assistance, emergency medical assistance, or emergency police assistance at the touch of a finger or, for more sophisticated systems, if a vehicle's air bag deploys.

ATIS concepts represent a new paradigm in travel information; these systems will replace the traffic information that has been available since the 1950's through radio traffic broadcast companies. For example, traffic broadcasters provide radio stations with discrete profiles of traffic hot spots at 5- to IO-minute intervals. ATIS can provide the traveler with an array of travel options for any specific destination at the moment the service is queried. ATIS can also draw on a broader range of travel information infrastructure and are more accurate, comprehensive, and tailored to the customer. ATIS can be easily accessed through a variety of information media and provide context-sensitive information of specific interest to individual travelers.

Traveler information used by ATIS is currently collected and broadcast by both public agencies and private companies. As in the past, general traffic infor-

SHAKEN-UP TRAVELERS SEE NEED FOR INFORMATION

Plagued by smog from vehicle emissions, Los Angeles has repeatedly encouraged the use of mass transit and ridesharing among focal travelers. To motivate a switch to earth-friendly transportation, the city decided to inform the public of high-occupancy transportation choices through the California SmartTraveler project

The project called for placing three kiosks offering advanced traveler information in public locations. When the I994 earthquake destroyed major roads and forced many commuters to investigate alternative routes and modes of transportation, the number of kiosks shot to 80 to accommodate the sudden demand for information. Located in shopping mails, public buildings, business parks, and such gathering spots as the YMCA, the kiosks enabled travelers to plan transit trips, find carpools, view traffic conditions on the freeway system, and print travel itineraries.

One year after the earthquake, kiosk usage remained high, averaging 60,000 inquiries a month. When funding for the program ran out, however, the city was forced to remove the kiosks, despite popular demand. The city is currently seeking a private funder who could operate the kiosks and return them to their former locations. The only requirement the City would make under a public-private partnership is that the kiosks include traveler information and transit routes and schedules. Private funders could enhance the kiosks with any additional information they want to convey to the public.

Despite funding shortfalls, the Smart Traveler project proved that, even in the automobile capital of the world, travelers value timely information on multiple travel options.

mation is available to travelers through such media as televisions, radios, and telephones. Enhanced traveler information is available in most major cities as part of the bundle of information services customers receive with their subscriptions to cellular phones. In certain regions, such as greater Los Angeles and Houston, enhanced traffic information is also available as part of subscriptions to pager service, cable television, and the World Wide Web. In several major cities, including Los Angeles, Minneapolis, Seattle, and Atlanta, publicly financed kiosks are used to disseminate regional multimodal traveler information.

A new set of ATIS travel products that has emerged from the private sector since 1993 includes digitized maps, route guidance software, enhanced GPS location identification, and points of interest for location referencing (such as the nearest gas station or bank). The products are available as software packages for use on personal computers and as stand-alone products for installation in automobiles. Manufacturers of several of these traveler information products are experimenting with adding live traffic and transit information to their data bases and route guidance algorithms; others expect to provide dynamic route guidance on future models. This product niche is developing more slowly in the United States than in Japan and Europe because of uncertainty about U.S. consumers' willingness to pay for travel information.

Program Goals

The goals of the ATIS program are to increase safety and reduce travel time for the traveling public. Objectives include determining the best methods for providing travelers with real-time information on traffic and transit conditions, understanding the interdependency of public and private investments in the continued development of ATIS products and services, and developing information standards and communication protocols for the dissemination of multimodal traveler information.

Program Activities

The program's deployment-oriented agenda includes research on user acceptance and human factors, evaluations of field demonstrations, development of architecture and standards, outreach, and deployment support.

User Acceptance Research: This program was created in response to the challenges of developing ATIS services that travelers will value and use, providing data to transportation planners and policy makers on how ATIS can enhance the efficiency of the transportation network, and understanding the relationship between public and private investments in accelerating ATIS deployment.

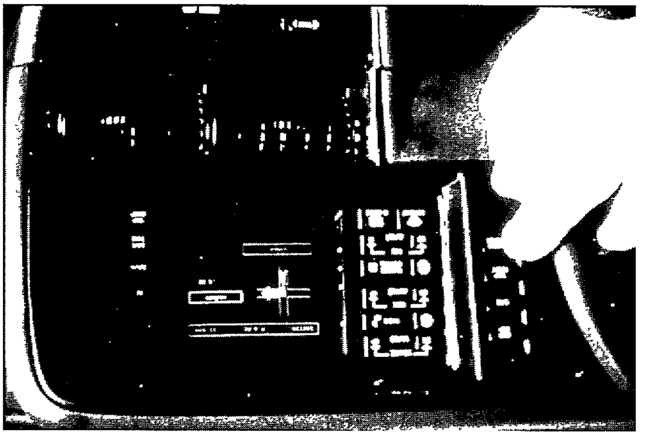
The program has three parts. First, research on the value and impact of ATIS is pursued directly with private travelers. The private traveler research program, which will be completed in 1997, will answer such questions as: How will the various types of ATIS be valued by different user groups and in different contexts? Second, the program provides direction to other ATIS researchers, such as field test evaluators, on how to structure and manage consumer acceptance research. To that end, the program produced a research primer, a research handbook, and a specialized seminar. Third, the research program has focused on documenting and analyzing the evolution of the market for ATIS products and services.

Research papers are written periodically to update and analyze the evolution of the ATIS marketplace and track the emergence of new products and services that provide traffic information, route guidance, navigation, and Mayday products. The first paper was written in 1993 when very few ATIS products were available to travelers; it focused on the predominant traffic news services and their underlying business models. The second paper, written in 1996, updates the earlier findings with a catalog of ATIS products and services available for sale in the United States and Europe, as well as a critical review of the business strategies evident from the companies' market activities.

These reports are used by industry to support competitive analyses of the traveler information marketplace. The reports provide an objective snapshot of ATIS market activities, enabling both companies that are currently invested in ATIS and those that are considering entry into the market to examine their own strategies in relation to other national and international companies. Government agencies use the reports to familiarize themselves with the activities and logic of this newly emerging market. These reports also help to inform State and local government investment decisions related to integrating and broadcasting traffic information to the traveling public.

Human Factors Research: FHWA and NHTSA are pursuing human factors research to measure the safety consequences of in-vehicle information systems. As the number of in-vehicle driver distractions increases, the question of motorist and highway safety becomes paramount. One project is developing in-vehicle information system prototypes that can handle multiple sources of information. A second research project is developing human factors guidelines for in-vehicle ATIS components. These human factors issues are examined in the context of in-vehicle routing and navigation systems, motorist information services, safety advisory and warning systems, and in-vehicle display systems.

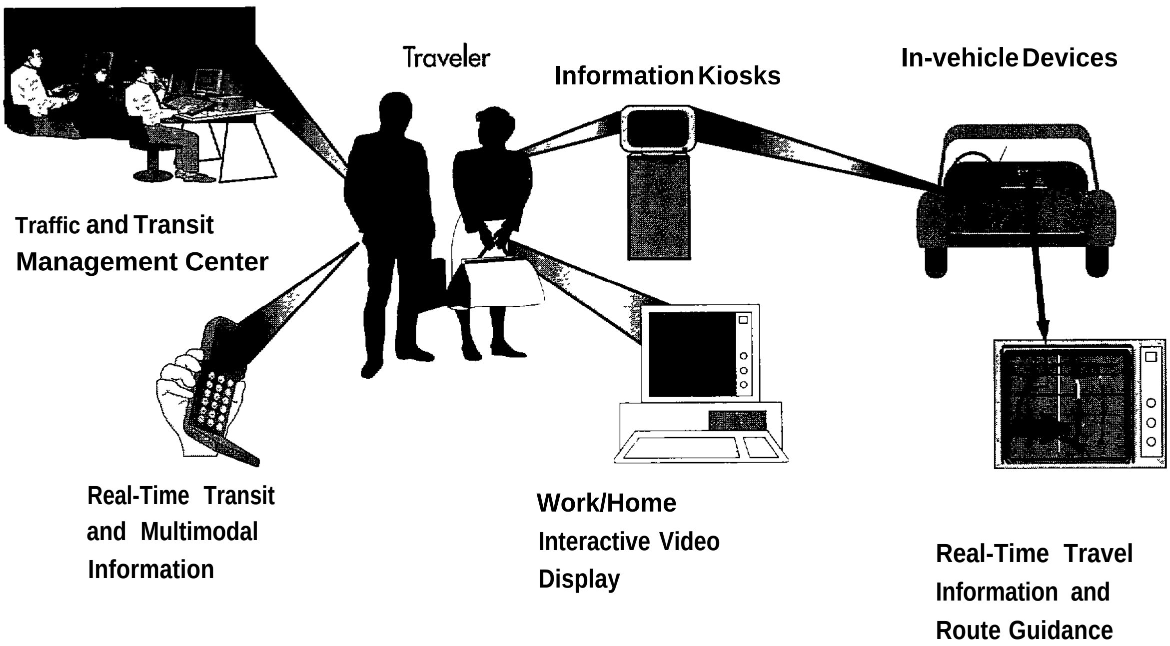
Field Operational Testing: U.S. DOT has launched 15 ATIS field operational tests, 5 of which are complete. Evaluations have addressed technical operations, institutional issues, and user response and acceptance. For example, users' responses to the Orlando TravTek field evaluation of an in-vehicle navigation and route guidance system led the private sector partners to further refine the in-vehicle ATIS prototype. Subsequently, Rockwell International commercialized the system and is successfully selling the product to Oldsmobile and to Hertz, Avis, and National rental car companies for use in their rental fleets. A similar product is currently available in California as original manufacturer's equipment on the Acura 3.5 RL. The ADVANCE project in Chicago, IL, revealed that drivers who are already familiar with the road network may prefer generating their own routes instead of using those generated by the in-vehicle device. The evaluation of the Boston SmarTraveler field test of real-time traffic and transit information concluded that travelers obtain value from accurate, real-time information. More than 50 percent of SmarTraveler users reported that they adjust their travel plans in response to the SmarTraveler real-time traffic report.



In-vehicle route guidance systems using moving maps, GPS, and vehicle location technology can help dn'vers navigate in unfamiliar areas and avoid congested routes.

Archictecture and Standards: The ATIS Interoperability Summit, jointly sponsored by FHWA, FTA, and ITS America in May 1996, brought together public and private sector providers of advanced traveler information products and services to discuss architecture and standards. The objective was to define priorities and direction for the development of information exchange standards in the framework of the national ITS architecture. A draft listing of near-term priority information elements that would be exchanged between traffic and transit management subsystems

EXHIBIT III-6
SYNOPSIS OF ATIS TECHNICAL LESSONS LEARNED



ATIS technologies include an array of public and proprietary multimodal traveler information products and services. ATIS technologies also include a set of mobile personal security and safety services, commonly referred to as "Mayday" products. We have learned the following about technical issues:

- Field operational tests, such as TravTek, have demonstrated that in-vehicle display devices using moving maps, GPS, and vehicle location technology are technically feasible.
- The ITS Program has developed preliminary human factors design guidelines for in-vehicle driver interfaces that address safety and effectiveness.
- Field tests have shown that properly designed in-vehicle devices do not degrade safety.

and information service providers was developed for review and use by stakeholders and SDOs. Development of standards and protocols will accelerate ITS deployment by reducing the cost of developing ATIS products and services. Standards will also help minimize local redesign of existing infrastructure by allowing interoperability of ATIS products throughout the Nation. The Society of Automotive Engineers and the Institute of Traffic Engineers are the primary SDOs responsible for these activities.

TECHNICAL LESSONS

The ATIS lessons learned thus far have come from the field operational tests, direct user acceptance research, human factors research, and observation of private companies' efforts to bring ATIS products to market.

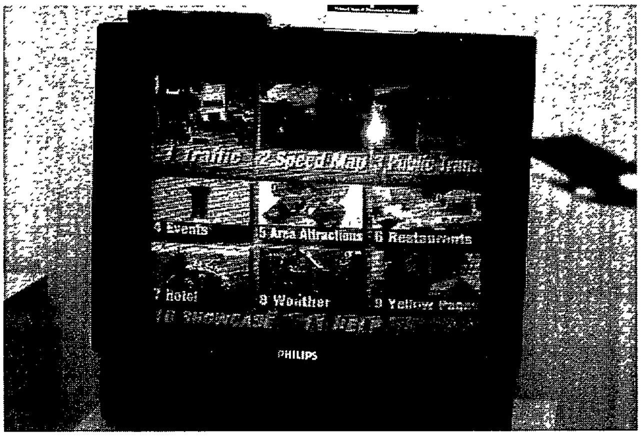
Research has revealed that in-vehicle devices, incorporating vehicle location technologies and two-way communications, are feasible. Two field operational test studies, FastTrac and ADVANCE, have shown that properly designed in-vehicle devices do not degrade safety. Further human factors safety research is planned by NHTSA to systematically study the safety effects of in-vehicle devices. In addition, current operational testing is exploring the feasibility of using cellular phones and electronic toll collection tags as traffic probes to supplement other more expensive, infrastructure-based tools for monitoring traffic. Field tests and industry research have established that FM sidebands can be used to transmit relevant traffic information. Industry R&D efforts are currently pushing toward development of products that seamlessly integrate traffic information with navigation assistance for dynamic route guidance. Exhibit III-6 highlights technical lessons learned in the ATIS program.

BENEFITS

Travelers have cited several benefits of ATIS programs, including their ability to provide more efficient use of travel time, greater control of daily schedules, increased confidence about finding destinations in unfamiliar territory, and an improved sense of person-

EXHIBIT III-7
BENEFITS OF ATIS

ATIS Element	Benefits	Source
In-Vehicle Navigation and Route Guidance	• Model simulations estimate that in-vehicle information can decrease travel times by 8 to 25% in congested conditions. • The TravTrek operational test showed that, for drivers that are unfamiliar with an area, in-vehicle systems can reduce wrong turns by 33% and travel time by 20% compared with using paper maps. Travel planning time decreased by 80%.	Mitretek Systems, *Assessment of ITS Benefits: Emerging* Successes, prepared for FHWA, September 1996.
Traveler Information Systems	• By providing motorist information via variable message signs, the Information for Motorists (INFORM) program in Long Island reduced annual delay by as much as 1,900 vehicle-hours during rush hour periods and 300,000 hours in incident-related delays. • A Mitretek simulation study predicted that pre-trip information about incidents could reduce delay by 2 1% when travel options are presented and pre-trip information is universally available.	Ibid.



Real-time information can be provided by cable television and the World Wide Web.

al security. Exhibit III-7 provides more specific examples of benefits, obtained from operational tests and other research.

Institutional Issues and User Acceptance

Travelers of all types and in all contexts value ATIS services and will use them when they are provided free of charge. The value that a traveler assigns to the information or service varies in relation to external factors, the influences of which are not yet fully understood. For example. a synthesis of findings on how users value ATIS indicates that travelers are willing to pay for navigation and route guidance information in rental cars driven in unfamiliar cities, but are unwilling to pay for similar information in the family car. Drivers are willing to pay for traffic information during winter in such regions as Minneapolis and Boston, but drivers in more moderate climates will not.

The biggest growth in ATIS market offerings was in aftermarket in-vehicle navigation products available for sale through auto electronics and stereo stores. Their high average price of $2,000 per unit prevents broad market response, and sales in 1996 were slow. The next two largest increases in market offerings were computer-based route guidance and navigation software and traffic and travel offerings on the Internet. The most distinct trends at this time are the sale of in-vehicle navigation and route guidance products, offered as manufacturers' original equipment in high-end German and Japanese imports, and bundled information services, including traffic information, made available as part of a subscription with existing communication media, such as cellular telephones, cable television, and the Internet.

The evolving ATIS business model involves collecting, processing, and disseminating information on traffic and transit conditions. Throughout most of the Nation, public agencies already collect real-time traffic and transit information for system management purposes. Private companies, acting as value-added resellers, collect information from the agencies, process it for resale, and make it available to customers-either the travelers themselves or intermediary service providers, such as cellular telephone, pager, or cable television companies. Several private companies are also collecting proprietary data to supplement public sources of traffic and transit information and are selling their information to the public sector and to intermediary proprietary service providers. It is still too early to predict whether any single approach to traveler information services will dominate. Both models serve the interests of the traveling public.

The TravTek operational test revealed that 38 percent of all users of in-vehicle navigation devices found them helpful in navigating through unfamiliar areas, and 63 percent of local drivers found the technology convenient. Rental car vendors report that customers pay a premium for the devices in rental vehicles.

In addition, preliminary reports of multimodal information kiosks in Los Angeles revealed that 79 percent of users find them easy to use, and 84 percent would use the kiosks again. Most users were interested in information for future trips rather than for immediate transportation purposes. Similar positive responses were obtained from the kiosk users at Atlanta's Traveler Information Showcase during the 1996 Olympics.

Although these developments are encouraging, several significant challenges exist to the widespread effective deployment of ATIS. Effective deployment requires that real-time traffic and transit information be available to travelers at home, in public or private vehicles, and at work. Continued development of private sector ATIS products and services requires both quantitative information on the condition of the transportation network and standards for information exchange and communications. Private sector involvement is also predicated on the value placed on ATIS services by travelers and their willingness to pay for these services. Finally, full realization of the benefits of ATIS ultimately requires that each State deploy an integrated system of traffic detection and information dissemination that has been developed in accordance with the communication and information exchange approach of the national ITS architecture.

One institutional issue affecting ATIS deployment is the question of who owns rights to the information collected from monitors installed on the infrastructure. Currently, in areas where the public sector collects regional multimodal information to meet its own traffic management requirements (such as in Houston; Montgomery County, MD; Phoenix; and San Francisco), private traffic broadcast companies are allowed direct access to the information. Most States and private companies expect this institutional model to continue to dominate. In Boston, however, SmartRoute System, Inc., receives State funds to collect, process, and broadcast traffic information gathered from public and proprietary sources for the SmarTraveler program. A partnership agreement with the Massachusetts Highway Department stipulates that SmartRoute System can sell the information to other value-added resellers, but must split profits from the sale with the State.

FUTURE DIRECTIONS

When the mdi process is completed in early 1998, four metropolitan areas will support dynamic ATIS and serve as a proving ground for private products and services, as well as a showcase for the benefits of ATIS to travelers. The San Francisco Bay Area TravInfo project will be fully operational in 1997 and will provide the private market with another testbed for assessing the value of ATIS.

FHWA and NHTSA will pursue the ITS research program for the driver-vehicle interface through 2002. This effort will result in human factors recommendations on how integrated driver information systems should be designed and should function to maximize safety, mobility, efficiency, and driver acceptance. In 1997, the user acceptance research program will com-

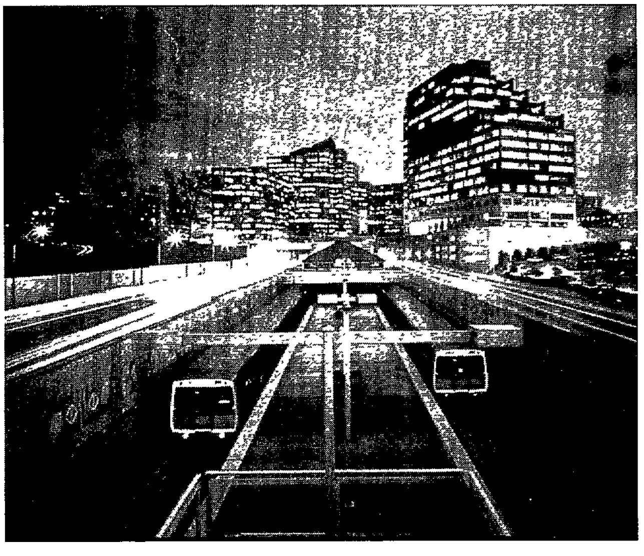
Smart kiosks at transit stations, shopping centers, and other public places can provide travelers with up-to-the-minute information on transit schedules, road conditions and alternative routes, giving a measure of sanity, control, and predictability to the transportation system.

plete a major project on consumer response to ATIS, which is expected to result in a greater understanding of travelers' needs and values.

Other future activities in the ATIS program include continued development of information standards and communication protocols, operational test evaluations, and the National Capital Region Traveler Information Project, serving the Washington, DC, metropolitan area. Finally, the education and outreach program is planning to expand its reach beyond elected officials and transportation managers to the general public.

ADVANCED PUBLIC TRANSPORTATION SYSTEMS

Smart investments in public transportation are critical to balancing and strengthening intermodal surface transportation systems. With the advanced public transportation systems (APTS) program, the ITS Program accurately reflects the broad range of intermodal needs of the Nation's surface transportation system, which includes not only highways and services to private and single-occupancy vehicles, but also bus and rail fleets, paratransit operations, and ridesharing programs. The APTS program has guided the evolution of the U.S. DOT's ITS Program toward the inclusion of transit, identifying opportunities suited to ITS applications. Through the support of operational tests and evaluations, the APTS program has collected and disseminated extensive information about the performance and benefits of APTS technologies.



Transit customers can benefit from their local operators success in using APTS technologies to save money and implement safer and more efficient services.

APTS technologies are aimed at both transit operators and riders. Transit operators are interested in implementing ITS to enhance customer convenience, improve passenger and operator safety, assist in reducing surface congestion, decrease operating costs, and increase ridership. Transit customers can benefit in turn from their local transit operators' success in saving money and implementing safer and more efficient services.

The APTS program, administered by FTA, focuses on three fundamental applications for public transportation that relate to vehicles, fares, and customers:

- **Transit fleet management systems** embrace a broad set of technologies that boost the efficiency of transit systems, reduce operating costs, and improve transit services to the public through more precise adherence to schedules. The technologies include AVL devices; annunciators and signs in the vehicle; computer-aided dispatching; "vehicle priority" technologies, including devices allowing transit operators to manage traffic signals; automatic passenger-counting equipment; engine condition sensors; and silent alarms from bus to dispatcher.
- **Electronic fare payment systems** use advanced fare media, such as magnetic stripe cards and smart cards, and electronic communication, data processing, and data storage to make fare payment more convenient to travelers and revenue collection less costly for transit providers. Electronic payment systems also gather real-time transit information

on travel demand for better planning and scheduling of services.

- **Traveler information systems** use computer and communication technologies to provide real-time vehicle information, made possible with the use of AVL systems, to travelers at home, at work, on the roadside, or at bus and rail transit stations. The real-time information allows travelers to choose the most efficient and convenient modes of travel. Not only can travelers learn when the next bus is due, but also how congested the freeways are.

PROGRAM GOALS

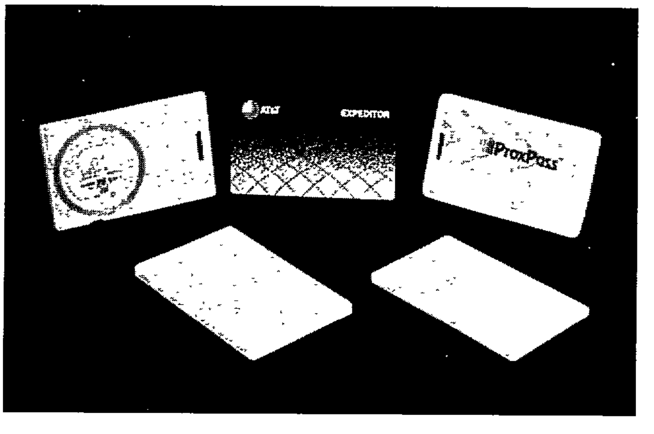
The purpose of the APTS program is to develop, test, and deploy ITS technologies and services that will improve the mobility, safety, and convenience of transit passengers and make operations more efficient and cost effective for transit providers. Specifically, the program has two goals: to improve the quality of public transportation service for users through increased service reliability, reduced travel times, more convenient fare payment, more accurate and easily obtained travel information, and faster incident response; and to enhance the cost effectiveness of transit operations, maintenance, and planning through automatic data collection and improved real-time scheduling of vehicles.

The PTA, in cooperation with the ITS JPO, has developed a comprehensive APTS program plan that presents goals and objectives, areas of focus, and near- and long-term projects. The program plan was completed at the end of 1996 and will be updated as needed.

PROGRAM ACTIVITIES

APT'S program activities aim to advance the state of the art and the state of the practice for APTS technologies and services and facilitate their integration with other components of ITS infrastructure in metropolitan and rural areas. Primary activities include applied research, field testing and evaluations, and training and outreach efforts. The U.S. DOT's efforts have encouraged almost one-half of the transit agencies in the Nation to use or plan for APTS technologies within the next decade. More agencies are expected to begin planning for ITS deployments as technologies are further mainstreamed and their benefits better quantified.

R&D: Applied R&D has advanced the state-of-the-practice APTS technologies through technical feasibility studies. The U.S. DOT evaluates new technologies to assess their potential benefits to transit. The results are published periodically in *Advanced Public Transportation Systems: The State of the Art.* In addition, FTA is coordinating with the FCC and others to ensure that communication frequencies for transit and ITS are not negatively affected by proposed radio frequency refarming legislation. Future studies will address transit system architecture requirements, human factors issues, frequency spectrum requirements and allocations, multimodal fare/toll payment smart cards, automatic vehicle monitoring and management system implementations, and map and spatial data base requirements. Technical support will include research and assistance to transit authorities implementing APTS technologies. In addition, FTA is evaluating computer reservation, dispatching, and billing



Smart cards can electronically pay for an array of services, including transit fares, tolls, and parking. By eliminating cash handling. these cards make fare payment more convenient to travelers and revenue collection less costly for service providers.

IMPROVING TRANSIT PRODUCTIVITY IN KANSAS CITY

Facing a funding squeeze and the need for greater efficiency, the Kansas City Area Transportation Authority (KCATA) turned to technology for answers. Rather than spending $2 million to replace an outdated radio communication system, KCATA opted to spend an additional $250,000 to outfit its entire fleet of 240 buses with an AVL system. The cost also included installation of 150 smart signposts along bus routes to read and communicate bus locations directly to a new computer-aided dispatch center.

At dispatch headquarters, a console monitors the actual location of each bus and compares it with the bus' planned route and schedule. Dispatchers can focus on buses that are ahead of or behind schedule and make appropriate adjustments. A digital readout in every bus provides drivers with the same real-time information, indicating whether they are running early or late on their scheduled routes. All buses are also equipped with silent alarms for emergency situations.

In operation since November 1990 the AVL system has served Kansas City well. On-time performance of the transit system has increased from 78 to 95 percent, enabling a reduction in the road supervisor fleet. In addition, KCATA was able to eliminate seven buses from its routes and estimates savings of $400,000 annually in operating expenses-without diminishing service to its passengers. The system has far surpassed initial expectations. Dispatchers are pleased with the way the AVL system assists them in performing their duties, and drivers appreciate the added safety the system provides; response time for handling emergencies has been slashed from up to ten minutes to approximately one minute.

The original signpost system has experienced some technical problems in the last 2 years, and KCATA has begun a $209,000 replacement and upgrade of all the signposts. Once they are fully operational in early 1997, the upgraded signposts will enhance the system with such features as automated passenger counting, automated stop announcements, and improved driver and passenger security systems.

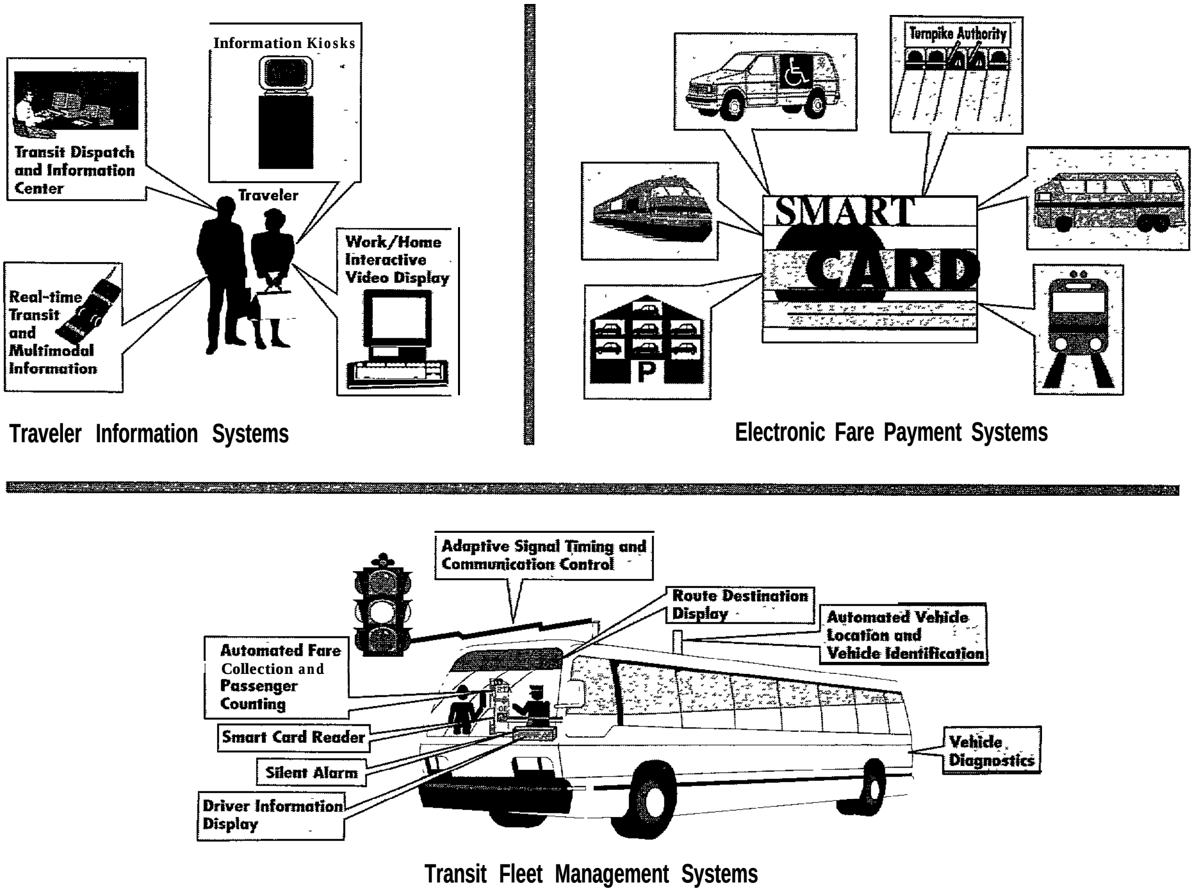
services for small urban and rural transit operations. This study will assess combinations of hardware and software and recommend procurement guidelines. PTA is also developing a program to apply APTS technologies to rural transit systems. Through this program, the benefits of improved service and increased efficiencies will be transferred to rural fixed-route, paratransit, and ridesharing systems.

Field Testing: The extensive APTS field operational test program is aimed at resolving technical and institutional issues and developing a better understanding of the cost effectiveness of APTS technologies and services. The program has established 29 multiyear field operational tests. 13 of which are complete. The available results, and other evaluations of early deployments, are the subject of several studies, most recently the August 1996 report. *Benefits Assessment of Advanced Public Transportation Systems.* Evaluation results are shared with transit agencies to assist them in determining how APTS technologies can meet their performance objectives.

Standards: The APTS program is working with the standards program to ensure that transit agencies can share information with each other. other planning departments, and regional traffic management centers. As part of this process. ITE has developed a preliminary transit communications interface protocol (TCIP). TCIP permits the development of a "plug-and-play" environment for information-based transit applications, such as scheduling software. traveler information systems, and AVL systems. In addition, the APTS program has supported IS0 Technical Committee 204, Working Group 8, to develop international transit and emergency ITS standards. International standards enhance product quality and reliability; increase compatibility, interoperability, and efficiency; and reduce development, production, and training costs.

The three functional areas of APTS, transit fleet management, electronic fare payment, and multimodal

EXHIBIT III-8
SYNOPSIS OF APTS TECHNICAL LESSONS LEARNED



APTS applications include transit fleet management, electronic fare payment, and traveler information systems. Over the past 5 years, we have learned much about the technical issues of APTS including:

- First-generation smart cards are technically viable for rail and bus travel. Current efforts are targeting the development of universal cards that can pay for a wider range of services, including toll fees and public parking.
- For transit fleet management systems, techniques have been developed to leverage personal computer technology, geographic information systems, wireless communications, and AVL systems.
- Because of the costs of the operation centers, larger transit agencies (those that have 100 or more buses in the fleet) have deployed fleet management systems more often than smaller agencies. However, the smaller operators, who generally cover a larger geographic area, have the greatest need for these systems.
- Operational tests have shown that disseminating transit information via kiosks, signs, home computers, cable television, and personal communicators is technically viable.

EXHIBIT III-9
BENEFITS OF APTS

APTS Element	Benefits	Source
Transit Fleet Management	• Maryland Mass Transit Administration's AVL system increased on-time performance on test buses by 23%.	ITS America
	• Kansas City Area Transit Authority's average response time to calls for bus operator assistance was reduced from 10 minutes to 1 minute with its AVL system.	FTA
	• Winston-Salem Transit Authority's AX/computer-aided dispatch system increased paratransit ridership by 17.5% and decreased paratransit passenger waiting times by 50% in North Carolina. The system also decreased operating expenses by 2% per passenger and by 9% per vehicle mile.	Ibid.
	• Massachusetts Bay Transportation Authority's Gasoline Alley advanced vehicle management project produced savings of $500,000 by improving maintenance and data processing and reducing waste and pilferage.	Ibid.
Electronic Fare Payment	• Nationally, decreases in fare evasions at those transit systems that have installed electronic fare payment technology have resulted in increases in revenues of 3% to 30%. • Faretrans, an operational test in Ventura County, CA, estimates that its smart card system can save $9.5 million per year in reduced fare evasion, $5 million per year in reduced data collection costs, and $990,000 per year by elimination of transfer slips. • New Jersey Transit Corporation estimates that its automated fare collection system can save $2.7 million in fare-handling costs. The system increased revenues by 12%. • New York City's Metropolitan Transit Authority estimates that its metro card system will save $70 million per year in fare evasion.	Mitretek Systems, *Assessment of ITS Benefits: Emerging* Successes, prepared for FHWA September 1996.
Traveler Information Systems	• The California DOT reported that over 85% of Smart Traveler kiosk users in Los Angeles plan to continue using the kiosk to obtain travel information. • San Diego County's interactive voice response system increased information agent productivity by 21%. • Rochester-Genessee Regional Transportation Authority's automated transit information system will allow the authority to reduce operating costs. • New Jersey Transit's automated voice response telephone information system has reduced caller waiting time from 85 seconds to 27 seconds and the caller hangup rate from 10% to 3%. The system also handled 400,000 more calls than the previous year.	Ibid.

traveler information, are also a part of the metropolitan intelligent transportation infrastructure. As a result, the APTS program encourages those deploying APT'S technologies to use the national ITS architecture-the framework that enables ITS user services to share information and work together.

Outreach: Through outreach efforts, the APTS program disseminates the results and lessons learned from its research activities to transit professionals and passengers. As part of the program for building professional capacity, the APTS program recently developed a training module on transit management systems to train transportation professionals about the technical and operational requirements of APTS technologies and services. These sessions began in September 1996. In addition, the APTS program's ongoing support of the National Transit Institute at Rutgers University provides further opportunities for transit professionals to expand their knowledge through various courses. Finally, the APTS program has reached out to professional organizations, including the American Public Transit Association, with grants to conduct seminars and other training sessions on new technologies and to disseminate ITS publications to their memberships.

TECHNICAL LESSONS

First-generation transit technologies are viable and feasible, although early projects took longer than expected to implement because of hardware, software, and system integration problems. Standards are critical to guide the development of mobile communication systems and vehicle location devices on buses. Currently, transit operators must have these systems custom-made; standards will likely reduce their perunit cost. Exhibit III-8 highlights technical lessons learned in the APTS program.

BENEFITS

As shown in Exhibit 111-9, many of the anticipated benefits of APTS have been realized. The FTA's recent analysis of benefits to the transit industry indicates that current and planned deployments at U.S. transit authorities will yield cost savings totaling between $3.8 billion and $7.4 billion (in 1996 dollars) over the next 10 years. FTA's total budget over the next decade is estimated to be $38 billion; therefore, if the transit industry achieves even the low estimate of $3.8 billion in savings, the return on the Federal investment will be 10 percent annually. In addition to reductions in operating costs for transit operators, other benefits could be achieved if APTS can help reduce demand for vehicular travel.

The APTS program is continuing to evaluate projects to better understand the potential benefits of specific technologies. The program has not yet determined if electronic fare payment systems induce people to switch to transit. Further research must also be conducted to determine which method of disseminating traveler information (i.e., kiosks, PCs, en route systems) is most effective to reach the largest number of travelers and whether providing real-time travel and traffic data will encourage more people to ride transit.

INSTITUTIONAL ISSUES AND USER ACCEPTANCE

User acceptance of APTS technologies is high and continues to grow. Exhibit III-IO shows the number of actual and planned APTS deployments in the United States in the next decade.

Fleet management technologies-particularly GPS-based vehicle location systems-continue to be deployed at ever-increasing rates. The U.S. DOT found that 27 transit systems are operating more than 9,250 vehicles under AVL supervision; another 42 systems are in procurement or testing. Automated fare technologies are also finding markets; at least 28 public transit systems in the United States are increasing the level of automation in their fare collection systems. The 1996 report entitled *Advanced Public Transportation Systems Deployment in the United States* documents existing and planned implementa-

EXHIBIT III- IO
ACTUAL AND EXPECTED APTS DEPLOYMENTS IN THE UNITED STATES

System Deployments"'	Transit Fleet Management	Electronic Fare Payment	Traveler Information	Total Transit Industry"
Agencies operating systems in 1996 (% of all agencies)	147 (29.8%)	28 (5.7%)	53 (10.8%)	174 (35.3%)
Agencies operating systems by 2005 (% of all agencies)	214 (43.4%)	66 (13.4%)	97 (19.7%)	246 (49.9%)
Total vehicles in agencies operating systems in 1996 (% of all vehicles)	20,918 (32.4%)	10,913 (11.8%)	19,242 (20.8%)	39,662 (42.9%)
Total vehicles in agencies operating systems by 2005 (% of all vehicles)	49,986 (54.1%)	21,710 (23.5%)	33,465 (34.2%)	54,296 (58.7%)

Note:
"'The total number of agencies used in this comparison is 493 and the total number of vehicles is 92,436. The vehicle count includes fixed-route motor bus (53,720 vehicles), demand responsive (17,447 vehicles, primarily buses), heavy rail (10,282 vehicles), commuter rail (5,126 vehicles), Vanpool, jitney (4,005 vehicles), light rail (1,031 vehicles), trolleybus (643 vehicles), ferryboat (86 vehicles), automated guideway (41 vehicles), cable car (39 vehicles), inclined plane (8 vehicles), monorail (8 vehicles).
'"'Total transit industry counts are lower than sum of previous three columns, since most agencies deploy more than one of the three APTS elements.

Sources: *FTA's 1994 National Transit Database* and *APTS Deployment in the* U.S., August 1996.

tion of APTS technologies and services. APTS are, however, only gradually being integrated with other components of the metropolitan intelligent infrastructure, such as traffic management systems. In addition, although traveler information technologies can help transit agencies disseminate timely and accurate service information, the agencies are often reluctant to provide transit schedule information for fear that the broadcast may not accurately describe system status. In addition, if the operators quickly implement strategies to restore schedule performance, the bus may arrive before it is expected, and people may miss it.

Interagency cooperation, training, and education are critical to successful deployment of APTS products and services. Transit authorities, which are usually independent of other transportation agencies (such as municipal public works agencies), will need to work cooperatively to deploy APTS successfully. Transit agencies and municipalities, for example, must collaborate to develop and implement signal priority systems for transit vehicles. Training and education are also needed to prepare transit professionals for future challenges and to overcome individual reluctance to accept new technologies. A major objective of courses offered at the National Transit Institute and other universities is to increase the number of new skilled transit professionals. FTA and the ITS JPO are addressing these training issues through their program for building professional capacity.

Universal multi-use smart cards require the cooperation of major banks and credit card companies. After agreeing on international standards for stored-value cash cards in early 1995, Visa and Mastercard are supporting pilot projects for multi-use cards. The open system arrangement allows transit agencies to take advantage of the extensive communication and financial management infrastructure being established by the financial industry for electronic payment systems.

Labor relations in the transit industry are extremely important because unions have the power to demand that transit agencies secure agreement from labor before investing in capital facilities, including new technologies. As a result, outreach efforts must reach union representatives, particularly those responsible for bus operators, who may be hesitant to use new technologies, fearing loss of personal privacy and excessive management supervision.

FUTURE DIRECTIONS

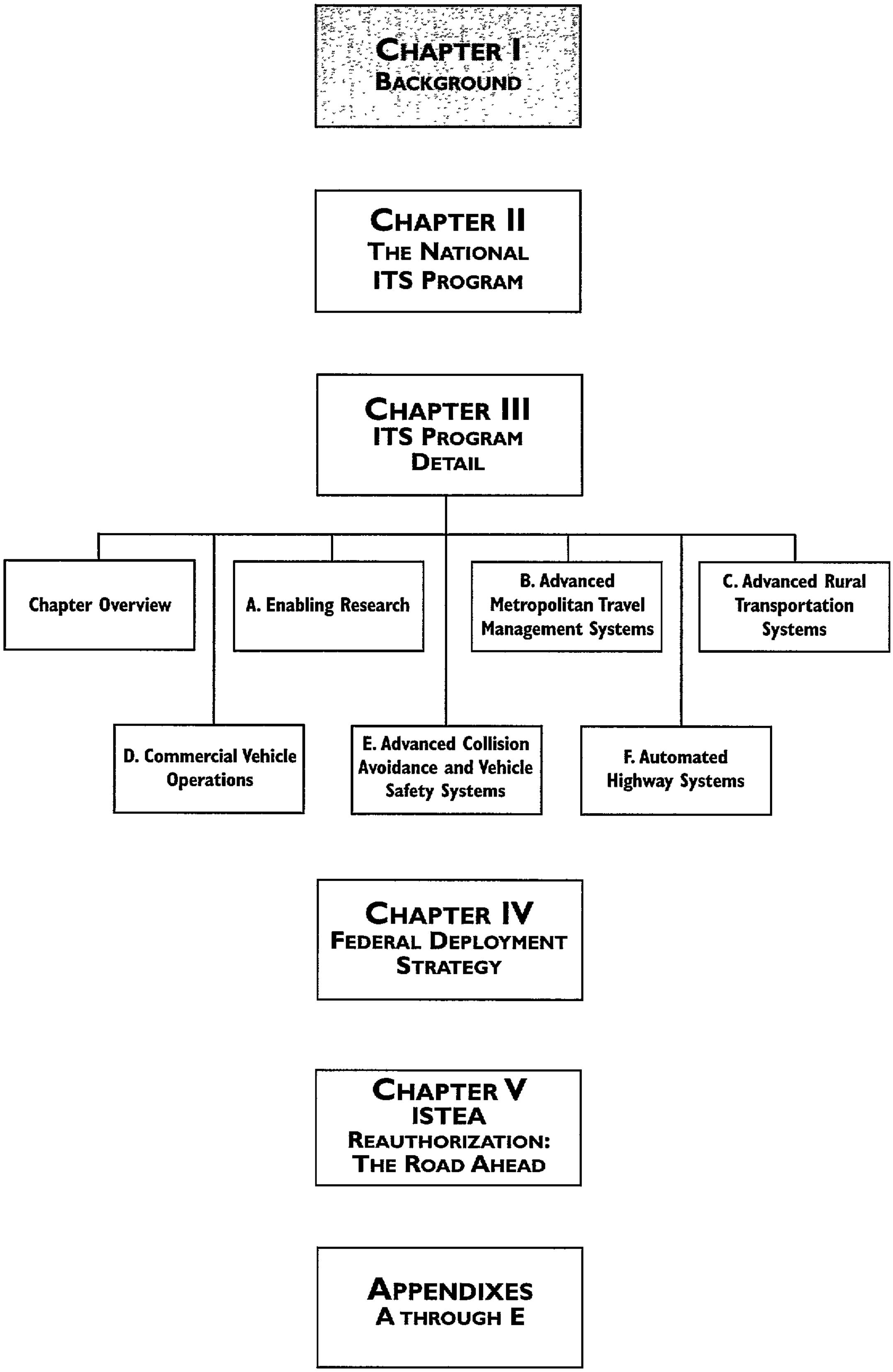
The APTS program will continue to foster acceptance of APTS technologies and their integration into the metropolitan ITS infrastructure. Future work will also emphasize standards to promote information sharing, expand product selection for public transit providers, and facilitate system integration.

The APTS program also will push to advance the state of the art in all three areas of APTS services through research and field testing. For transit fleet management, the program will examine, consider, and develop new communication systems and other technologies to streamline passenger counting, assist in operational strategies for flexible routing of vehicles, facilitate multiple-agency regional fleet management, and enhance automated system diagnostics.

Efforts in the electronic fare payment program will be directed at developing the next-generation smart card that is “contactless” and compatible with Europay/Master&d/Visa chip card standards. This card would move toward a universal standard that would enable it to be used for a variety of services, including electronic toll collection, transit fares, and public parking. Pilot tests in field settings are in process. For example, a “VISA CASH” stored-value card was tested in Atlanta during the 1996 Olympic games.

The program will seek to improve the quality and supply of information to support traveler information systems. This work includes continued investigation of new media (such as personal communication devices) through which to present traveler information. Much of the research and field testing of these technologies is also already underway in the ATIS and ATMS programs. Integration of real-time transit information with traffic information is the next step in developing regional multimodal traveler information systems.

Growth of the Nation’s highway capacity is increasingly constrained by costs and other issues associated with building more roads. This situation will increase the demand for transit to carry a greater share of growing transportation needs. Demand for public transit to make do with fewer public dollars will also continue. The APTS program will identify and define solutions to meet these challenges. In addition, the program will continue to ensure that transit in the United States is equipped with the most efficient technologies and provides an unprecedented level of customer-oriented service to bring transit use further into the mainstream.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C. Advanced Rural Transportation Systems

The transportation needs of rural areas differ significantly from those of urban areas. Although less than 40 percent of annual vehicle-miles traveled is on rural roads, these roads account for 60 percent of all traffic fatalities because of higher speeds and relatively slow emergency response. Further, many rural residents are isolated, without a car or access to public transportation. Currently, 38 percent of rural residents live in areas without any public transit service; another 28 percent live in areas where the level of transit service is negligible. In addition, visitors to rural tourist areas have limited access to directions and other basic travel information.

The rural element of the ITS Program brings together FHWA, FTA, and NHTSA to advance the strategic application of ITS technologies and services to improve the quality of life for rural travelers by providing better access to people, goods, services, and information. Some of these services have urban counterparts, while others are specifically for rural applications. Advanced rural transportation systems (ARTS) are clustered into seven critical program areas:

- **Traveler safety and security** technologies alert drivers to hazardous conditions and dangers and include wide-area dissemination systems to provide safety information, site-specific safety advisories and warnings, and safety surveillance and monitoring. Collision avoidance systems will significantly reduce traffic deaths and injuries.
- **Emergency service** technologies automatically notify emergency response services-ambulances, police, fire fighters-of collisions and other emergencies. Examples are Mayday systems, automatic collision notification systems, and advanced emergency response systems.
- **Tourism and travel information services** provide information to travelers who are unfamiliar with the local rural area. These systems include information services provided at fixed locations and en route, mobility services, and smart card payment/ transaction systems.
- **Public traveler services/public mobility services** improve the efficiency of transit services and their accessibility to rural inhabitants. APTS technologies can offer rural transit operators the benefits of better scheduling capabilities, leading to greater operational efficiencies. Technologies include AVL and improved dispatching, smart card payment/ transaction systems, and advanced ridesharing and ride-matching systems.
- **Infrastructure operation and maintenance** technologies improve the ability of transportation personnel to maintain and operate rural roads. They include severe weather information services, early detection of pavement problems, and detection of dangers to work zone crews.
- **Fleet operation and maintenance** systems improve the efficiency of the scheduling, routing,

Quick Facts on Rural Areas

- **Rural areas include 83 percent of the Nation's land, 2 I percent of its population, I8 percent of its jobs, and 14 percent of its earnings.**
- **In 1990, 2,288 of the Nation's 3,04 I counties were rural.**
- **Compared with urban areas, rural areas contain greater percentages of elderly citizens, people in poverty, households with incomes below the national median, and homeowners.**
- **Rural economic shifts have diminished land-based industry to 7.6 percent of the work force. Service sector industries employ up to 5 1 percent of the rural work force. The highest producers of economic growth and employment are recreation and tourism.**

and maintenance of rural transit fleets. These systems use advanced dispatching and routing and advanced vehicle-tracking technology.

- CVO systems manage the movement and logistics of commercial vehicles, include technologies specifically for rural areas that monitor vehicle and driver performance, and locate vehicles during emergencies and breakdowns.

Program Goals

The primary purpose of the ARTS program is to judiciously apply advanced technologies to support the safe, secure, available, and efficient movement of people and goods throughout rural America. The program has five goals:

- Improve the safety and security of users of the rural transportation system.
- Enhance personal mobility and access to services and enhance the convenience and comfort of all users of the rural transportation system including those that are unfamiliar with the area.
- Increase the operational efficiency and productivity of the transportation system, focusing on system providers.
- Enhance the economic productivity of individuals, businesses, and organizations.
- Reduce energy consumption and environmental costs and impact.

The program brings together the highway and public transportation communities through public-public and public-private partnerships to ensure that ARTS are sustainable and seamlessly connected, where appropriate, to other deployed ITS in adjacent corridors and metropolitan areas.

Program Activities

The ARTS program encompasses R&D activities, as well as field testing of rural ITS applications. The program is still young; major research and field demonstrations are ahead.

In early 1993, FHWA initiated a comprehensive study of rural applications of ATIS. The study produced an assessment of rural user needs, a technology review, development of rural system concepts, and an assessment of ARTS activities. Based on this study, the ITS JPO formed a rural action team in 1995 to develop a vision, strategic plan, and program plan for the ARTS program. The preliminary versions of these plans were completed in September 1996. The team is also producing a strategy for creating an ITS infrastructure to support ARTS applications. In addition, FTA, with the help of the rural action team, has produced recommendations for ITS to be used in rural public transportation systems. The results of this work will be guidance materials on applying ITS solutions to rural transportation problems and mainstreaming these solutions into standard transportation planning processes.

In addition to these studies, the program has launched six operational tests investigating the technical viability of traveler, weather, and storm-warning information systems and will initiate two to three more tests during FY 1997. The rural action team is developing a listing of field tests and demonstrations that might have rural applications and assessing their potential benefits for rural communities. The rural applications investigated include automated collision notification (Mayday) systems, automated warnings at highway-railroad crossings, and demand-responsive paratransit.

Technical Lessons

Most of the technologies needed for ARTS applications exist or are being developed for general ITS user services. Although some R&D for rural technology may be justified, the major problems are determining how to deploy the technologies optimally, and how to handle such issues as information dissemination, training, and financial resources to deploy existing technology.

The needs and user services associated with ARTS are common to all ITS users and will best be met by a national ITS infrastructure that is integrated and interoperable. Developing separate, disconnected, or overly specialized systems for rural environments would be counterproductive to creating a national system.

Rural transportation issues differ from urban issues, however, because they must address such factors as longer travel distances, low population densities, and sparse, unmarked, or rugged environments. Although rural applications generally do not emphasize congestion as much as urban applications, some rural communities need help coping with part-time or seasonal traffic congestion. For example, advanced traffic control systems could be useful technologies for tourist hot spots, seasonal events, small communities that have population densities just below the urban threshold, and rural areas on metropolitan fringes.

All of the seven ARTS program areas have functions that require good radio propagation for communications and location-positioning information. ITS often rely on cellular communication, which in sparsely populated and rugged areas is currently unavailable and may remain so until cheap low-orbital satellite systems are developed. In rugged terrain, coverage of satellite positioning signals and communications may be unreliable. Because of these economic and technical issues, it is unclear when and where some ITS functions will be available in many rural environments.

It is also necessary to precisely define the cost effectiveness of ARTS applications given the sparse development and expansiveness of many rural areas. After the feasibility limits are defined, explicit decisions can be made about whether Federal resources can reasonably extend the borders

Automated Collision Notification in Rural Areas

Saving lives and reducing medical response time in critical traffic accidents are propelling devefopment of automated collision notification (ACN) systems. Currently in the development and testing stages, ACN systems automatically and immediately report an accident and its location to an emergency medical service, significantly reducing the time it takes to assist crash victims. Such technology is vital in rural areas, where many accidents are not immediately discovered or reported and people injured in accidents might wait helplessly for medical aid.

According to NHTSA, in 30 percent of rural traffic fatalities, more than one hour elapses from the time of a crash until victims arrive at a hospital. In 23 percent of fatal rural accidents, more than 10 minutes elapse from the time of an accident until emergency medical services are notified. In sharp contrast, less than 8 percent of fatal urban crashes require more than IO minutes for notification of emergency medical services.

An ACN system will use in-vehicle equipment to detect a crash and instantaneously relay information on crash location and severity to an emergency 9 I I system. As ACN technology is enhanced, it will include special algorithms that may provide estimates of crash victims' medical conditions and smart card technology designed to provide medical histories to the emergency medical service dispatcher. Two-way communications also will be developed to acknowledge an assistance request and assure victims that help is on the way.

Currently, an operational field test is underway near Buffalo, NY, that will integrate crash sensors, cellular communication equipment, GPS position location devices, and automated map display technologies in a working ACN system. NHTSA is administering the test to determine whether the technology works as intended, how travelers accept and use the technology, and whether travelers are willing to pay for the technology. Test results should determine the effectiveness of the ACN prototype system, measure user acceptance, and test the feasibility of widespread use,

In the meantime, less advanced products are on the market, including cellular phones for notification and GPS location systems for pinpointing an accident site. These technologies require that the driver is capable of making a phone call, unlike ACN systems. ACN will ultimately become a critical element of ITS, especially for rural areas where it will save lives, reduce injuries, and improve efficiency of emergency response.

of ITS services. In other words, rural demonstrations need careful planning to efficiently explore the economic feasibility of the spectrum of ARTS applications.

Whether or not Federal resources for ARTS can be increased, a key strategy to speed deployment is to increase the efficiency of operations and reduce unit costs. Besides developing new technologies, one way to accomplish these goals is to use scale economies of systems that are not differentiated or localized for particular rural areas. Another way to increase efficiency and reduce cost is to consolidate or coordinate technologies within rural areas. Institutional barriers between local agencies could, however, impede these efforts.

Benefits

The focus of upcoming efforts of the ARTS program is to document the benefits of advanced traveler information, collision avoidance, and public transit systems in the rural context. Given the enormous needs of rural transportation system users, ARTS services are expected to create significant benefits. For instance, faster response time to incidents and crashes has been shown to save lives and reduce medical costs. Security systems, such as Mayday technologies and traveler information services, improve customer satisfaction and peace of mind. The program is developing specific performance goals to assess ARTS benefits in the context of user needs.

Institutional Issues and User Acceptance

The market for rural travel services includes all residents of rural communities; commuters from rural to metropolitan areas, residents of large, sparsely populated rural areas; commercial movers of goods; public transit operators; and metropolitan area residents traveling into rural areas, such as tourist destinations. The following items are the key institutional and user acceptance issues:

- Early focus group research suggests that residents of rural communities particularly value the benefits of Mayday and weather advisory services; however, liability is a major issue for safety and security technology such as Mayday and emergency response systems.
- Transportation operators view vehicle diagnostics (road, traffic, and weather condition) and vehicle location and navigation services as valuable for safety and operation of both fixed-route and demand-responsive services. Many rural transit agencies are demand-responsive operations and require information on passenger needs, but do not have computerized data bases to manage that information.
- The private sector is expected to take the lead in developing and deploying ARTS through partnering initiatives involving the highway and public transportation communities. This new way of providing service will require innovative financing principles.
- For emergency services, integrating dispatching, sharing actuarial data, and coordinating with non-emergency transportation are important issues that may meet with institutional resistance.
- The National Park Service is an important Federal player in tourism, but other Federal roles in local economic development must be carefully defined. The tension between local interests and the national need to integrate information services may create institutional barriers.
- Traffic management and public mobility services raise questions of appropriate jurisdictional integration to achieve cost effectiveness and economy of scale.
- State DOTs will be dominant players in fleet operating and maintenance systems, but there is no existing mechanism to bring all relevant fleets and providers together. Technical outreach to small providers is essential.

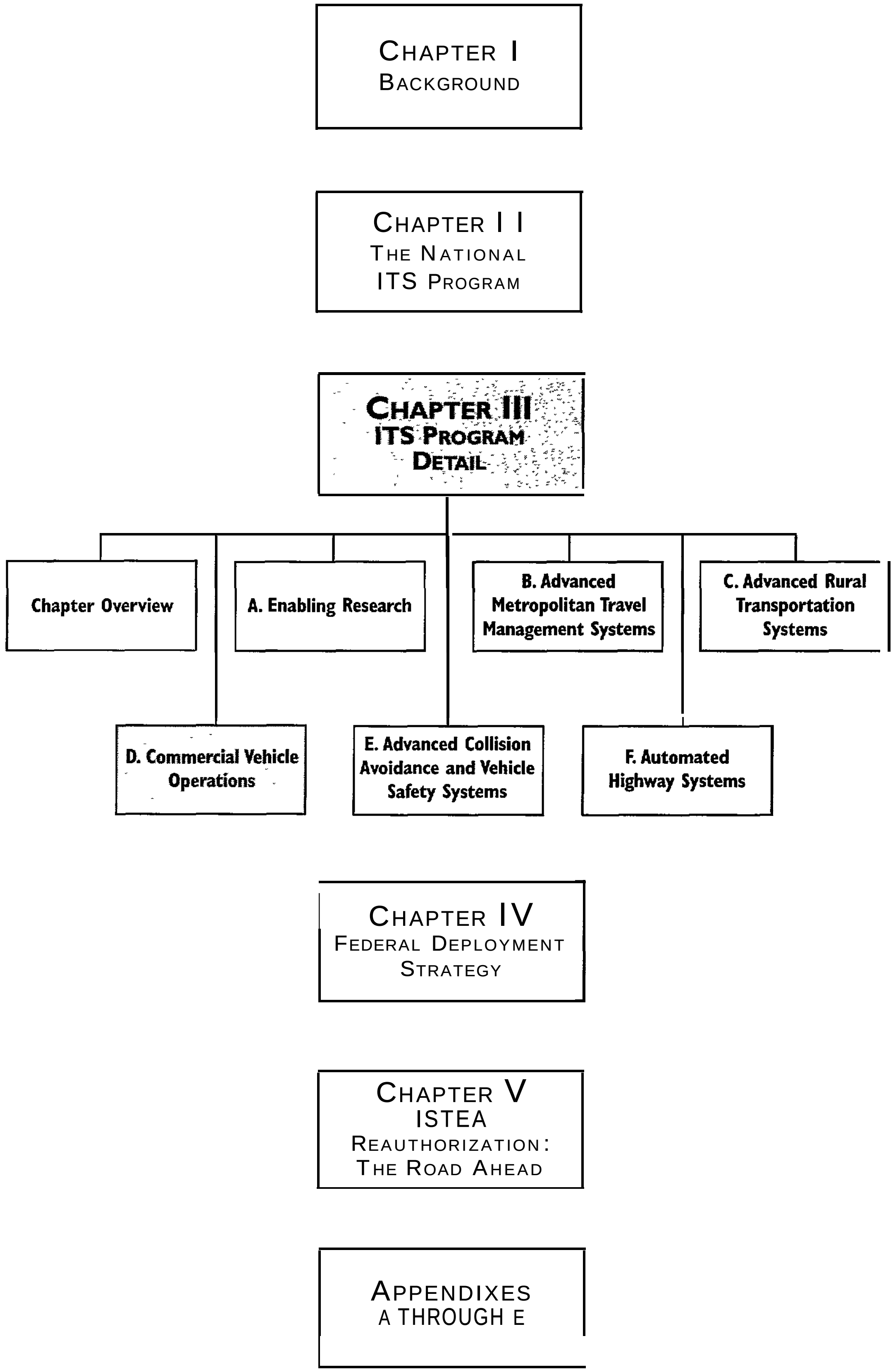
The Federal Government has always been concerned with rural needs. ARTS concepts provide opportunities for various Federal agency and other public-public and public-private partnerships. Coordination between U.S. DOT and the National Park Service, as well as the Departments of Agriculture, Commerce, Health and Human Services, and Defense will be important. The Federal Government also needs to strengthen its understanding of rural transportation needs to ensure appropriate ITS applications.

Future Directions

In the near term, the ARTS program is compiling knowledge that can be transferred from other aspects of the ITS Program to better design and apply technologies and services to rural settings. When this compilation is complete, the program will segment user needs according to market-based technological applications, evaluate these applications through operational tests, incorporate the needs into EDP strategies, and devise deployment guidance in the form of a "toolbox" for rural communities.

As the knowledge base matures, the seven critical program areas are expected to evolve into the elements of a comprehensive ITS infrastructure, which will help spur and support private sector investment and market development. Recognizing that public benefits come only through commercialization of safe and effective products, the program also aims to build cooperative relations between government and industry.

In the long term, the program will focus on the research, development, and testing of more sophisticated technologies that show promise of meeting rural needs over the next 10 to 20 years. These technologies include advanced collision avoidance systems, the next generation of traveler management techniques, and automated highway concepts.



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III. ITS PROGRAM DETAIL

D. Commercial Vehicle Operations

The interstate commercial motor vehicle industry includes approximately 400,000 motor carriers, 4,000 for-hire passenger carriers, and 6.6 million commercial drivers. It is a complex mix of businesses ranging from one-truck operations to fleets with thousands of vehicles and drivers that transport both goods and passengers. On the average, interstate motor carriers may deal with five or six public agencies in each of the States in which they operate. They are legally required to obtain numerous credentials and clearances that require extensive information; approximately 225,000 of these carriers operate without a safety rating because of the limited number of inspectors available to monitor new and established carriers.

In addition, regulatory compliance entails inefficient administrative procedures and redundant, often manual, data entry. As a result, States cannot easily share information, and the information that is shared is often inadequate. The administrative burden associated with regulatory compliance also increases labor costs for the motor carrier industry. Compliance costs for the industry (including record keeping, safety programs, and tax filing) have been estimated to be as high as $5 billion annually. The public sector's costs are even greater because of the paperwork associated with inspecting vehicles, issuing credentials, and collecting taxes.

The CVO program, administered by FHWA's Office for Motor Carriers and supported by FIIWA's Office for Research and Development, addresses all facets of commercial operations, including vehicles, drivers, motor carriers, and sometimes cargo. The vision of the ITS/CVO program is to apply advanced information and communication technologies to enhance the safety and mobility of commercial trucks and buses and reduce the costs of regulatory compliance. The primary users of these technologies are State regulatory, administrative, and enforcement personnel; Federal motor carrier officials; and the motor carrier industry.

At the center of the ITS/CVO program are commercial vehicle information systems and networks (CVISN), which are illustrated in Exhibit 111-l1. CVISN will link existing disparate and cumbersome information systems and data bases (currently used by regulators to obtain compliance information) and allow electronic exchange of information.

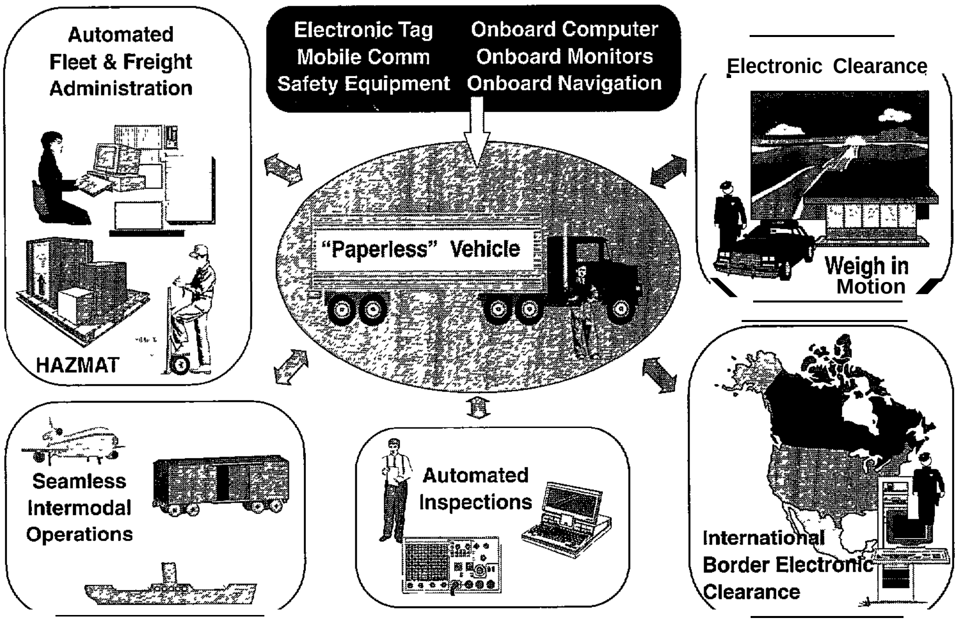
Together, all these commercial vehicle information systems and networks will become the building block for major commercial vehicle communication and data exchange operations, enabling more efficient public and private sector services. CVISN will encompass the systems that, among other things, permit trucks to transmit and receive messages from the roadside, allow vehicles to be weighed without stopping, provide electronic screening and driver alertness management programs, and expedite international border crossings. Safety information provided by CVISN will be used to identify unsafe and illegal operations without hindering the productivity and efficiency of safe carriers. Motor carrier inspectors will be able to focus their attention and scarce resources on high-risk carriers. In many cases, information and operating credentials will be available instantly, as opposed to within weeks or months.

CVISN encompass six ITS/CVO user services:

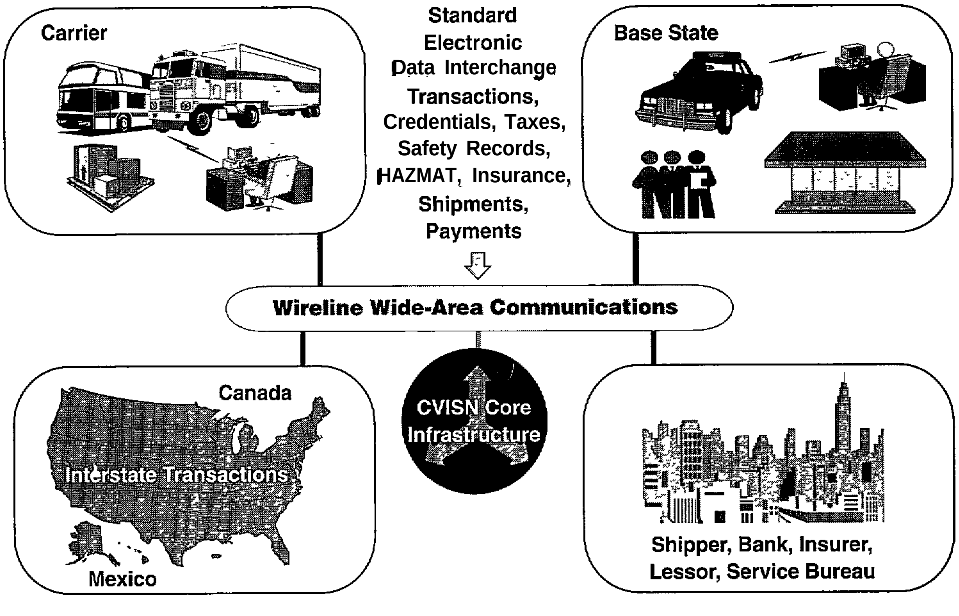
- **Commercial vehicle electronic clearance systems** enable safe and legal carriers equipped with transponders to pass through compliance checks at weigh stations, border crossings, and other inspection sites without stopping repeatedly.
- **Automated roadside safety inspection systems** combine safety data provided by the electronic clearance service with other technologies to check vehicle safety and driver alertness and fitness for duty.
- **Onboard safety monitoring technologies** use methods that are not intrusive to monitor the driver, vehicle, and cargo and notify the driver, carrier, and possibly enforcement personnel of any unsafe situations, such as driver fatigue, vehicle failure, and shifting or unbalanced cargo.

EXHIBIT III-1 I
VISIONS OF CVISN

VISION: SAFE AND EFFICIENT SHIPPING OPERATIONS



VISION: ELECTRONIC BUSINESS TRANSACTIONS



- **Commercial vehicle administrative processes** allow carriers to purchase credentials and to collect and report fuel and mileage tax information electronically.
- **Freight mobility systems** provide communication links between drivers, dispatchers, and intermodal transportation providers, supplying real-time information that allows carriers to plan and schedule vehicle trips and routing.
- **Hazardous materials incident response technologies** provide emergency personnel with data currently maintained by hazardous materials transporters, including data about the cargo load, response instructions, and emergency response phone numbers.

Program Goals

The mission of the CVO program is to advance high-quality, efficient, safe, and legally compliant commercial vehicle shipping and busing services throughout North America. CVISN activities are expanding the vision of ITS/CVO to establish a fully integrated collection of motor carrier information systems. These unified systems will support safe and seamless commercial transportation throughout North America by providing timely and easily accessible information to authorized users. The CVO program's three primary goals are to improve highway safety, increase motor carrier productivity, and streamline regulatory and enforcement procedures.

Program Activities

The CVO program is comprehensive and expansive; it encompasses the large and varied information needs of State, customs, and transportation agencies, as well as motor carriers and operators. The activities of the program fall into seven areas: R&D, field operational tests, the roadside MCSAP computer systems program, the North American Trade Automation Prototype (NATAP), standards development, mainstreaming, and MDIs.

> **Distinction of Terms**
>
> **CVO are those operations and regulatory activities associated with the commercial movement of goods and passengers across the North American highway system and international borders. Operations include activities related to commercial vehicle credentials and tax administration, roadside operations, safety, freight and fleet management, border crossings, and vehicle operations. ITS/CVO are the elements of ITS that support CVO, including CVISN and other elements of ITS, such as sensors and control technologies. CVISN are the ITS information system elements and communication networks that support CVO, including information systems owned and operated by governments, carriers, and other stakeholders.**

R&D

R&D efforts support conceptual designs of ITS/CVO systems and services. Other feasibility studies, such as *Benefit/Cost Analysis of the ITS/CVO User Services,* address cost/benefit analysis of CVO services and investigate supporting technologies, such as brake inspection methods for CVO user services. Developmental activities include inspection selection algorithms that target higher risk vehicles and enable carriers to obtain one-stop electronic clearance credentials from State agencies.

R&D of onboard safety monitoring systems is also underway. Project participants are developing sensors and diagnostics and are testing prototype electronic systems that monitor brake performance and assess the fitness of commercial motor vehicles for duty.

A prototype of carrier automated transaction (CAT) software was also developed to allow carriers to obtain credentials for registration, fuel tax, oversize/overweight operation, and hazardous materials transport. The CAT software runs on a personal computer and allows carriers to file quarterly tax reports and perform other routine carrier-to-State transactions electronically.

R&D is also underway in partnerships with International Registration Plan, Inc., and International Fuel Tax Agreement, Inc., nonprofit companies formed by the States and managed by boards of directors who are State administrators. Through this partnership, R&D efforts are designing interstate exchange capabilities in support of the CVISN architecture.

Field Operational Tests

The program has launched 12 field operational tests at numerous locations along the Nation's major long-haul corridors; 3 tests are completed. The technologies covered by operational tests include one-stop electronic clearance, automated safety inspections, hazardous materials response, and international border-crossing systems.

Advantage I-75: Advantage I-75 represents a multistate partnership of public and private sector interests along the I-75 corridor in Florida, Georgia, Tennessee, Kentucky, Ohio, Michigan, and Ontario, Canada. The project, which began in January 1991, facilitates motor carrier operations by allowing trucks that are equipped with transponders and properly documented to travel any segment along the entire length of I-75 at mainline speeds with minimal stopping at weigh/inspection stations. Electronic clearance decisions at downstream stations are based on truck size and weight measurements taken upstream and on computerized checking of operating credentials in each State. Advantage I-75 features the application of transponder technology and decentralized control; each State retains its constitutional and statutory authority relative to motor carriers and their operations.

One-Stop Electronic Clearance: The electronic one-stop shopping tests bring together Help, Inc., and 14 Midwestern and Southwestern States. The program tests different approaches to one-stop, multistate electronic purchase of credentials, registration, fuel tax, and overdimension permits from participating base States. Help, Inc.'s pre-pass clearance system is an example of an operational test that has transcended the public sector and now operates in the private sector. Now a commercially viable venture between 10 States, the pre-clearance system uses no direct Federal funds.

Automated Safety Inspections: The ITS/CVO program also provides access to vehicle and driver information and historical interstate carrier safety information in the national Safety and Fitness Electronic Records (SAFER) system operational test. Inspections targeted by the inspection selection system, an integral part of SAFER, gave a 30 percent higher out-of-service rate for drivers and a 75 percent higher out-of-service rate for vehicles than traditional inspection procedures.

Two operational tests are currently underway in Minnesota/Wisconsin and Idaho that use technologies to provide automatic, real-time out-of-service verification at the roadside. The Wisconsin/Minnesota project uses video identification equipment and a data base, which contains out-of-service data on specific vehicles. Subsequent downstream identification of vehicles determines whether a vehicle is in violation of an out-of-service order. The Idaho project uses AVI tags, video-imaging analysis, and an inspection site alarm system that is activated when an out-of-service vehicle attempts to leave.

International Border Crossing: The ITS/CVO program demonstrates electronic clearance, inspection, and identification at international borders in the electronic clearance for international borders tests. The U.S. DOT has partnered with U.S. Customs, U.S. Immigration, U.S. Treasury, State DOTs, and private sector stakeholders to investigate the feasibility of applying CVO technologies to facilitate international border crossings, which are often a source of substantial delay for motor carriers. The program has designed border-crossing systems and is conducting operational tests of these systems at crossing points on

Automated .CLEARANCE SHORTING WAITS ALONG INTERSTATE 75

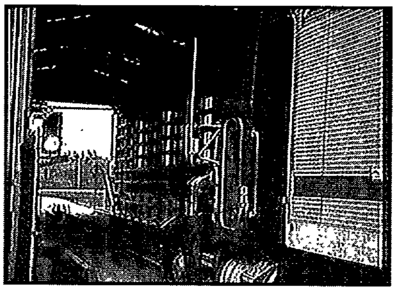
Extending from Miami to Detroit, interstate 75 receives some of the heaviest commercial vehicle traffic in the Nation. The entire corridor, which continues all the way to Belleview, Ontario, as Canadian Highway 401 is one of the longest and busiest trucking routes on the continent. With 30 weigh stations-22 in the United States and 8 in Canada-waiting in line to weigh in, undergo inspection, or have paperwork reviewed adds up to lost efficiency and productivity for many commercial carriers.

The Advantage I-75 operational test project is designed to reduce long lines of trucks by providing electronic clearance at all the weigh stations. A system called Mainline Automated Clearance System (MACS) processes trucks electronically, eliminating their need to stop at multiple weigh stations during a trip on the 751401 corridor. MACS incorporates AVI technology, which uses truck-mounted transponders and roadside readers to electronically identify and process a truck After entering the highway, a truck is processed at the first weigh station where specific information is collected and stored electronically in the truck's transponder The data are automatically communicated ahead to subsequent stations for compliance checks when the truck arrives. As the truck approaches another weigh station, the transponder communicates the results of the compliance check with the driver, who may be authorized to bypass the weigh station.

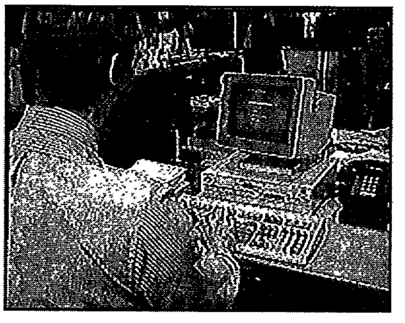
Currently, 4,500 vehicles are participating in the Advantage I-75 operational test, and the MACS system is now installed in every weigh station from Miami to Belleview, Ontario.The 2-year test is expected to increase productivity and efficiency, which will uttimately tead to reliable, on-time delivery of goods and reduced transportation costs. An early study on pre-clearance showed a benefit-cost ratio of 7.2: I. Based on preliminary data, the field test is saving time for both truckers and government regutators, reducing vehicle operating costs, and increasing safety and regulatory compliance from truckers.

Advantage I-75 is a partnership of public and private groups interested in reducing congestion, increasing efficiency, and promoting safety along Interstate 75. In mid- 1990, a group of conference participants connected with the 75/401 corridor began discussing the feasibility of an intelligent transportation system for commercial vehicles along the heavily traveled interstate.The Advantage t-75 Partnership was launched. Project partners include FHWA, the States of Florida, Georgia,Tennessee, Kentucky, Ohio, and Michigan; the Province of Ontario; the Canadian Ministry of Transport; U.S. and Canadian trucking associations; and various trucking companies.

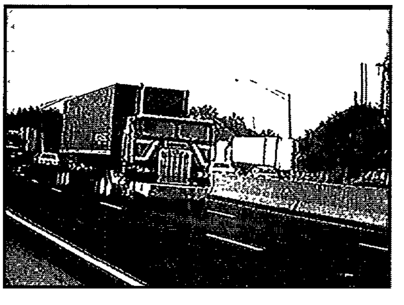
This operational test offers an excellent example of how intelligent transportation technologies can be applied now-at moderate cost and with tangible benefits-while allowing for expansion as new technologies develop.



1. When a transponder-equipped truck begins *a* trip on *the* I-75 corridor and is *processed* through *a* weigh station, specific information about the truck and *the* transaction (such as truck identification, locafion, weight data, and *axle* data) is collected and stored electronically in the *truck's* transponder.



2. As the truck *continues* ifs trip, the information is transmitted to the next downstream station. *which checks the* truck's operating credentials. Upon *reaching the station,* the *truck's* transponder is read by a roadside *reader equipped* with *automated* vehicle *identification* technology. The reoder's computer processes the information and makes a clearance decision.



3. *If* precleared, the truck is individually *directed* by means of *a* roadside changeable *message sign to* bypass the station ond continue ifs trip.

southern and northern borders. The tests are underway in Otay Mesa, CA; Nogales, AZ; Buffalo, NY, and Detroit, MI. In addition, FHWA is demonstrating the feasibility of electronic clearance at border crossings in El Paso and Laredo, TX, in conjunction with the U.S. Customs NATAP efforts.

U.S. Customs and FHWA have also conducted successful tests of the movement of goods, southbound via truck, from the Port of Los Angeles to the SONY Maquiladora site; test shipments moved through the U.S. Cargo West facility and the corresponding Mexican Import Facility. This exercise demonstrated many aspects of ITS/CVO technology, including the physical, electronic, and procedural issues connected with moving goods across the border. In addition, Sandia Laboratory is developing an inter-modal system at Santa Teresa, NM, that could be used at all border crossings.

Hazardous Materials Response: Using computerized emergency response data, the CVO program identifies shipments of hazardous materials, links systems that handle incidents, and facilitates responses to accidents and incidents involving hazardous materials in the National Institute for Environmental Renewal test. Another project, Operation Respond, is designed to provide an electronic link with 911 operators and participating carriers during the initial response to hazardous material accidents. The project is currently being expanded to establish computerized information systems for emergency responders and participating railroads and motor carriers serving Mexican and Canadian border crossings. The crucial information provided by this innovative system will give emergency responders real-time access to hazardous materials information on the scene across North America to help with assessment of situations and to determine appropriate actions.

Other Field Tests: The Oregon ITS/CVO Green Light Project, which began in October 1994, aims to improve the safety and efficiency of CVO and increase the performance of the highway system. The project electronically verifies safety and weight information on drivers, vehicles, and carriers from fixed and mobile roadside sites at highway speeds. The test of the dynamic truck speed warning for long downgrades, located in Colorado, uses a weigh-in-motion station to determine the weight of each truck passing the site, disregarding vehicles under 30,000 pounds gross vehicle weight. The test also measures vehicle speed. The information is processed and conveyed to variable message signs, which advise truckers of safe speeds at downgrades.

Roadside MCSAP Computer System Program

The motor carrier safety assistance program (MCSAP) is a federally funded program that provides grants to States, the District of Columbia, and territories for conducting motor carrier safety enforcement activities. MCSAP aims to reduce the number and severity of accidents and hazardous materials incidents involving commercial motor vehicles by increasing the detection of unsafe practices to take high-risk drivers and vehicles off the road. As part of this program, Congress requested that the U.S. DOT provide electronic access to carrier safety data and driver's license status from at least 100 MCSAP inspection sites. The number is to be expanded to 250 sites by mid-1998. By December 1996, the program had finished equipping 200 MCSAP sites with information system technology to better target inspections, improve driver's license checks, and provide for electronic recording of inspection data via pen-based computers. The MCSAP/CVO project is linked to the SAFER system project.

North American Trade Automation Prototype

The NATAP initiative, stewarded by the U.S. Customs Service, promotes the use of advanced communication technologies to facilitate the flow of commercial vehicles across international borders. The prototype has developed common data elements and processes incorporating electronic data interchange (EDI), radio-frequency identification (RFID), and vehicle roadside communication (VRC) technologies to process commercial cargo shipment data at the Canadian and Mexican land borders. By automating data transmission to obtain cargo clearance, NATAP eliminates redundant data entry for a number of U.S. agencies and their counterparts in Mexico and Canada. In the near future, a shipper will be able to transmit shipment information via ED1 to a value-added network serving the border agencies, allowing Customs officials to determine whether the shipper is in compliance with cargo admissibility criteria while the vehicle is still in transit. As the shipment approaches the border, the RFIDNRC reader transmits transaction identification to the Customs value-added network. On arrival, the vehicle will receive a green light if clearance is granted or a red light if data or a cargo examination are required. Field demonstrations of NATAP are being conducted at Detroit, Buffalo, Otay Mesa, Nogales, El Paso, and Laredo border crossings. FHWA/DOT has been coordinating its electronic clearance field tests at the Canadian and Mexican land borders with the NATAP efforts to ensure compliance with vehicle, driver, and carrier safety and credential requirements, while streamlining the flow of trade traffic.

Standards Development

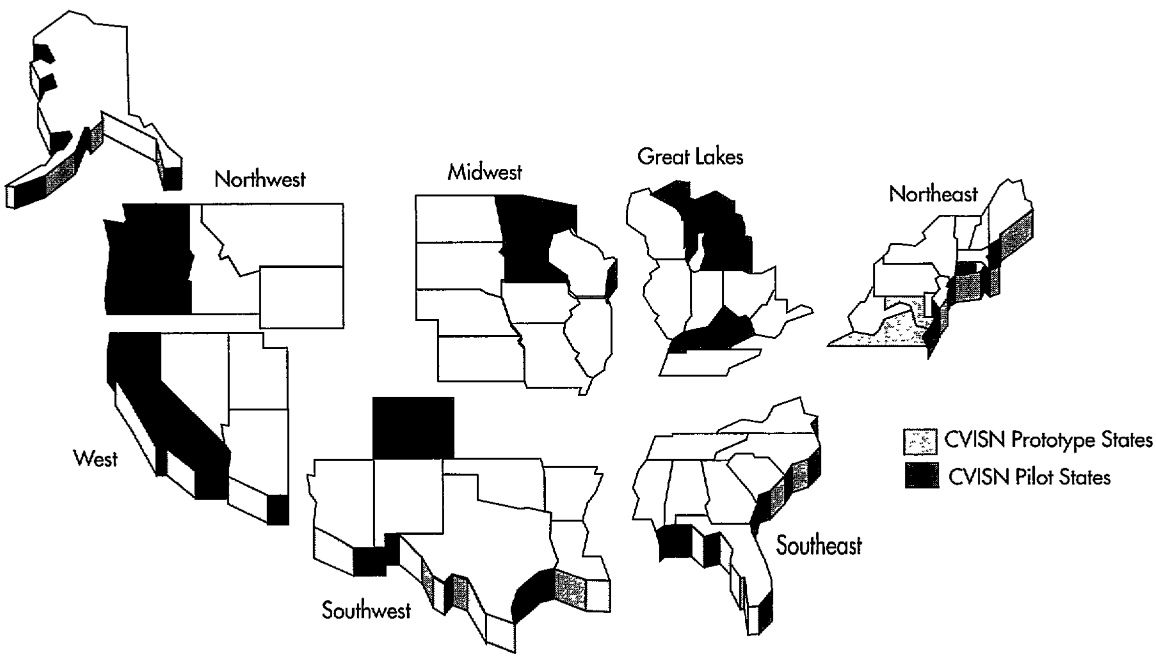
As part of the overall standards development program, the U.S. DOT is establishing CVO standards, primarily to support DSRC, which is necessary for electronic clearance and weigh-in-motion systems, and EDI activities. The Applied Physics Laboratory of Johns Hopkins University is working with the American National Standards Institute (ANSI) to develop standards for information interchange among all commercial vehicle information systems and users, including motor carrier systems, State credential systems, national systems, roadside enforcement officers, and commercial users (e.g., shippers, banks, and insurers). These standards will also allow vehicles to register electronically from a personal computer. The ITS Program is pioneering the development of standards for DSRC, which allows wireless communication between vehicles and the roadside, through the five SDOs.

Electronic clearance technologies will allow drivers to submit credentials electronically, reducing paperwork for both motor carriers and public agency regulators.

Mainstreaming

Thirty-three States have followed the U.S. DOT's recommendation and formed seven regional forums to ensure that CVO services are delivered to areas that have the greatest trucking volumes and that services within these areas are relatively uniform from a carrier's perspective. These forums are based on seven major population and economic regional "truckssheds" in New England, Southeast, Mid-Atlantic, Great Lakes, Mississippi Valley, West, and Northwest. They are designed to improve motor carrier operations, build capacity, and explain the purposes, technologies, costs, and benefits of ITS/CVO to State legislatures, private industry, and the public. Each State that has opted to become part of a regional forum will develop an ITS/CVO business plan that will outline the specifics of CVO and help States plan for ITS deployment. State ITS/CVO business plans are expected to be completed by December 1997; regional plans should be completed by 1998. In concert, regional "champions" are expected to be launched by spring 1997. These champions will provide dedicated, full-

EXHIBIT III-12
LOCATION OF CVISN PROJECTS



Note: The following States are included in multiple truckshreds: Arizona, Illinois, Tennessee, Virginia, West Virginia, Wisconsin.

time support, guidance, and assistance to Federal and State decision makers in areas of CVO.

MDI

The CVISN MDI, initiated by FHWA in cooperation with States and government and industry associations, will move ITS/CVO user services beyond the conceptual phase into operation. The CVISN pilot project consists of an initial deployment of selected CVISN elements in eight States and seven regional truckshreds centered around Connecticut, Kentucky, Michigan, Minnesota, Colorado, Washington/Oregon, and California. Knowledge gained from CVISN prototypes in Maryland and Virginia is helping to direct the design of CVISN pilots. Exhibit III-12 identifies States that have CVISN pilots and prototypes within truckshreds managed by the CVO program. Exhibits III-13a and b illustrate the interaction among systems and agencies in the pilot project.

The pilot sites will demonstrate the operational feasibility and effectiveness of CVISN before full-scale development. In linking automated roadside inspection, commercial vehicle administrative processes, and electronic clearance user services, CVISN will enable motor carriers to purchase operating credentials electronically, allow inspectors to have automatic access to up-to-date safety information on carriers, and permit commercial vehicles to pass through inspection stations at highway speeds without stopping. CVISN will eventually expand to all interested States.

EXHIBIT III-13A
CVISN PILOT

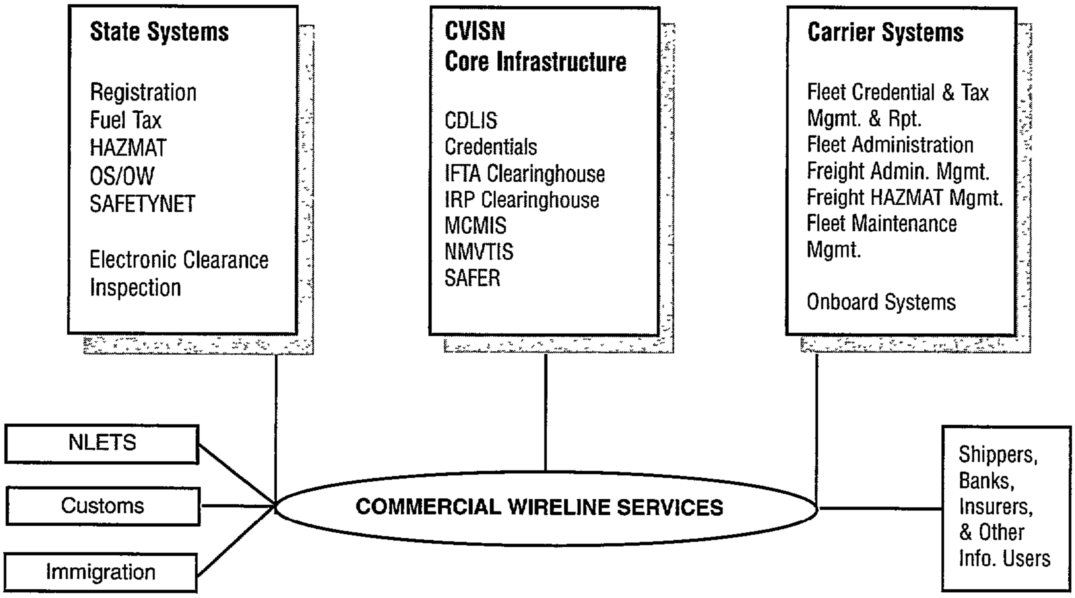


EXHIBIT III-13B
CVISN CORE INFRASTRUCTURE

- **Commercial Driver's License Information System (CDLIS)**—a nationwide software system that tracks the complete driver records kept by the State issuing the license.
- **Credentials**—a project to allow motor carrier operators and owners to obtain credentials electronically at their place of business. Credentials include registration, fuel tax payment, oversize and overweight permits, and special trip permits.
- **International Fuel Tax Agreement (IFTA) Clearinghouse**—a pilot data base that develops standards to support administration of fuel-use tax and processing, collection, and disbursement of the funds.
- **International Registration Plan (IRP) Clearance**—a pilot project to establish a clearinghouse (a data base of vehicle registration information) and test the use of electronic exchange of information needed for assessing fees and apportioning taxes from interstate motor carriers.
- **MCMIS/SAFETYNET**—a system containing a comprehensive record of the safety performance of motor carriers and hazardous materials shippers subject to Federal regulations.
- **National Motor Vehicle Title Information System (NMVTIS)**—a system allowing users to check the validity and status of vehicle title documents in other jurisdictions.
- **Safety and Fitness Electronic Records (SAFER)**—a system that provides carrier, driver, or vehicle safety information at the roadside through inspection selection system software. This software allows inspection officers to target vehicles or drivers selected for inspection, using pen-based computer systems.

TECHNICAL LESSONS

CVO technologies and services have succeeded in developing a system to streamline the regulatory enforcement process by increasing access to information. Electronic weigh-in-motion, AVI, and ED1 have been proven technically feasible. Integrating these technologies has enabled electronic purchasing of credentials, automated clearances, and screening of vehicles, drivers, and carriers for safety compliance. Exhibit III- 14 highlights technical lessons learned.

Many technologies used by CVO systems are rooted in other ITS areas. An operational test of a CVO dynamic truck-speed warning system showed the positive safety effects of variable message signs that recommended a safe speed to truckers traveling on a downgrade. These signs are usually considered part of freeway management technology. Similarly, AVI and AVL technologies, which are integral to transit management, are also essential to commercial vehicle electronic clearance, a major category of interest to the CVO program. Eventually, CVO systems will be fully integrated and interoperable with metropolitan and rural ITS, which will enable the development of new services.

BENEFITS

CVO applications have brought numerous benefits to both regulators and private industry. The American Trucking Association's Foundation's June 1996 report, *Benefit/Cost Analysis of the ITS/CVO User Services*, quantifies the benefits of deploying user services from the carrier's perspective and identifies critical market acceptance factors. The benefits and costs vary by size of carrier and user service, but the industry estimates that CVO user services can produce compelling benefits, including considerable time savings and reduced labor costs for carriers. Public sector officials will realize significant savings in processing paperwork. In fact, as electronic exchange of credentials and permits becomes the state of the practice, those carriers that remain with manual operations will lack a competitive advantage. Exhibit III-15 shows examples of ITSKVO benefits.

Public sector benefits from CVO are also impressive. A recent study completed for the U.S. DOT found that the adoption of ITS/CVO services by the public sector has a 2:l benefit-cost ratio. Public sector benefits include enhanced administrative efficiency, reduced

EXHIBIT III- I4
SYNOPSIS OF ITS/CVO TECHNICAL LESSONS LEARNED

- Deployment of nearly all CVO services is technically feasible; weigh-in-motion, AVI, EDI, and wireless communication can meet user needs.
- CVISN will fulfill two needs for CVO services. First, CVISN will address the need for national clearinghouses that can distribute data or refer inquiries to other locations. Second, CVISN will meet the need for systems that can integrate multiple technologies and operate in real time.
- R&D efforts developed an inspection selection algorithm that targets higher risk vehicles and enables carriers to obtain one-stop electronic clearance credentials from State agencies.
- ED1 and DSRC are key standards for ITS/CVO.

infrastructure investment, expanded revenues from increased compliance, reduced damage to highways, and improved public safety. For example, an information network in Oregon increased the number of weighings and safety inspections by 90 and 428 percent, respectively, between 1980 and 1989, although staff size increased by only 23 percent. ITS/CVO technologies are predicted to reduce the annual cost of hazardous material incidents by $1.7 million per State; deter tax evasion, saving between $500,000 to $1.8 million per State; and reduce the operating costs of each weigh station by up to $160,000. Other ITS/CVO benefits are documented in *Review of ITS Benefits: Emerging Successes.*

The vast number of carriers, agencies, and systems involved in the operation of commercial vehicles makes CVO systems inherently complex. Historically, the organizations that regulate CVO have had no medium for communication and interaction. CVISN will bring these diverse agencies, organizations, systems, and networks together under one umbrella. In a single State, for example, CVISN will assemble all the agencies (e.g., police, department of motor vehicles, regulatory agencies, treasury) that deal with the information necessary for a truck to operate in that State and will provide a common environment in which the agencies can interact and exchange information freely. When applied to all the agencies that address commercial vehicles throughout the 50 States, CVISN will help revolutionize commercial operations and will be the guiding force that brings these separate and historically incompatible agencies together for the first time.

Institutional Issues and User Acceptance

The major challenges facing future CVO deployment are institutional, as opposed to technical. Coordination and consensus among 49 States-with 4 to 5 agencies per State, 400,000 carriers, and 6.6 million drivers-create a significant challenge to the development of data and information systems. Interstate coordination in the development of standards and the operation of CVO systems is essential to the success of the program.

The ITS/CVO program calls for coordinating a variety of Federal and State regulatory requirements (e.g., registration, fuel-use tax reporting, operating authority, and safety performance record keeping); however, the program is not mandated. Only if the private sector perceives that CVO systems are cost-effective will it participate. It is, therefore, imperative that the participants agree on a specific set of uniform policies and procedures. The program recognized early on that overcoming barriers to cooperative planning and implementation would encourage the development of ITS/CVO The CVO institutional studies were instrumental in getting States to think about new working relationships in the early stages of the program.

Public-private partnerships are the foundation on which tbe CVO program is built. Many private commercial vehicle operators have sophisticated tracking and identification capabilities. These advanced products will affect the specific choices that the U.S. DOT makes in setting requirements and settling on standards. The program must pursue maximum interoperability with private sector systems and must be able to benefit from the experience that private sector operators have had with these systems.

As CVO applications move from research and operational testing into deployment, traditional methods of highway infrastructure financing may become a barrier to procuring advanced technologies and funding from the Federal Government. Federal aid is traditionally used for construction and signal systems, not for development of motor carrier information or clearance systems. Because some CVO technologies, such as video imaging, are expensive and because traditional highway infrastructures use standard methods for identifying and securing funding, deployment of ITS/CVO is likely to face significant barriers in the absence of Federal incentives and funding. In addi-

EXHIBIT III. I5
BENEFITS OF ITS/CVO

ITS/CVO Element	Benefits	Source
Commercial Vehicle Administrative Processes	• The American Trucking Association's Foundation estimates medium-sized motor carriers will realize a benefit/cost ratio of 4.2:1 large-sized carriers will realize a benefit/cost ratio of 19.8:1, and small carriers will realize benefits at least equal to the costs of participating from automated administrative processes.	ATA Foundation, *Assessment of Intelligent* ***Transportation*** *Systems/Commercial Vehicle Operations User Services: ITS/CVO Qualitative Benefit/Cost Analysis*, prepared for FHWA, June 1996.
	• A 1994 report estimates a benefit/cost ratio of 7.9: 1 for "one-stop/no-stop shopping" systems.	Mitretek Systems, ***Assessment of ITS*** *Benefits: Emerging* Successes, prepared for FHWA, September 1996
Electronic Clearance	• An early information network in Oregon enabled an increase of 90% in the number of weighings and 428% in the number of safety inspections between 1980 and 1989, despite the fact that staff increased by only 23%.	Ibid.
	• The HELP/Crescent project estimated that operating costs of a weigh station could be reduced up to $160,000 annually per State.	ATA Foundation
	• Electronic clearance can reduce labor costs for carriers that pay drivers based on time worked. The benefit/cost ratios are: 3.3: 1 to 6.5: 1 for small carriers, 3.7: 1 to 7.4: 1 for medium-sized carriers, and 1.9: 1 to 3.8: 1 for large carriers.	ATA Foundation
Automated Roadside Safety Inspections	• The benefit/cost ratio of such programs as MCSAP is estimated at 2.5: 1 and the reduction in accidents is estimated to be 2,400 to 3,500 annually.	ATA Foundation
	• The HELP/Crescent project estimated that automated safety inspections could save $156,000 to $78 1,000 in costs of avoided accidents annually per State.	Mitretek Systems
	• A 1994 U.S. DOT report estimates that the benefit/cost ratio to the Government is 5.4: 1 for automated roadside inspections.	Mitretek Systems
On-Board Safety Monitoring	• Onboard safety systems, along with electronic clearance and automated roadside safety inspections, could reduce fatalities by 14 to 32%.	Mitretek Systems

EXHIBIT III-15 (CONT.)
BENEFITS OF ITS/CVO

ITS/CVO Element	Benefits	Source
Hazardous Materials Incident Response	• The ability to identify hazardous cargo on vehicles involved in crashes can reduce the risk of loss of life to those involved in the crash, the emergency response team, and people living and working near the crash scene by reducing the time needed to properly handle the material.	Mitretek Systems
	• The HELP/Crescent project estimated that the impact of hazardous material incidents could be reduced by $1.7 million annually per State.	Mitretek Systems
Freight Mobility	• Carriers that use computer-aided dispatch systems achieved productivity gains from an increase in the number of pickups and deliveries per truck per day ranging from 5% to more than 25%. Most gains were clustered in the 10 to 20% range.	Mitretek Systems
	• Vehicle tracking and mapping software allowed a national carrier to double dispatch productivity and reduce telephone use by 60%.	Mitretek Systems

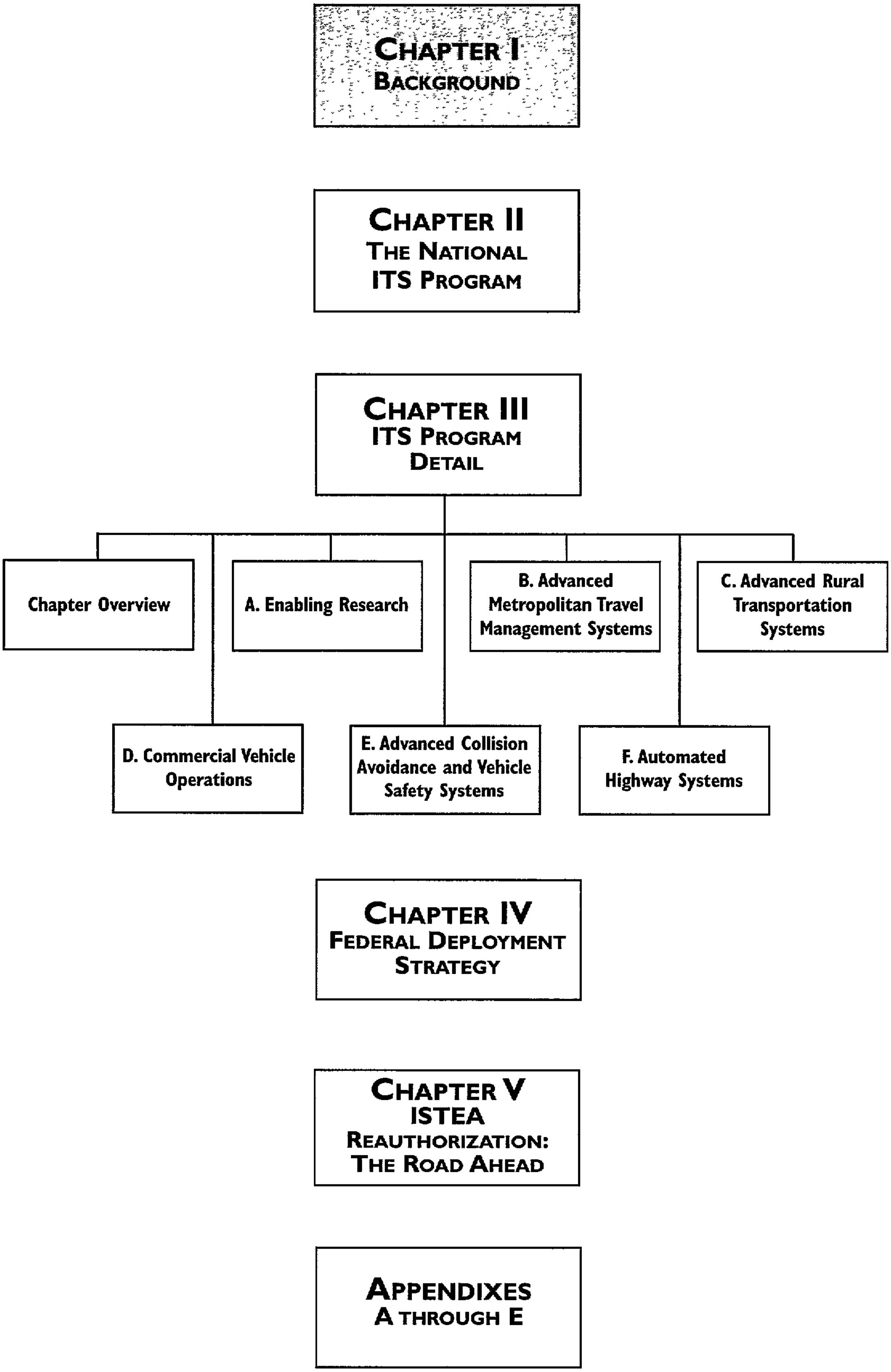
tion, funding for the operation and maintenance of deployed systems is a major issue facing the States. ISTEA funds have only been used for research, institutional issue studies, pre-deployment, and testing of emergency technologies. The use of Federal-aid funds for CVO operations and maintenance costs must be explored.

A study on the acceptance of CVO services by interstate truck and bus drivers found that commercial vehicle drivers are generally receptive to and supportive of these services. Some drivers do express concern that certain technologies may invade privacy, and they caution against allowing systems to diminish the role of the human operator. Driver characteristics played an important role in reaction to CVO technologies. Older, more experienced, owner-operator truck drivers are more wary of the technologies; whereas younger, less experienced, company-employed drivers who reported spending more time on administrative procedures are more positive about the increased efficiencies promised by the new technologies. These findings are documented in a study by Penn and Schoen Associates, Inc., *Critical Issues Relating to Acceptance of CVO Services by Interstate Truck and Bus Drivers.*

FUTURE DIRECTIONS

The vision for the CVO program is that, by the year 2005, carriers will apply and pay for credentials, including registration and permits, electronically. They will also file and pay for fuel taxes electronically and will deal with one base State for all business transactions, which will simplify carrier administration by distributing fees or taxes to other States. By building new institutions, the CVISN infrastructure will allow all these agencies access to the information necessary to make the commercial vehicle industry more efficient and safe. The development and deployment of information-driven systems and processes for assessing safety performance and fitness, such as SAFER, will greatly improve overall roadway safety conditions and save lives.

The development of the CVISN architecture has paralleled the efforts of the national ITS architecture program since 1994, and the two are currently being aligned. When it is complete, the CVISN architecture will provide a technical framework and direction for CVISN activities. Formal standards will be finalized, and the capabilities of a prototype will be demonstrated in the Johns Hopkins University/Applied Physics Laboratory. The CVO program is vigorously pursuing onboard safety monitoring, using sensors to monitor critical vehicle and driver performance attributes, and developing national and international standards for hardware, communications, and procedures. In addition, because motor carrier operations are intermodal, ITS/CVO systems will ultimately need to be compatible with cargo systems used in rail, air, and marine transportation throughout North America. Closer coordination with officials from Canada and Mexico is necessary to ensure that developing systems are compatible and reciprocal The program also expects to initiate a clearinghouse to disseminate information on CVO activities. CVISN will serve as the infrastructure that ties these systems together.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III. ITS PROGRAM DETAIL

E. Advanced Collision Avoidance and Vehicle Safety Systems

More than 6 million motor vehicle collisions occur on the Nation's highways every year, causing approximately 5.2 million injuries and more than 41,000 fatalities and costing more than $150 billion per year. Approximately three-quarters of these collisions occur because the driver's attention was diverted in the moments before collision.

NHTSA is responsible for understanding the causes of highway collisions and resulting deaths and injuries and for seeking solutions. NHTSA has continued this role within the national ITS Program, investigating why collisions occur and how the use of intelligent technologies can prevent them. Dramatic advances in sensing technologies and computational power now offer a real possibility for the development of in-vehicle systems that can alert drivers-through effective and practical in-vehicle electronic driver aids and warning systems-to hazardous situations and impending collisions, and even take temporary control of the vehicle to avoid a collision. Other innovations could monitor driver alertness, improve a driver's effective vision, and automatically call for emergency services immediately after a collision.

NHTSA's advanced collision avoidance and vehicle safety systems program seeks to deepen our understanding of the causes of collisions, identify and evaluate potential solutions, and work in partnership with industry to facilitate development and deployment of effective collision avoidance products. The program includes projects in these areas of concentration:

- Specific crash types, including rear-end, intersection, road departure, lane change or merge, and heavy vehicle stability.
- Driver performance enhancement, which includes combating drowsiness and enhancing vision.
- Crash consequences mitigation, particularly automatic collision notification.

Program Goals

The goal of the crash avoidance and vehicle safety system program is to significantly reduce deaths and injuries on the Nation's highways and roads by preventing collisions. One essential objective of the program is to develop performance specifications for in-vehicle collision avoidance systems and other systems that enhance driving safety.

For each area of concentration, NHTSA is assessing system capability, user acceptance, and benefits of potential countermeasure systems. Capability refers to the technical performance of the systems and components-sensors, processors, and driver interface or controls. User acceptance addresses the interaction between drivers and technology, including ease of use, effects on driver performance, and affordability. The primary benefits of these efforts are reductions in the number of collisions and their associated injuries and costs.

Program Activities

In 1991, NHTSA launched a major new initiative to improve the collision avoidance capabilities of motor vehicles. Aware that widespread deployment of effective collision warning technologies was a decade or more away, NHTSA laid out a strategic plan to facilitate development and early deployment of safety-related electronic systems. NHTSA has made significant progress, gathering extensive accident information and using it to identify opportunities for crash avoidance to guide concept development. Important human factor and system design issues remain a major focus of study. NHTSA has also developed preliminary performance specifications to ensure that products in development will be effective.

A number of joint efforts for research and technology assessment have been completed or are well underway with motor vehicle industry partners. New research tools are being developed that will significantly enhance capabilities for analyzing and evaluating

THE VISION OF ADVANCED COLLISION AVOIDANCE AND VEHICLE SAFETY SYSTEMS

The future driver-vehicle highway environment could be transformed by a wide variety of safety innovations to supplement drivers' efforts to drive safely. Among the systems envisioned are new products that will monitor the driver's state of fitness, continuously enhance driver awareness, warn of potential danger, intervene and assist with emergency control if a crash is imminent, and perhaps even automate some or all aspects of driving on specialized roadways.

The next-generation cruise control system, **for example, will automatically maintain a safe distance from vehicles ahead, greatly reducing the threat of rear-end collisions. With a** lane-tracking system, **onboard electronics can help alert and prevent a driver from drifting into the next lane or leaving the roadway. A** cooperative intersection **will communicate data** on **traffic signals and oncoming vehicles that might conflict with the driver's path, reducing the risk of intersection collisions.**

Nighttime and bad weather vision enhancement systems **will make indistinct vehicles and hazards near the vehicle easier to see. When a crash does occur,** automated collision notification systems **will alert medical and other emergency service personnel to the location and severity of the crash, perhaps even supplying driver medical history and current condition of injury through a combination of smart card technology and sensors.**

To meet the special safety needs of commercial and heavy vehicles, driver-monitoring systems **are being studied that can continuously assess driver performance and alertness, warn drivers of degraded performance, and perhaps work with control technologies to momentarily take over driving tasks if the driver becomes drowsy or inattentive. Other technologies will help stabilize heavy vehicles, warn of impending collisions, and improve braking performance.**

Collision avoidance systems will also be able to communicate with other vehicles and roadside devices and will assist the driver through visual, audio, and tactile presentations, as well as through supplementary control.

Research into many safety-related advanced ITS products is being coordinated with AHS research, particularly for products that would promote smoother traffic flow on busy roadways. ITS safety technologies supplement the more traditional program activities that have already served to prevent or reduce the severity of vehicle collisions.

technical performance of crash avoidance countermeasures and estimating their real-world operational benefits.

Performance Specifications

The heart of the ITS collision avoidance program is the development of performance specifications for systems that can assist drivers in avoiding collisions. The ITS Program is working cooperatively with the motor vehicle industry to develop performance guidelines that are clear, concise, and consistent.

Preliminary performance specifications, which were developed initially through analysis of data from NHTSA accident tiles, assessment of causal factors, and data generated by driving simulators, are being refined and updated using results from technology studies, ongoing or planned simulator studies. test vehicle projects, and field operational test activities. Exhibit III-16 summarizes the preliminary performance specifications developed so far for the sensing elements of five types of collision avoidance systems. The specifications reveal the complexity of developing crash avoidance technologies. NHTSA and ITS America jointly sponsored a peer review workshop as a forum for sharing these preliminary results with interested individuals and organizations. Feedback from this workshop has helped guide the program's activities.

Human Factors and System Design

NHTSA has completed a wide array of studies that reveal important information and characteristics about driver behavior and system design. These studies act as the foundation for developing and evaluating crash avoidance concepts as products are brought to market.

Two studies addressed potential health or safety hazards from the use of active collision avoid-

EXHIBIT III-16
PRELIMINARY PERFORMANCE SPECIFICATIONS FOR SENSING ELEMENTS

Specification	Type of Collision Avoidance System				
	Rear-End	Lane Change	Backing	Intersection	Road Departure
Type of Sensor Beam	Multibeam of scanned object	TBD	TBD	TBD	TBD
Horizontal Field of Regard	+ / - 8 degrees	90 degrees	width of vehicle	+ / - 110 degrees	NA
Horizontal Angular Resolution	1.6 degrees	TBD	TBD	TBD	NA
Acquisition Range	> 400 ft	80 ft	13 ft	300 ft	TBD
Range Accuracy	+ / - 2 ft	+ / - 2 ft	TBD	TBD	TBD
Range Rate Accuracy	+ / - 1 ft/sec	+ / - 5 ft/sec	TBD	+ / - 1 ft/sec	TBD
Subject Vehicle Speed Accuracy	+ / - 1 ft/sec	TBD	TBD	+ / - 1 ft/sec	+ / - 4 ft/sec
Accuracy of Lateral Position	NA	+ / - 2 ft	TBD	TBD	+ / - 0.1 ft
Minimum Radius of Curvature That Can Be Accommodated	TBD	TBD	TBD	TBD	200 ft

TBD = To be determined
NA = Not applicable

ance sensors. One reviewed the physiological basis for current standards addressing the health effects of non-ionizing electromagnetic radiation. The second study developed a computer model to estimate field strength in the vicinity of one or more radiation sources.

An assessment of the vehicle crash experiences of older drivers revealed that older drivers are under-represented in crashes and fatalities relative to their number in the U.S. population, but their per-mile and fatality rates are higher than those for other driver groups. A separate study is addressing the concept of a vehicle-based device to unobtrusively monitor driver performance and, potentially, psychophysiological status.

Feasibility Studies

A key objective of the crash avoidance program is to work with private industry to develop safe and effective products. Nine cooperative agreements with industry have been used to develop and test systems for crash avoidance, heavy commercial vehicles, lane-position detection, and intelligent cruise control.

For example, the program completed a feasibility study of automatic braking for heavy vehicles. The project identified design requirements to accomplish assisted braking by modifying existing antilock brake/traction control system components. The study also investigated costs and benefits of potential acci-

EXHIBIT III- 17
PUBLIC-PRIVATE PARTNERSHIP AGREEMENTS FOR CRASH AVOIDANCE SYSTEMS

Company	Agreement	Status
Ford Motor Company	Establish guidelines for key intelligent cruise control operational and interface designs.	Completed baseline testing of car, following performance of drivers and an experiment to determine location and labeling of headway controls that drivers prefer and understand.
Environmental Research Institute of Michigan and TRW	Develop a knowledge base of radar data from laboratory measurements and a variety of freeway settings, using a prototype forward-looking automotive radar sensor.	Lab testing is completed, and an advanced sensor is being integrated for road testing.
Delco Electronics/ General Motors	Refine existing collision avoidance technologies, accelerate development of promising immature technologies, and investigate the preferred method of providing warning cues to the driver.	Significant progress has been made on development of reliable and low-cost sensors that can be manufactured (such as forward-looking radar sensors) and on a high-performance heads-up display.
Eaton	Conduct a feasibility study for adding automatic braking to heavy commercial vehicles.	Prototype demonstrated in July 1995; final report published in December 1996.
Rockwell	Conduct a 2-year field evaluation of a prototype machine-vision lane-detection sensor.	Testing complete; final report delivered in October 1996.
University of Michigan Transportation Research Institute and Leica	Study the performance of intelligent cruise control systems and determine how performance can be extended to foster the development, evaluation, and deployment of forward crash avoidance systems.	Completed second year of a 3-year cooperative agreement.
University of Michigan Transportation Research Institute (UMTRI)	Develop a prototype roll stability adviser as a rollover warning system for tractor-trailers to provide the driver with information on the vehicle's rollover threshold. Develop a rearward amplification suppression system for double- and triple-trailer trucks to prevent rear trailer rollovers, using a differential braking strategy to enhance vehicle stability.	The first trailer, equipped with an electronic braking system, and the tractor have been delivered to UMTRI. Vehicle parameter measurements are underway and instrumented fifth-wheel issues are being resolved.
Delco Electronics and Ryder Trucks	Develop, evaluate, and demonstrate communication and powering links between the tractor and trailer for heavy-duty commercial vehicles.	First unit delivered for 1 year of in-service evaluation in commercial service. Second unit was delivered in March 1997 for a year of evaluation in commercial service.
Eaton/Paccar	Develop, evaluate, and demonstrate communication and powering links between the tractor and trailer for heavy-duty commercial vehicles.	Prototype demonstrated in August 1996; draft final report is being reviewed.

dent reductions and examined how to provide an early indication of driver reaction to assisted braking under controlled conditions. Exhibit III-17 lists the status of the nine agreements.

Research Tools

NHTSA is developing a set of research tools that will allow investigators to monitor, record, and measure driver behaviors without jeopardizing the safety of test subjects. The tools are listed in Exhibit III-18 The tools will be used to improve the level of understanding of driver performance, both with and without the assistance of collision avoidance systems.

TECHNICAL LESSONS

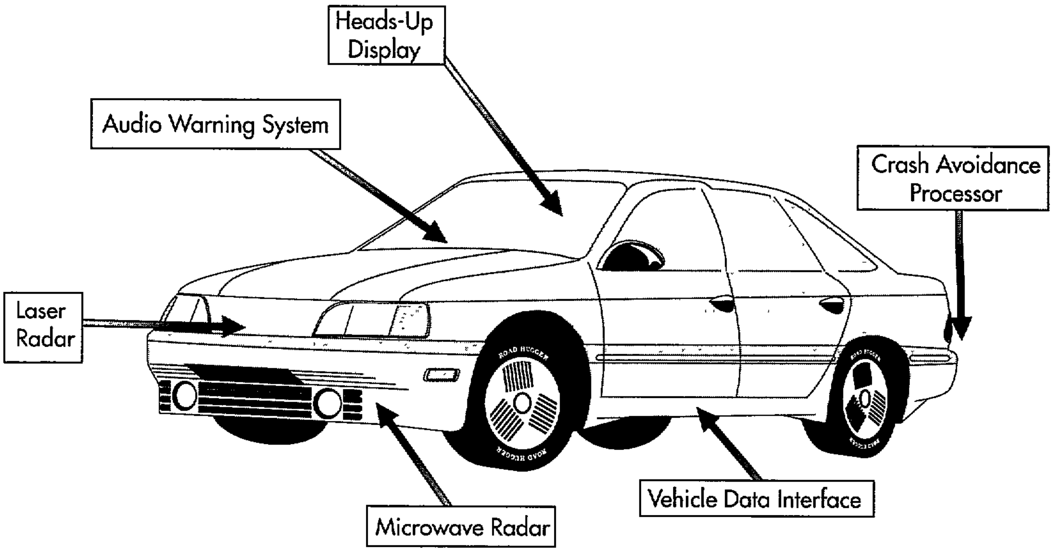
The collision avoidance program moved from conducting purely technical R&D to initiating field tests of products that have commercial potential and potential for improving safety. The technologies that are on the brink of entering the market are intelligent cruise control and automated collision notification.

Many of the technologies used in crash avoidance systems-radar detection, heads-up display, location referencing-have been used in the defense industry for decades; however, transferring these technologies from military applications to the driving environment has been difficult. First, the driving environment is

EXHIBIT III- 18
NHTSA RESEARCH TOOLS

Tool	Description	Status
Data Acquisition System for Crash Avoidance (DASCAR)	A portable, onboard, data-gathering system that can monitor and record vehicle performance and the driver's physical reactions.	Evaluation of a DASCAR system was completed, and application in a study of lane-change maneuvers has begun.
National Advanced Driving Simulator (NADS)	An advanced driving simulator that will allow risk-free controlled studies of operator behavior in crash-imminent situations.	A contract was awarded for Phase II design, construction, testing, and installation of the NADS. The simulator is expected to be completed by 1999.
System for Assessing the Vehicle Motion Environment (SAVME)	A roadside measurement system to assess the movement of vehicles in real traffic.	Preliminary designs are currently undergoing full-scale testing.
Variable-Dynamics Test Vehicle (VDTV)	A test vehicle with computer control of throttle, brake, and steering that can help determine how drivers will react to various proposed ITS crash avoidance designs.	An agreement has been signed with the Jet Propulsion Laboratory of the California Institute of Technology for design and construction of a VDTV. It is expected to be operational in mid-1998.

EXHIBIT III-19
SYNOPSIS OF COLLISION AVOIDANCE SYSTEMS TECHNICAL LESSONS LEARNED



Collision avoidance systems will alert drivers to hazardous situations and impending collisions and even take temporary control of the vehicle to avoid a collision. Other innovations could monitor driver alertness, improve a driver's effective vision, and automatically call for emergency services immediately after a collision. We have learned much about technical issues, including:

- Statistical analysis of accident files determined that 75 percent of crashes result from driver error.
- Program research has increased our preliminary understanding of the performance features needed for effective collision avoidance systems.
- It is difficult for existing technologies to meet all performance requirements at prices acceptable to consumers.
- The FCC has set aside radio frequency spectrum and specified power limits for collision avoidance systems. FCC spectrum designation is a significant step toward commercialization of advanced crash avoidance technologies.
- A knowledge base of human factors has been established and continues to be developed. The focus is on understanding driver behavior in collision avoidance situations, developing a better understanding of the relationship between characteristics of driver interfaces and driver performance, and determining the effects of new technologies on driver capabilities and workload.
- Preliminary performance specifications have been developed for several collision avoidance systems.

complex; varying patterns of driver and traffic behavior, uneven road conditions, changing weather, and other variables must all be taken into account. Second, the technologies must be re-engineered for mass production and made for much less cost to be marketable as standard or optional equipment on motor vehicles. One of the challenges that remains for the program is to bring the cost requirements for these technologies within an acceptable consumer range while maintaining sufficient performance.

Despite these challenges, a growing array of technologies is becoming available or in development as potential countermeasure systems for various crash types. Recent advances in sensors, processors, control systems, and displays now allow for the design of crash avoidance systems that offer increased performance, reduced cost, and high reliability. Although research and analysis have provided a preliminary understanding of the performance features needed for effective collision avoidance systems, it will be a challenge to develop technologies that can meet all the performance requirements at prices acceptable to consumers. Exhibit III-19 summarizes technical lessons learned thus far in the collision avoidance program.

Benefits

NHTSA estimates that 1.1 million crashes could be prevented annually if all vehicles were equipped with just three of the primary ITS crash avoidance systems-rear-end, roadway departure, and lane change/merge. This represents 17 percent of all accidents, which if prevented could save thousands of lives and $26 billion per year. Exhibit III-20 shows estimates of crash countermeasure system effectiveness and the number of avoided crashes. These estimates are based on the number of annual crashes in the United States and the best research available on operation of collision avoidance systems. Many assumptions were made to develop these results; thus, they must be considered preliminary, pending further research and field experience.

Although benefits are expected from crash avoidance technologies, field experience on which to base estimates of benefits is not available. Estimates of system performance must also consider the number and types of collisions that will be avoided, as well as negative performance factors, such as erroneous warnings, that could reduce expected benefits.

Institutional Issues and User Acceptance

Developing public-private collaboration on infrastructure-based safety is another key issue. The operational and funding responsibilities of public and private partners must be determined for deploying such systems as intersection crash avoidance systems, weather-based systems, and systems that warn drivers of upcoming hazards.

Performance, consumer cost, and perceived value and acceptability to drivers will determine user acceptance of collision avoidance systems. Together, these factors will directly influence the ability to deploy new collision avoidance products in motor vehicles. Successful integration of all in-vehicle technologies in a manner that is acceptable to drivers and supports travel needs may help overcome some of these obstacles.

The acceptability of a system to a driver also depends on whether the driver perceives the benefits obtained from the system to be greater than its costs. "Costs" can include the initial cost of the system and maintenance costs as well as such intangibles as the annoyance caused by systems that prove to be unreliable, difficult to understand, or in need of frequent attention. The private sector anticipates a profitable market for advanced crash avoidance technologies, despite the current need for breakthroughs in cost effectiveness and affordability.

Future Directions

The strategic goals of the program for the next 5 to 10 years are to demonstrate improved capability of colli-

EXHIBIT III-20
ESTIMATED BENEFITS FROM CRASH COUNTERMEASURES

Crash Condition	Total Number of Crashes	Relevant Crashes Addressed by Countermeasures	Effectiveness Estimates for Relevant Crashes	Number of Crashes Reduced
Rear-End	1,660,000	1,547,000	51.1%	791,000
Lane-Change/ Merge	244.000	190,000	47.6%	90,000
Road Departure	1,238,000	458,000	64.9%	297,000
Totals	3,142,000	2,195,000		1,178,000

sion avoidance systems, to ensure that systems are both effective and usable to consumers, and to provide a basis for understanding the benefits of the systems (i.e., avoidance or reduction of collisions, injuries, and fatalities). In each area, projects will evolve from a rudimentary understanding to refinements that provide a more rigorous and defensible knowledge base.

Starting in 1997, there will be a major shift in the character of the projects. Strictly focused research projects will lead to projects that address the larger issues of system capability, usability, and benefits. This shift in focus recognizes that effective collision avoidance systems will be made available to consumers if the motor vehicle industry is convinced that these products will be successful in the marketplace. Consequently, NHTSA will intensify outreach activities to increase public awareness of the capabilities and benefits of crash avoidance products. Operational tests and demonstrations of crash avoidance systems will be tailored to provide broad exposure of these systems to the driving public.

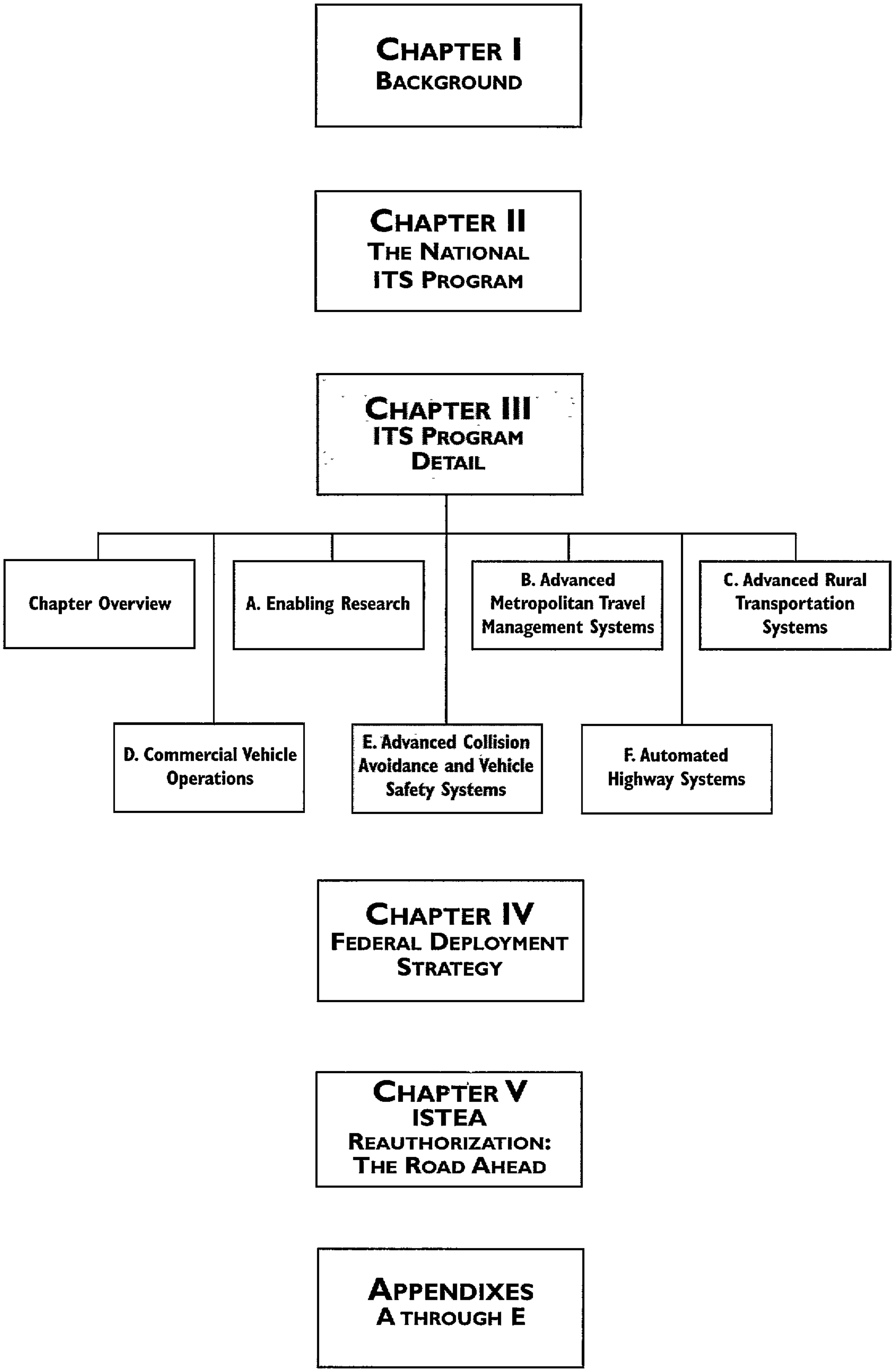
To date, the crash avoidance program has evaluated how individual crash avoidance technologies could affect drivers and safety. The program is also investigating how to integrate multiple technologies. This integration will require knowledge of how multiple technologies can function together, as well as their combined impact on safety performance. These integrated systems will incorporate and build on other in-vehicle capabilities, such as route guidance, which may enhance the performance of crash avoidance systems, even though they are not directly related to solving safety problems. The development of an in-vehicle data bus, which can transfer information from sensor, computational, driver interface, and control elements, has the potential of helping to reduce costs of collision-warning devices.

EXHIBIT III-21
LEVELS OF UNDERSTANDING TO MEET PROGRAM OBJECTIVES

Objective	Level of Understanding		
	Rudimentary	Improved	Full
Evaluating Capabilities	Expressed in terms of subsystem performance. Based on models, literature review, and limited testing.	Expressed as a mixture of objective test procedures for sensors and subsystem performance for computational element and driver interface for all driving situations in which warning is needed. User acceptance factors are also considered.	Expressed as objective test procedures and criteria on system performance for all pertinent driving situations, including those that require a warning and those for which a warning should not be issued. Based on track tests, VDTV, and available driving simulator data.
Measuring User Acceptance	General relationship between measures of performance and benefits. Performance measures include alarm accuracy, workload, and cost. Based on limited focus groups, questionnaires, interviews, and generic testing.	Understanding of acceptance for specific systems based on simulator and test track data.	Based on operational tests; includes consideration of workload in conjunction with other systems.
Assessing Benefits	Based on computer models and minimal experimental data. Relies on general descriptions of system capability. Assumes no risk compensation, full utilization, etc.	Based on baseline data from DASCAR or SAVME and experimental data from simulators for some subdivisions of collision type. No consideration of user acceptance effects.	Based on baseline data and countermeasure performance data from simulators, test track, and operational tests for each collision type. Includes consideration of user acceptance effects, risk compensation, confidence bounds on statistical data elements, and changes in severity of collisions that occur.

A full understanding of potential benefits is a major research goal of each crash avoidance program area. In some cases, these goals will not be easy to achieve in the immediate future. For example, in providing for pedestrian safety near school buses, we may never have an experimental basis for estimating benefits; therefore, the program may focus on improving understanding of user acceptance. The program plan hopes to achieve the goals in the shortest possible time frame. Progress in achieving these objectives is measured by the levels of understanding reached-rudimentary. improved, and full. The definitions of these levels are presented in Exhibit III-2 1.

One other area in which we lack full understanding is the relationship between collision avoidance systems and an AHS. The common link between the two programs is the organization of systems that enable both services. Collision avoidance systems and an AHS will both consist of three subsystems: the sensor, the computational element, and the driver interface. It is generally accepted that the final AHS concept will rely heavily on vehicle-based intelligence systems, including collision avoidance systems. After the final AHS concept is selected, it will be possible to determine the most appropriate areas for coordination and complementary work.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III. ITS PROGRAM DETAIL

F. Automated Highway System

The AHS concept defines a new relationship between vehicles and the highway infrastructure. AHS will use control technologies to shift driving functions from the operator to the vehicle and communication technologies to recognize and react to the external infrastructure's real-time traffic conditions. A fully deployed AHS will be capable of a level of performance and service that is a generation beyond other ITS services: it can double or triple the efficiency of today's most congested highway lanes while significantly increasing safety and trip quality. The promise of AHS is an expansion of the safety benefits of advanced collision avoidance systems and a major performance gain in flow capacity compared with today's highways traveled by conventional vehicles. One participant in the AHS design process called AHS the "ultimate embodiment of ITS."

A fully deployed AHS will be capable of a level of performance and service that is a generation beyond other ITS services: it can double or triple the efficiency of today's most congested highway lanes while significantly increasing safety and trip quality.

In response to the opportunity to improve safety and efficiency, ISTEA mandated an AHS program by requiring U.S. DOT to "develop an automated highway and vehicle prototype from which future fully automated intelligent vehicle-highway systems can be developed. Such development shall include research in human factors to ensure the success of the man-machine relationship. The goal of this program is to have the first fully automated roadway or test track in operation by 1997."

The AHS mandate was made feasible by the "technology push" of the late 1980's, during which new and advanced technologies enabled more powerful information-sensing and processing capabilities. This push and the "market pull" of roadway congestion provided the impetus for the development of automated highway concepts.

The AHS concept combines onboard vehicle intelligence with a range of intelligent technologies installed onto the existing highway infrastructure. Vehicle intelligence builds on the technologies of advanced vehicle collision avoidance and safety systems, which are designed to monitor the driving environment and alert the driver to potential dangers. AHS will use these technologies to broadcast vehicle data to the environment (i.e., other vehicles and roadside system components, such as beacons) and to receive further information that assists in vehicle control.

The automobile is becoming smarter with every new model year. Even now, intelligent cruise control systems are on the market in some countries, which maintain a driver-selected speed, yet slow down when the onboard radar system senses a slower vehicle ahead. These systems are being readied for U.S. introduction by vehicle manufacturers. With time, greater capability will be added as car buyers find these driving aids useful. If, however, these advances are left to unpredictable market-driven processes, they will take several decades to reach full application. If, instead, the process is accelerated and actively managed, significant safety and efficiency benefits can result much sooner. The AHS concept might progress as follows: Initial implementation builds on collision warning and avoidance systems to provide driver assistance safety systems ("copilots") that do not rely on infrastructure support. As highways are gradually equipped with AHS technology, vehicle-highway communication and coordination enable smoother traffic flow. As both vehicles and highways are enhanced over time, the combined systems perform at ever greater levels, giving transportation agencies a powerful tool for addressing safety and congestion problems. The need to accelerate this integration of the vehicle and the highway to increase performance of existing infrastructure is all the more urgent given the difficult and sometimes impossible prospect of building more highway lanes.

AHS development will be a long-term, multiphase process. This incremental approach will ensure that the right technologies are optimized, drivers will be allowed to become comfortable with increasingly capable in-vehicle technologies, driver and industry concerns are addressed, and concurrent upgrades in driving-such as energy-efficient alternative propulsion methods-are incorporated. Moreover, long-term implementation will ensure that the expensive technologies needed in AHS design will be significantly more cost effective and accessible when they are used on a mass scale.

PROGRAM GOALS

The AHS program is focused on developing an automated vehicle-highway system to serve the Nation's transportation needs in the 21st century through an orderly introduction of new capabilities.

The goals of the AHS program are being realized through a cost-shared cooperative agreement with the National AHS Consortium (NAHSC). The NAHSC consists of public and private stakeholders that have a broad range of perspectives on AHS. Through a consensus process, the consortium will specify, develop, and demonstrate a prototype AHS and provide for evolutionary deployment that can be tailored to regional and local transportation needs. An essential task of the consortium is to seek opportunities for early introduction of vehicle and highway automation technologies to achieve initial benefits for all surface transportation users. Exhibit III-22 lists the core members of the NAHSC.

Since the inception of the NAHSC in 1994, the consortium has completed a system description document that defines AHS goals, objectives, and functions; initiated identification and evaluation of AHS approaches and a small set of concepts; prepared a detailed work plan for the 1997 AHS technology prototype demonstration; launched research into institutional issues; and conducted outreach, including three major workshops for research.

The specific goals of the AHS program are as follows:

- **Improve safety.** Automated control will eliminate many driver errors attributable to poor judgment, fatigue, unpredictable behavior, and personal impairment. Roughly 75 percent of crashes are

EXHIBIT III-22
CORE NAHSC MEMBERSHIP

- Bechtel Corporation
- Caltrans (California DOT)
- Carnegie-Mellon University
- Delco Electronic
- General Motors R&D Center
- Hughes Electronics
- Lockheed Martin
- Parsons Brinckerhoff
- PATH - University of California at Berkeley
- U.S. DOT

attributed to driver error. By transferring driver control to the vehicles during travel on AHS highways, the automated system will reduce vehicle mishaps per highway kilometer by as much as 50 to 80 percent. In addition, the AHS program strives to completely eliminate collisions; AHS will interact positively with onboard vehicle monitoring systems to exclude defective and manually controlled vehicles from automated control lanes.

- **Increase efficiency.** By reducing incidents and crashes, AHS will increase the throughput of all accommodated vehicle types in the United States by as much as 300 percent. Throughput improvement varies depending on weather conditions, traffic conditions at exit points, and vehicle types (e.g., passenger cars, trucks, buses) accommodated on a specific AHS. The net per-lane throughput of an automobile-only AHS will be at least double and, perhaps, triple the per-lane throughput of a conventional highway under dry and good weather conditions, barring reductions caused by specific site conditions. Efficiency gains will be lower in AHS lanes accommodating a mix of heavy vehicle and automobile traffic
- **Enhance mobility and access. The** AHS will provide shorter, more predictable trip times and easier, more reliable travel in inclement weather. Rapid movement of people and freight, made possible by reduced highway congestion, will translate into noticeably shorter trip times and into the ability to move people and freight to more locations in the time available. This improvement will offer significant benefits to private, commercial, and transit vehicle users and operators.
- **Provide more convenient and comfortable highway traveling.** After entering an automated highway, a driver will be free to relax and engage in nondriving tasks, perhaps improving personal productivity. Under normal circumstances, drivers will not be required to resume any driving tasks until the requested exit is approached.

Program Activities

The NAHSC work plan lays out a multiyear effort to develop and advance the critical technologies required to support the 1997 AHS demonstration, select and evaluate AHS concepts, and build and test an AHS prototype. Investment decisions are informed by a thorough understanding of the current state of technology development. Where applicable, efforts build on the technical capability developed by NHTSA's crash avoidance research and other elements of ITS research (e.g., vehicle-roadside communications, satellite positioning, advanced traffic management centers). The program is organized into three phases: analysis, system definition, and operational testing and evaluation.

FHWA has developed milestones to track the progress of the system definition phase and ensure that the AHS is developed in a logical fashion on the basis of previously completed work. The milestones are listed in Exhibit III-23.

Analysis Phase

During the analysis phase, numerous in-depth research studies were conducted to acknowledge and assess issues related to AHS design, development, and deployment. These studies fell into three groups: precursor system analyses, human factors research, and NHTSA-sponsored collision avoidance analyses, which focused on vehicle-warning and control services. Much of the analysis phase was completed during FY 1996.

FHWA awarded 15 precursor system analysis contracts, totaling $14.1 million, to investigate the issues and risks related to AHS design, development, and implementation. The contract work included researching, analyzing, and debating a broad spectrum of AHS-related issues. The innovative structure of these contracts identified a matrix of 16 activities to be investigated by multidisciplinary, multi-organizational

EXHIBIT III-23
AHS PROGRAM MILESTONES

Milestone	Completion
Performance and Design Objectives Established	November 1995
Proof of Feasibility Demonstrated	August 1997
Feasible AHS Concepts Selected	June 1998
Preferred AHS Configuration Selected	March 1999
AHS Prototype Testing Completed	September 2002

teams representing diverse perspectives, including State and local transportation departments, academia, aerospace and automotive industries, and defense and high-tech research organizations. These contractors investigated the following specific AHS activity areas:

- AHS in urban and rural operational environments.
- Certification of proper vehicle functioning for automated operation (automated check-in).
- Certification of proper vehicle and driver functioning for manual operation (automated check-out).
- Lateral and longitudinal control of an automated vehicle.
- Malfunction management.
- Unique AHS-related needs of commercial and transit vehicles.
- Lessons learned from deployment of comparable systems.
- Deployment of possible AHS configurations within existing freeway networks.
- Impact of AHS on nearby non-AHS roadways.
- AHS entry/exit implementation.
- Ongoing AHS operation.
- AHS vehicle operation, including vehicle retrofitting.
- Impact of alternative propulsion systems on AHS deployment and operation.
- AHS safety issues.
- Institutional and societal aspects of AHS deployment.
- Assessment of AHS preliminary cost/benefit factors.

A CD-ROM containing reports on all these areas is available through the Volpe National Transportation Systems Center.

Human factors questions surrounding AHS involve the transition from manual to automated driving and back again, normal automated driving, and handling of emergency events. The research is informed by analyses of other automated roadway systems that involve human operators, including Germany's O-Bahn system (which has buses equipped with an automated system to take over steering control in narrow tunnels); the Channel Tunnel repair vehicle (which operates on both normal and automated roadways); the Washington, DC, Metro subway system (which has a speed control feature that is normally automated but must sometimes be controlled manually); and airplane autopilot systems.

Because driving simulation is a key component of AHS human factors research, the University of Iowa's highly sophisticated motion-based driving simulator is used. The simulator is a Ford Taurus that is surrounded by three seamless wide-screen projection systems showing realistic computer-generated roadway scenes. The vehicle is equipped with a motion system that creates the sensations of braking and accelerating.

Human factors researchers continue to investigate the following AHS issues and questions:

- Speeds and headway distances and driver adaption to new combinations of technologies.
- Entry and exit on automated lanes and driver maneuvering.
- Behavior of drivers in automated lanes and the amount of driver attention that can be relied on in case of a malfunction in the automation.
- Proximity of vehicles in the automated lane and driver reaction.
- Driver reaction when switching from automation back to manual control.

NHTSA-sponsored collision avoidance analyses are closely coordinated with AHS research to leverage technical results.

System Definition Phase

The system definition phase, the second stage of the AHS efforts, will establish performance and design objectives; identify and evaluate alternative AHS concepts; conduct a full-scale demonstration in 1997 of AHS technical feasibility as required by ISTEA; select a preferred system approach; demonstrate, test, and evaluate a prototype of the preferred approach; and prepare documentation for this configuration.

An important milestone identified by the NAHSC work plan is NAHSC Demonstration '97, which will showcase current applications of technologies, systems, and subsystems that will contribute to a future AHS prototype. A kickoff ceremony was held at the site of the first AHS demonstration-the I- 15 Express Lane in San Diego County-on June 28, 1996. The demonstration will include passenger vehicles, transit buses, and heavy trucks, showcasing both partial and full automation to give participants a clear sense of both short- and long-term applications of the technology. The demonstration will include mini-demonstrations of some of these technologies in a large parking lot. NAHSC will also cosponsor a technical conference with the Society of Automotive Engineers to showcase state-of-the-art and evolving technologies that will become critical elements of the AHS.

FHWA expects that the system definition phase will last through 2001 or 2002. At the conclusion of this phase, all specifications and documentation needed for product developers and transportation agencies will be available, including viable deployment paths.

Operational Test and Evaluation Phase

The third stage of the AHS program, the operational test and evaluation phase, will evaluate one or more implementations of vehicle-highway automation at selected U.S. locations in several operational settings. The implementations will be integrated into existing institutional, technological, regulatory, and highway environments. This final phase of the AHS program is expected to begin some time after 2002 and will establish guidelines that U.S. DOT will use to support AHS deployment.

Technical Lessons

The AI-IS program is a long-term and complex R&D effort, In particular, detection of roadway obstacles presents a major technical challenge for AHS. NAHSC is currently investigating several promising technological approaches to this problem. In addition, human factors research has revealed that drivers

FIRST AUTOMATED HIGHWAY CONCEPT TO BE TESTED IN SAN DIEGO

Highways of the future may feature relaxed drivers talking on the phone, faxing documents, or reading a novel while an automated highway system controls the vehicle's steering, braking, and throttle and allows for "hands-off, feet-off" driving. Beginning in August, the NAHSC will demonstrate that the vision of an automated highway system can be made a reality.

As required by ISTEA, in August 1997, the NAHSC will show proof-of-technical-feasibility in a demonstration project north of San Diego to establish that AHS is a viable and practical option for meeting travel demands and enhancing mobility-without building new highways. The demonstration will be a full-scale, live vehicle exhibition integrating the latest technological achievements of the NAHSC and the transportation industry. The demonstration also will show that the technologies needed to create an automated highway already exist or can be developed in the near future.

A 7.6-mile HOV segment of Interstate 15, located 10 miles north of downtown San Diego, will be the site of the August demonstration. Each day, continuous demonstrations will run for about five hours in various sequences to test the AHS system in seven areas, ranging from cruise control to obstacle detection. Members of Congress, congressional staff, State and local transportation decisionmakers, and private sector executives will be invited to experience the automation technology through rides in demonstration vehicles.

Although the demonstration may not directly represent the final AHS prototype concept, it will offer as many elements of a prototype as possible.The demonstration will focus on existing technologies that can be integrated quickly to provide a solid proof of technical feasibility. Near-term partial automation capabilities will be key components of the demonstration to illustrate a gradual implementation approach.

The demonstration results will help the intelligent transportation community select the most promising AHS technologies and conceptual approach, which ultimately will lead to an AHS operational test with public participation. With the summer demonstration, the NAHSC program plan will have achieved its first major milestone and set the stage for a future AHS prototype.

should not be expected to act as immediate backups for vehicle control in an emergency situation. Exhibit III-24 highlights technical lessons learned.

The benefits and requirements of the AHS concept still need to be analyzed and integrated with other advanced technologies at a regional level. For example, the efficient and safe operation of AHS depends on optimizing traffic flow at entrances and exits to highways through precise application of enhanced traffic management techniques and proper infrastructure design. Several viable approaches have been put forward, and research is ongoing for choosing among them. Technical and institutional factors render AHS concepts based on full infrastructure control impractical.

BENEFITS

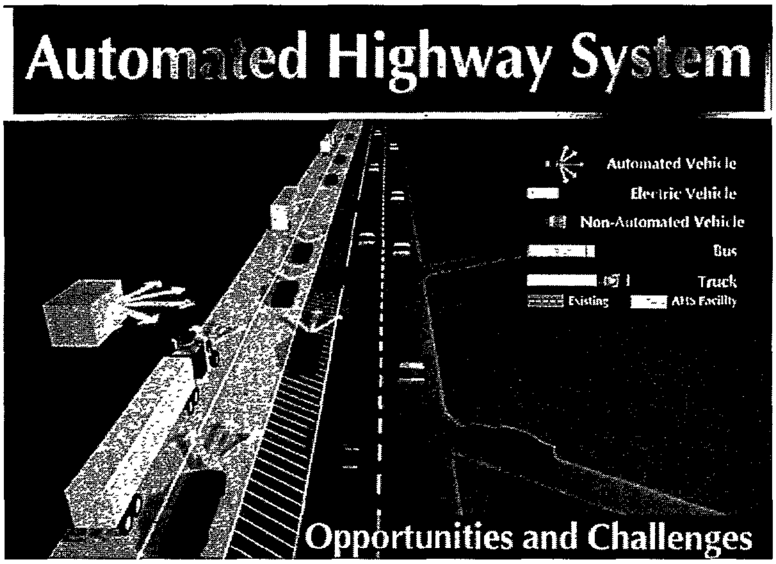
The precursor studies indicate that AHS can double or triple the number of vehicles per lane per hour, cut travel time by 33 to 50 percent, and have the potential to reduce accidents by 50 to 80 percent. NAHSC also expects that AHS could improve driving safety, decrease congestion, and reduce fuel consumption and emissions. Specific benefits are listed in Exhibit 111-25.

Transit and commercial vehicle operations and roadway maintenance have been identified as potential early winners that can benefit from AHS. Long-distance buses are also likely to enjoy safe travel with more reliable travel times. For CVO, AHS technology offers advantages in long-distance trucking, including establishing fleet convoys. AHS could also help improve current land use patterns by allowing planners to enhance or alter current transportation patterns.

INSTITUTIONAL ISSUES AND USER ACCEPTANCE

The AHS program has changed R&D processes within FHWA. By fostering strong stakeholder involvement, AHS has also put formal mechanisms and struc-

EXHIBIT III-24
SYNOPSIS OF AHS TECHNICAL LESSONS LEARNED



AHS concepts will likely progress from vehicles equipped with collision avoidance systems toward fully integrated vehicle-highway communication and coordination that will enable automated vehicles to operate with human-operated vehicles. We have learned a great deal about technical issues including:

- AHS is technically feasible and its design will follow an evolutionary path.
- One of the major technical challenges for the AHS program is to develop approaches to detecting roadway obstacles.
- Control intelligence will reside in a balance between the roadway infrastructure and the vehicle, using advanced vehicle crash avoidance and safety system techniques.
- Dedicated lanes enable AHS to ensure maximum safety and throughput benefits. Benefits are also achievable in mixed traffic.
- Ideally AHS technologies would accommodate mixed operation, with AHS and non-AHS vehicles operating together.
- AHS vehicles will have redundant control so that the driver does not have to act as backup in emergencies.

tures in place for stakeholders outside the Federal Government to influence decisionmaking. In addition to its core members, NAHSC includes over 100 associate members who represent nine categories of stakeholders: the vehicle industry, government agencies, the highway design industry, vehicle electronics manufacturers, environmental interests, trucking operators, transit operators, transportation users, and the insurance industry.

The associate participants in these categories engage in program activities that range from policy management to technical development. Their contributions and expertise are invaluable in the decisionmaking

EXHIBIT III-25
BENEFITS OF AHS

AHS Topic	Benefits	Source
Roadway Capacity	• AHS can accommodate more vehicles on the highway. The number of vehicles per hour per lane can be significantly increased as traffic speeds are standardized and increased and headway distances are decreased. Studies estimate that two to three times more vehicles could be accommodated through elimination of inefficiencies caused by inattentiveness, merging, weaving, and lane changing.	Nita Congress, The *Automated Highway System: An Idea Whose Time Has Come, date unknown.* *AHS Program Report to Congress*, September 1995.
Safety	• AI-IS will remove the human error associated with accidents and has the potential to reduce accidents by 30 percent.	Ibid.
Weather	• High-performance driving can be conducted without regard to weather and environmental conditions. Fog, haze, blowing dirt, low sun angle, rain, snow, darkness, and other conditions affecting driver visibility (and, thus, safety and traffic flow) will no longer hinder driving.	Ibid.
Mobility and Societal Access	• AHS offers enhanced mobility for people with disabilities, the elderly, and less experienced drivers. • Participants in focus groups expected that AHS would reduce stress and worry in highway travel, but expressed concerns for equity and access.	Ibid.
Air Quality and the Environment	• Fuel consumption and emissions can be reduced. In the short term, these reductions will be accomplished, because start-and-stop driving will be minimized and because onboard sensors will ensure that the vehicle is operating at top performance. In the long term, AHS can support future vehicle propulsion and fuel designs. • Land can be used more efficiently. Roads will not require as much land, because AHS facilities should allow for more effective use of capacity.	Ibid.
Commercial and Transit Efficiency	• AHS will enable more efficient commercial operations. Commercial trucking could realize an increase in trip reliability to support "just-in-time" delivery. • AHS could automate transit operations, extending the flexibility and convenience of transit to increase ridership and service.	Ibid.
Economic Gains	• "[The AHS program] provides the opportunity for U.S. industry to stake out a dominant position internationally in the unique technologies that will comprise the future automated highway system."	Rodney Slater, Former FHWA Administrator

process of the consortium. Examples of significant contributions from associate participants include:

- Active involvement in the 1997 demonstration in developing an integrated program and exhibiting new technology and research.
- Prominent roles in NAHSC case studies to leverage ongoing or future projects and ensure maximum benefit to stakeholders' programs.
- Active participation as working members of the group researching the societal and institutional viability of an AHS.

Most notably, stakeholders reoriented the AHS program from one of exclusive "automated platooning" to a more balanced, integrated mix of vehicles and incremental implementation. Stakeholders wanted to see more moderate, intermediate systems, especially because the private sector has an interest in deploying products that have near-term market potential.

As a result, during the past year, the U.S. DOT and its partners have redefined the AHS concept to be more evolutionary than revolutionary. Originally, automated highways were envisioned exclusively as roads on which drivers would not have to operate their vehicles. Vehicles would be automatically guided along dedicated lanes and kept a safe distance apart through the application of roadside technologies that "platooned" vehicles. Most recently, prototyping and testing of AHS technologies has oriented the program toward integration with existing traditional highway infrastructure. Based on feedback from public reviews of preliminary AHS concepts, the AHS program now seeks to strike a balance between in-vehicle and roadside technology intelligence, putting more of the intelligence into the vehicle.

The 1995 *Report to Congress on the Automated Highway System Program* notes that deployment of the AHS will face the same challenges that other transportation improvement programs experience:

AHS User Acceptance.

Change is inevitable in 5 progressive country change is constant

Benjamin Disraeli, 1867

The AHS will be a big change-a change on the scale of the transition from the horse and buggy to the automobile, from the adding machine to the calculator, from the pencil to the word processor. Like those changes, AHS represents automation of a task previously performed in a tedious, inefficient, and time-consuming manner, but does not preclude using older methods. Also like those changes-like all changes-AHS inspires resistance.

The AHS program recognizes that driver acceptance is a key issue in ensuring the feasibility and usability of the automated highway. As a result, the program is conducting focus groups to determine potential user attitudes. Human factors studies will also focus on user acceptance as AHS enters its system design phase.

Full automation of the Nation's roads cannot be achieved now and is not intended to be achieved for several decades. Driving as we know it today will not -become obsolete, either overnight or over the next generationjust as the advent of computers didn't supplant the workforce, the AHS won't take the place of drivers. Full-performance AHS will, in the beginning, be implemented only on certain high-grade, high-performance facilities. People will still need to drive on secondary roads to reach AHS facilities. Moreover, these facilities will probably not span a whole roadway, but will take up one or more lanes on a multitane expressway.

Finally, gradual implementation of AHS facilities will help build user acceptance. As the many advantages of AHS are consistently demonstrated, including its reliability, efficiency, safety, and timeliness, users can be expected to accept these new capabilities as valuable enhancements.

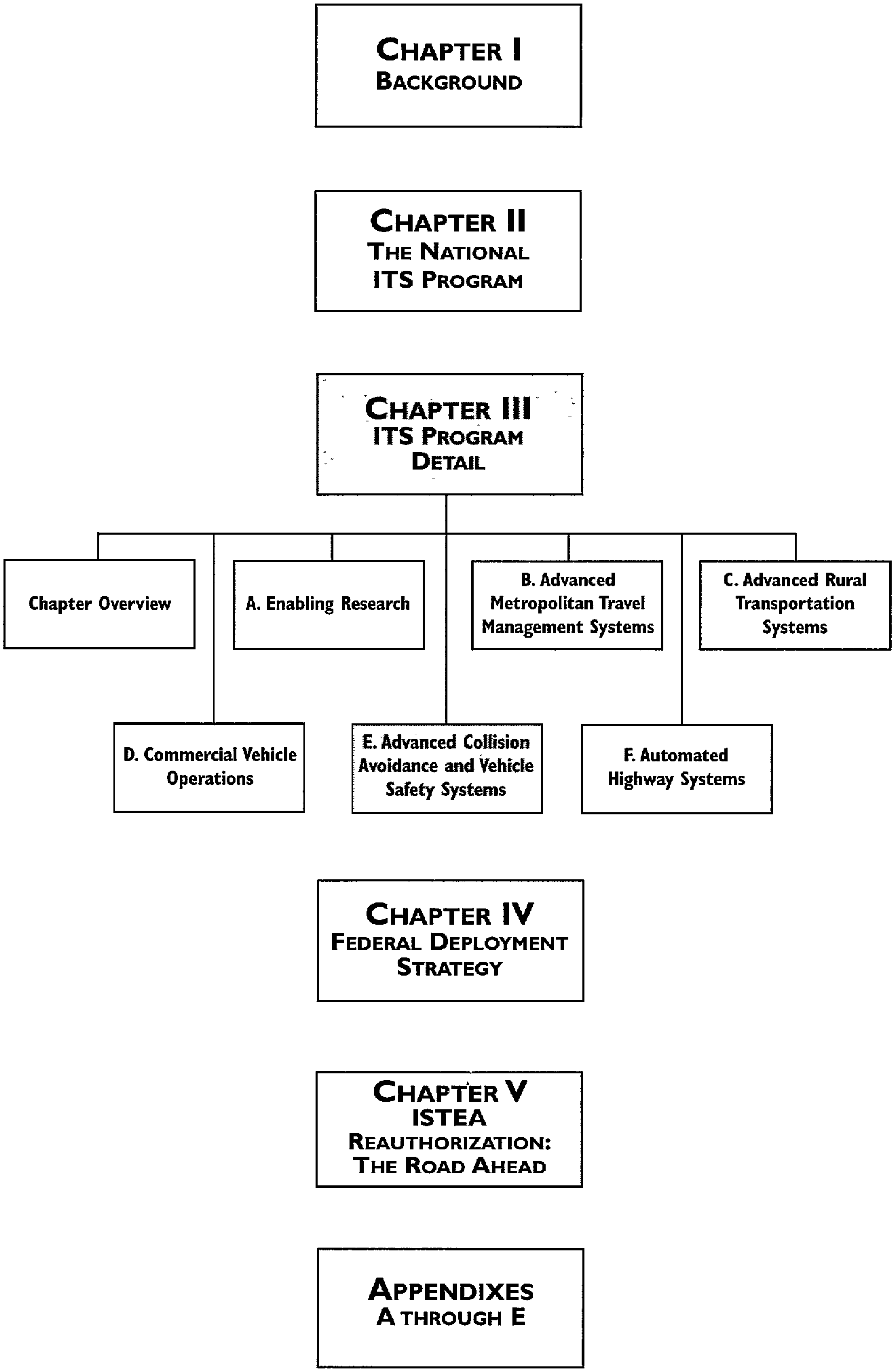
- **Societal concerns.** Potential environmental and land use impact, social equity issues, and the skills and responsibilities of the vehicle operator are among the concerns.
- **Legal issues.** Several studies have concluded that possible antitrust violations, invasion of privacy, and intellectual property disputes will not pose severe impediments. The concern over potential accident liability, however, increases as more control of the vehicle passes from the operator to the automated system. Such systems carry the risk of increased severity of damage resulting from higher speeds and reduced spacing of vehicles.
- **Funding issues.** AHS funding issues are similar to those encountered with traditional transportation projects, including the structuring and allocation of construction, operating, and maintenance costs; the sources of funding: the extent to which the market and government entities will support such a system; and the assignment of user fees.
- **Institutional issues.** To provide for a truly integrated system, officials from adjacent jurisdictions will have to cooperate and coordinate their activities. Staff will need the requisite skills to design, construct, operate, and maintain the systems. Also, uncertainty exists about the type of institution needed to implement an AHS, the unknown effects of AHS operation on insurance rates, and the resources needed to inspect vehicles using the system.
- **Standards.** Compatibility of regional AHS with nationally used technology and minimum levels of safety and performance are chief concerns. The 1995 AHS Report stresses the need to certify compliance of vehicle and roadside components with standards and specifications and ensure that all systems are operated and maintained according to standards.

Finally, an Internet user survey was conducted to measure consumers' attitudes toward AHS, the need for AHS, and consumer attitudes and perceptions of some of the AHS technologies. The survey found that a large proportion of respondents would like to see improvements in solutions to driving-induced stress, system safety, system cost, effects on environment, and effects on congestion.

FUTURE DIRECTIONS

The Federal role is essential to continued development of highway automation, supporting long-term, high-risk R&D that industry and public sector agencies cannot undertake alone. If AHS is to be successfully developed and implemented, public-private partnerships must continue to be pursued. NAHSC is working in cooperation with U.S. DOT, committing skilled resources and management energies to realizing the vision of AHS. The momentum must be maintained to help realize the potential of vehicle-highway automation.

The program will also continue critical vehicle control, communication, and human factors research. Beyond the 1997 demonstration is the selection and prototype testing of the preferred AHS configuration. In 1999, NAHSC will select a preferred system approach; operational tests will begin shortly thereafter, leading to a preferred system in 2002. The operational test and evaluation phase of the AHS program is critical to the successful deployment of AHS. Only through operational testing will the public understand, experience, and appreciate the promise of this technology.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IV. FEDERAL DEPLOYMENT STRATEGY

Forty years ago, the Federal Government conceived a plan to build the Interstate highway system, one of the Nation's most ambitious public works projects. Through its agent, the U.S. DOT, the Government executed a comprehensive strategy of innovative funding, unifying standards, and essential training that brought together stakeholders from urban and rural areas, from the public and private sectors, and from the country's diverse States and localities to build a highway system to meet the economic and social needs of the postwar era.

> ***Our challenge is this: how do we start with the transportation system as it is today and begin taking concrete steps toward making it an intelligent system? I believe that answering that question will be a test of our national will and a new form of Federal leadership. A leadership in which the Federal role is not "mandator" and "bankroller," but convener, " "facilitator," "researcher, " "catalyst," and "'Exemplar."***
>
> RODNEY E. SLATER
> SECRETARY OF TRANSPORTATION

Today our Nation requires a strategy that is no less ambitious to fulfill contemporary needs for safer, speedier, and more efficient transportation. For the past several years, the transportation system-encumbered by congestion, constrained budgets, and modal fragmentation-has been hard pressed to serve these needs.

As it did in 1956, the U.S. DOT is again serving as an agent to transform surface transportation. In 199 1, ISTEA charged the Secretary of Transportation with advancing the development and use of ITS to enhance the safety and efficiency of surface transportation and to help realize an intermodal system that seamlessly connects multiple transportation modes. ISTEA outlined two primary activities that make up U.S. DOT's strategy: "conduct a program to research, develop, and operationally test intelligent vehicle-highway systems" and "promote implementation of such systems."

During the past 5 years, the national program's research, field tests, and evaluations of ITS products and services have helped ITS evolve from a relatively visionary concept, unknown or ignored by most transportation planners and decision makers, into a viable and attractive solution to transportation problems. General concerns about the technological limitations of ITS have either been refined to specific questions or have been resolved.

With the basic feasibility, practicality, and value of key ITS services established, the U.S. DOT has increasingly advocated and facilitated ITS deployment across the Nation. An essential goal is to ensure that ITS technology is deployed as comprehensive and integrated systems that foster multimodalism and intermodalism.

In early 1996 the U.S. DOT established its principal deployment goal: to create an intelligent transportation infrastructure-a transportation communication and information backbone-to help ensure that ITS services can be integrated and are interoperable and intermodal. To date, the U.S. DOT has defined three components of this infrastructure:

- The metropolitan ITS infrastructure will integrate advanced traffic management, traveler information, and public transportation systems to meet the needs of metropolitan areas. In January 1996, then Secretary Peiia announced Operation Timesaver, a national goal aimed at deploying this infrastructure in 75 of the largest metropolitan areas within 10 years, with an eye toward cutting travel times in these areas by 15 percent.

- CVISN will integrate data, technology, and communication systems to make safety regulation of commercial vehicles faster and more effective and to make general compliance transactions more efficient for both motor carriers and regulators. The U.S. DOT's goal is to encourage the public and private sectors to build CVISN in all interested States by the year 2005.
- The rural ITS infrastructure proposes to advance communication and information technologies for 450 communities, rural roads, and the national highway system, as warranted, and to link rural areas to the metropolitan infrastructure.

The Federal Government does not propose to build intelligent transportation infrastructure, but rather to encourage public sector agencies to pursue infrastructure development using appropriate private sector support. The Government will also encourage both public and private sectors to develop and deploy infrastructure elements to provide some of the essential capabilities of the Interstate highway system, namely the ability to accommodate local needs and problems while providing regional and national interoperability. Providing leadership for this infrastructure, however, demands more than vision. Building the infrastructure requires a unifying and coordinated Federal strategy that includes such elements as showcasing the benefits of the ITS infrastructure through model deployment and awareness programs, developing innovative financing and acquisition processes, promoting the acceptance of standards, providing training and technical assistance, pursuing focused R&D, and encouraging critical partnerships and cooperative working relationships.

In developing its strategy to achieve nationwide implementation of ITS, the U.S. DOT has addressed three essential questions:

- What is the national interest in ITS deployment?
- How is ITS deployment currently evolving?
- What strategy is necessary to help diverse stakeholders, who are making independent decisions, realize the full national potential of ITS?

The National Interest in ITS Deployment

From its research and testing activities, the U.S. DOT has found that ITS applications can meet a wide range of societal needs (documented in Chapter III of this report). ITS services will allow more efficient use of our infrastructure and will substantially improve safety, mobility, accessibility, productivity, and the general quality of life, with minimal environmental impact.

Already the public sector, private industry, and the traveling public-both managers and users of transportation systems-have realized benefits from ITS technologies and services. Case studies of public sector benefits are highlighted in several reports, including *Traveling with Success: How Local Governments Use Intelligent Transportation Systems* and *Review of ITS Benefits: Emerging Successes*. The American Trucking Association's Foundation documented the benefits of the ITS/CVO components that will make up CVISN in *Benefit/Cost Analysis of the ITS/CVO User* Services. In FY 1996, ITS America and U.S. DOT began preparing a report, *ITS National investment and Market Analysis,* which quantifies the costs and direct benefits of basic ITS infrastructure deployment.

Although the program has convinced U.S. DOT that the benefits of deploying and purchasing individual ITS elements are significant, the value and cost effectiveness of an integrated and interoperable ITS infrastructure will be even greater. In particular, the U.S. DOT expects that ITS will serve the national interest by: (1) making surface transportation systems more efficient, (2) reducing the costs of government operations and services, (3) improving the safety of the surface transportation system, (4) improving the quality of life, and (5) advancing a new generation of ITS products and services.

Increasing Efficiency

Better management of transportation systems is central to achieving the efficiency envisioned by ISTEA; however, it is nearly impossible to manage the system-transit, streets, or highways-at a much higher level of efficiency unless system managers have access to data on system performance, such as where buses are running or the locations of accidents. Such information must also be supplemented by the means to respond by making adjustments to the system or communicating with travelers. ITS field tests and deployments have shown that strategic application of information and control systems can significantly improve efficiency for system managers. For example:

- The U.S. DOT estimates that deploying the intelligent transportation infrastructure in 50 of our largest metropolitan areas will reduce the need for new roads while saving taxpayers 35 percent of required investment in urban highways.
- Freeway management systems can enable freeways to handle 8 to 22 percent more traffic at speeds that are 16 to 62 percent faster than are possible under congested conditions.
- Incident management programs have reduced incident-related congestion and delays by 50 to 60 percent.
- Electronic toll collection has increased throughput by 200 to 300 percent compared with traditional attended lanes.
- Automated traffic signal systems can decrease travel times by 14 percent, reduce delay by 37 percent, and increase travel speeds by 22 percent.

Reducing Government Costs

In its October 1995 report entitled *High-Tech Highways: Intelligent Transportation Systems and Policy*, the Congressional Budget Office states, "ITS research may enable highway and transit authorities to provide better service at lower cost, possibly reducing the need for public subsidies." In an environment of limited budgets and cuts in public sector subsidies, the components of ITS infrastructure can dramatically reduce the costs of transit management, toll collecting, and truck safety inspections. For example:

- Estimated savings to transit operators from advanced public transportation management systems in 265 actual or planned deployments range from $3.8 billion to $7.4 billion (in 1996 dollars) in operating costs over the next decade.
- In Oklahoma, operating costs dropped from $176,000 to $16,000 per year per toll booth when booths were equipped with electronic debit systems, a cost reduction of 90 percent.
- Commercial vehicle administration programs have reduced compliance-related labor costs (for licenses, permits, registrations, fuel taxes, and credentials) by 9 to 18 percent through the use of advanced information technologies.

Improving Safety

Today, ITS technologies are allowing emergency response teams to locate incidents and reach victims more quickly and easily, dramatically improving the victims' chances of survival. Freeway management systems, such as ramp meters that help smooth traffic flow, have reduced accidents by 15 to 20 percent. New information technologies for commercial vehicles are allowing safety inspections to be run more efficiently and accurately, increasing inspectors' access to safety information, and automating hazardous materials incident response systems.

The emerging collision avoidance and vehicle safety systems will also offer significant safety benefits. These systems promise to shift the current focus of traffic safety from protection of individuals and property during an accident to prevention of the accident altogether. The new safety systems will ensure the driver's fitness (through driver monitoring), enhance driver perception, warn of impending danger, intervene with emergency control when a crash is imminent, and could completely automate driving when added to an intelligent highway. NHTSA estimates that 1.1 million crashes-17 percent of the total 6.4 million nationwide-could be prevented each year if all vehicles were equipped with three ITS crash avoidance countermeasures currently under development: rear-end crash warning systems, roadway departure warning systems, and lane-change/merge crash avoidance systems. These systems would save $26 billion annually in accident-related costs.

Improving Quality of Life

ISTEA emphasizes quality of life and environmental quality. Because ITS technology can enhance the capacity of the existing physical infrastructure, it can lessen the disruptions to wetlands, parks, open spaces, and neighborhoods that are caused by new construction. Also, ITS services and infrastructure can increase mobility by giving people more information and greater control over their transportation choices. In greater Boston, for example, a majority of travelers change their routes, times of travel, or modes when they are given up-to-date information through advanced services. National focus group research indicates that all income groups have a high level of interest in travel products that provide personal security and safety services, location assistance, advanced traffic notification, and alternative route advisories. Equally important as the Nation's baby-boomers age are in-vehicle safety and information technologies, which could enhance the capabilities of older drivers.

Although system managers and travelers across the country are using ITS products and services, no area has all the components of intelligent transportation infrastructure in place and, with very few exceptions, none has achieved integration of the components into a regional communication and information platform.

Advancing A New Generation of Products and Services

Building intelligent infrastructure that links users with transportation system performance data and expedites incident and emergency services within a local jurisdiction (as well as the sharing of data between jurisdictions) will engender a new generation of products and services much as the Interstate system "created" the trucking industry and numerous other businesses and the Internet is creating new products, business opportunities, and services today.

Most of the individual components of ITS can be implemented to some degree in limited regions and by individual jurisdictions or agencies; however, this raises the possibility of haphazard, regionally and modally fragmented deployment that is likely to impede the larger private market. As a representative of Motorola noted, "The absence of a public core infrastructure represents a barrier to market growth The infrastructure is extremely important for the dissemination of real-time traffic information . . . accurate and driver-specific information." A vice president at Siemens believes that a basic ITS infrastructure is a crucial step toward further development of traveler information services. By building a core intelligent transportation infrastructure, the public sector will establish a rational sequence of ITS deployment to meet essential traveler needs and provide the basis for commercially viable ITS products and services.

The Status of ITS Deployment

The U.S. DOT expects that the benefits of ITS infrastructure will transform surface transportation, making it more efficient, safe, cost effective, and responsive. This infrastructure will strengthen multiple modes of transportation and link those modes to create a functioning intermodal system. It will enable wise sequencing of ITS deployment within metropolitan and rural areas and for commercial operations.

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

Interviews and discussions with State and local transportation managers, private industry representatives, and private travelers have revealed five characteristics of ITS deployment, which are reviewed in the following five sections.

Growing Market and User Acceptance

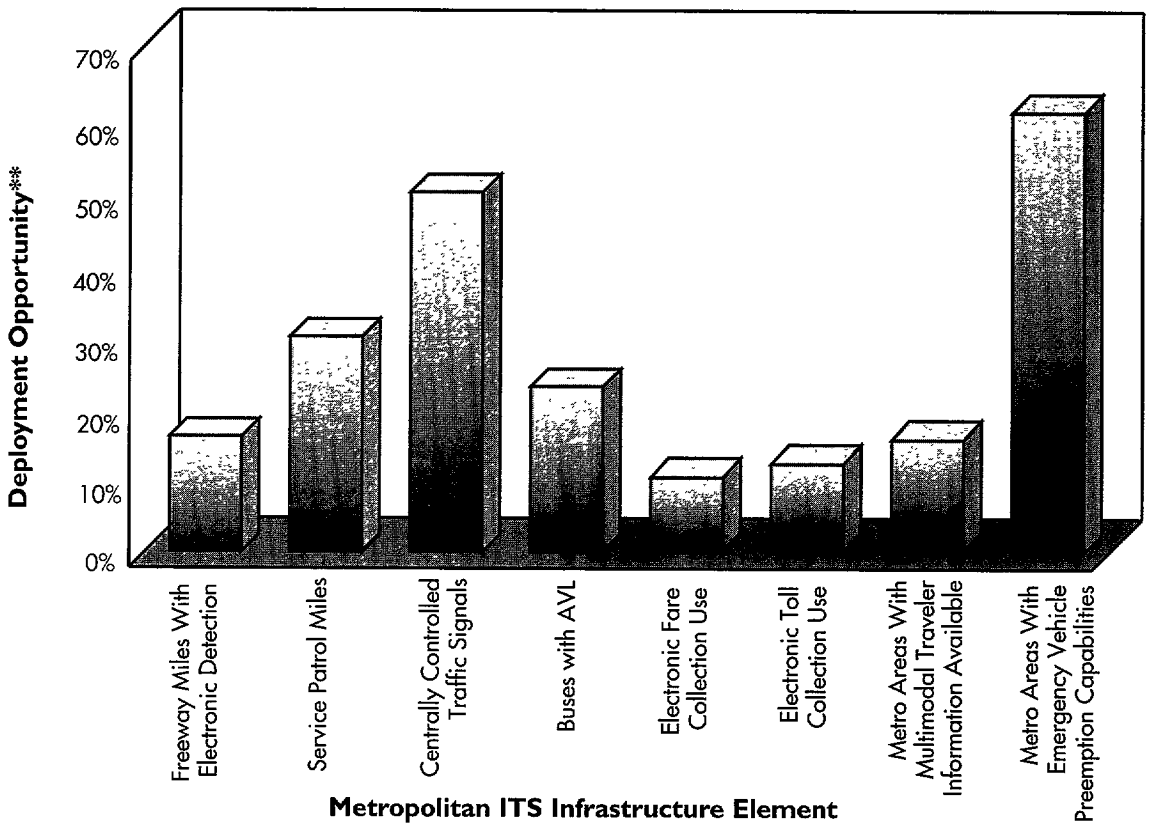
States and localities are investing in individual ITS infrastructure technologies and components. More than $1 billion of Federal-aid funding was used to deploy core ITS components in 1995, a 280-percent increase over 199 1. The use of Federal funds represents only a fraction of total State and local spending on ITS products and services. Further, our reviews of ITS deployment decisionmaking revealed that, when State and local officials have discretion over the use of funding to solve problems, ITS solutions rate very favorably. This is particularly true of air quality, congestion improvement, and efficiency programs. For example, over the last 4 years, the use of automatic vehicle location systems by transit systems has increased more than 200 percent in the United States, which has helped reduce operating costs and improve service.

Although metropolitan areas are making headway in deploying individual components of the ITS infrastructure, there is still great potential for further deployment. At the U.S. DOT's request, Oak Ridge National Laboratory investigated the extent to which 75 of the metropolitan areas targeted for the national goal have deployed or expect to deploy the core elements of the metropolitan intelligent transportation infrastructure. The preliminary results are shown in Exhibit IV-l for eight of the nine metropolitan ITS infrastructure elements (indicators for highway-rail crossing technologies have yet to be determined). These indicators present the level of deployment as a percentage of the total deployment potential. For example, slightly more than 50 percent of the traffic signals in the 75 metropolitan areas are automatically and centrally controlled, and barely 20 percent of the areas make traveler information available for more than one mode of travel.

In the private sector, survey research indicates that private consumers are interested primarily in ITS products and services that provide personal security and safety services, location assistance, advanced traffic notification, and alternative route advisories. Commercial motor carriers have increasingly applied electronic data-sharing and location technologies for over a decade to better manage the flow of inventories and vehicle fleets. Deployment of CVISN elements has, however, lagged deployment of metropolitan intelligent transportation infrastructure, and more important, there has been little natural integration of these services.

ITS deployment in rural areas is just beginning. The U.S. DOT has recently defined seven clusters of rural ITS applications and is preparing to launch a major operational test program. Nevertheless, there are strong indications of local interest. For example, Minnesota is field-testing an advanced emergency response system in rural counties, several States are investigating the feasibility of en route driver advisory systems and inter-regional traveler information sys-

EXHIBIT IV-1
PRELIMINARY INDICATORS* OF DEPLOYMENT OF METROPOLITAN ITS INFRASTRUCTURE
TOTAL FOR 75 LARGEST METROPOLITAN AREAS



* Indicators are single surrogates that do not necessarily reflect the full breadth of ITS infrastructure deployment activity. Data are as of September 1996 for 75 metropolitan areas.

** Deployment opportunity is the level of deployment as a percentage of the total deployment potential.

tems, and Idaho and North and South Dakota are demonstrating and evaluating advanced transportation weather information systems.

STOVEPIPED DEPLOYMENT

Transportation system managers and planners are making significant progress in deploying ITS components, but few consistent attempts are being made to integrate the components into a single communication and information network that could more comprehensively and effectively manage the transportation system. No single deploying agency has the incentive to take this difficult and "added-cost" step. For the most part, transportation officials and managers are electronically reinforcing the fragmentation of today's transportation systems and infrastructure, rather than using the technology to bridge the gap to a new era of intermodalism.

Transportation officials are primarily motivated to introduce advanced technologies to address a specific agency need or respond to a narrow mandate. For example, certain jurisdictions in air quality nonattainment areas are deploying dynamic traffic control systems on heavily traveled streets. However, they often do so independently of transit operators who may be deploying automated tracking systems to manage bus fleets. In addition, some areas that have significant freeway congestion are installing freeway management systems, but are not necessarily using the same information to support traveler information services. The current situation in ITS would be analogous to States, cities, and counties each building small parts of a limited access freeway with little regard for its connections to segments in other jurisdictions and no vision or blueprint of a national system.

Lack of Agency Coordination

Myriad agencies are responsible for operating, maintaining, and planning transportation systems, facilities, and support services, including State DOTs, transit agencies, municipal transportation organizations, MPOs, county transportation agencies, law enforcement agencies, toll authorities, and emergency response services. Although these agencies are independently interested in individual ITS applications, they are rarely interested in integrating their applications with those of other agencies, and no single agency can accomplish integration on its own.

In a review of ITS deployment and planning in seven metropolitan areas, none of the transportation officials stated that information sharing or system integration was a priority. In addition, because of jurisdictional boundaries, many transportation officials lack a regional perspective on transportation and do not recognize the importance of integration. For example, local officials may oppose a State-initiated freeway management or incident management system. They may believe that such a system would adversely affect local traffic because of potential diversion from the freeway entrances as a result of ramp metering. Also, transit officials may oppose large expenditures on highway-based ITS that do not directly benefit their operations.

For CVO, there is no agency that corresponds to the MPO-one that would oversee transportation planning and provide a forum for diverse stakeholders-although such coordination is needed to guide planning for interstate corridors and bring together State transportation, treasury, law enforcement, and other relevant agencies. This discontinuity, along with lack of Federal-aid money for transportation projects in corridors, presents a formidable obstacle for building CVISN. However, the level of interaction within and across States, among public and private sector transportation, enforcement, and administrative officials who are responsible for ITS deployment, is not only a predictor of positive support for ITS solutions, but also an effective enabler for future integration of these solutions.

Need for Standards

Regional and national integration and interoperability of ITS technologies cannot be accomplished without standards. In fact, several participants in field operational tests have stated that the lack of technical standards could delay the adoption of ITS products and services by other agencies in their own and other geographic areas. For the most part, public sector officials are hesitant to buy new ITS products that might become obsolete under future standards. In addition, private firms are reluctant to invest in technology that may not meet future performance requirements. Standards, as one study states, "offer access to global markets, the ability to specialize and still offer compatibility, the premise of reduced developing costs, and a level playing field."

Lack of Professional Capacity

We don't yet have the skills or professional capacity to build and effectively use the ITS infrastructure to realize the vision of ISTEA. In a 1995 survey and report by the Institute of Transportation Engineers, 50 percent of State agency respondents rated their staffs' ability to operate automated systems as fair or poor, and 66 percent rated their staffs' ability to maintain such systems as fair or poor.

The next generation of transportation planners, engineers, and managers at the Federal, State, and local levels must be trained to design and build future ITS infrastructure from a system integration perspective as effectively as the civil engineers designed and built the Interstate highway system. Elected officials and the public need to understand how ITS infrastructure can enhance "capacity" through better operational management.. Planners need better tools to evaluate the effectiveness of ITS solutions compared with traditional build-or-buy alternatives. Universities and colleges need to develop new programs to educate transportation professionals.

THE FEDERAL DEPLOYMENT STRATEGY

To close the gap between the great potential of integrated ITS solutions and the current state of fragmented ITS deployment, U.S. DOT has developed a five-pronged strategy for encouraging the public sector to build integrated ITS infrastructure. The challenge is to assist transportation professionals to continue to deploy ITS elements, both as solutions to today's problems and as components of a larger, more robust communication and information infrastructure in the future.

DEMONSTRATING THE BENEFITS OF ITS INFRASTRUCTURE

The more exposure individuals have to useful products and services, the more likely they are to accept, purchase, and use them. The 1996 MDI, which will demonstrate intelligent transportation infrastructure at about a dozen locations around the country, is expected to increase awareness of the benefits of integrated ITS services and encourage public sector officials to build supporting infrastructure.

By early 1998, the first four MD1 sites-New York/New Jersey/Connecticut, Phoenix, Seattle, and San Antonio-will have deployed and implemented integrated and functioning ITS infrastructure that will feature strong regional and multimodal traveler information service components. The Federal program will assist. in the development of both the institutional and technical infrastructure and will ensure that the benefits and effects of deployment are measured and evaluated, especially customer awareness, acceptance. and satisfaction associated with traveler information services.

The first prototype phase of the corresponding CVISN MDI has been ongoing since 1995 in Maryland and Virginia. These prototypes test the integration of a number of technologies in real-world environments. The two States will share their results with seven CVISN model deployments in eight States (California, Colorado, Connecticut, Kentucky, Michigan, Minnesota, and Washington/Oregon). The CVISN model deployments will be used to develop standards and demonstrate the operational feasibility and effectiveness of CVISN before full-scale development. Ultimately, the U.S. DOT seeks to encourage the expansion of CVISN deployment from the eight MDI States to an equal number of partner States in each region and, then, to deployment in all interested States. The MDI will also eventually be expanded to demonstrate rural ITS infrastructure.

CREATING FUNDING INCENTIVES

ITS deployment is gaining momentum under existing surface transportation programs, but not consistently, optimally, or systematically. Temporary funding incentives are necessary to intervene in the current deployment process to foster integration and national interoperability. The power of small incentives was shown dramatically in the recent MDI solicitation.

The solicitation catalyzed institutional collaboration, even among sites that were not selected. Many of these sites are now proceeding with their ITS deployment plans without direct U.S. DOT funding support. Specifically, deployment incentives would help to accomplish the following:

- Encourage the "institutional integration" necessary to initiate building the ITS infrastructure.
- Provide funding that does not currently exist for some elements of CVISN.
- Leverage equal. or potentially greater, State and local deployment funding and private sector investment.

ESTABLISHING STANDARDS

The relationship between standards and ITS infrastructure deployment is like the classic chicken-and-egg dilemma: we will have difficulty integrating ITS without standards, yet setting standards will be difficult without strong demand for integrated ITS services. Establishing standards goes hand-in-hand with offering deployment incentives as priorities in the U.S. DOT's ITS Program and must be supported by the reauthorization of ISTEA.

Forty years ago, the Federal Government drew the broad outlines of the Interstate highway system to ensure interconnectivity. In the same way, U.S. DOT has invested in attaining public and private sector consensus in a national ITS architecture to define minimum requirements for information exchange and interconnectivity and to allow for development of standards. The architecture-the product of this consensus-provides a framework to help ensure interoperability and communication among ITS components and functions, if it is followed.

THE METROPOLITAN MDI PROMPTS BUILDING OF ITS INFRASTRUCTURE

Early in 1996, then Secretary of Transportation Federico Pena announced a major ITS deployment goal of reducing travel time by at least IS percent in 75 of the Nation's largest metropolitan areas by deploying ITS infrastructure. To support this goal, the U.S. DOT sought applications from public and private sector partnerships to showcase model deployments of metropolitan intelligent transportation infrastructure. U.S. DOT made the pre-existence of some ITS components a criterion for selection to enable the MDI to focus on helping each area progress to the next stage of deployment: creating a comprehensive intelligent transportation infrastructure that supports integrated transportation management systems and regional traveler information services.

The US. DOT's request for participation sparked 23 applications from around the country, from which U.S. DOT selected four areas in mid- 1996: the New York tristate metropolitan area (New York, New Jersey, and Connecticut), Phoenix, San Antonio, and Seattle. The schedule calls for these areas to have operational systems by the end of 1997. Each of the selected sites is receiving 50 percent Federal ITS funding; the other 50 percent is a combination of State, local, and private funding.

Interestingly, many of the I9 cities that were not selected under the MDI are still moving toward establishing an integrated intelligent transportation infrastructure.The application process stimulated interjurisdictional and interagency cooperative agreements, as well as public-private partnerships. In some areas, this team-building approach has laid the foundation for developing a comprehensive intelligent transportation infrastructure, and U.S. DOT is encouraging these partnerships by providing ongoing technical assistance.

The selected sites are moving quickly to put their infrastructure deployment into place. Seattle, for example, already has selected its prime contractor, and the New York City region is currently in contract negotiations. As the infrastructure develops, U.S. DOT will evaluate consumer acceptance of traveler information services and products supported by the model deployment. At the same time, U.S. DOT will review the impact and cost effectiveness of metropolitan ITS infrastructure. U.S. DOT has also launched a parallel initiative to build CVISN to showcase ITS infrastructure for CVO.

In tandem with the architecture are standards that will help ITS avoid becoming a technological Tower of Babel: lots of talking with no communication. The U.S. DOT is now working with industry to facilitate the development and acceptance of essential standards.

Promoting Training and Awareness

"Education regarding ITS users, products, and services," stated one Denver transportation official, "is the best way to overcome institutional issues and change the way of thinking by politicians, practitioners, and the general public." Just as the Interstate construction program required new skills in roadbuilding and civil engineering, the ITS program requires skills in system integration, electronics, and communications. Because professionals with these skills currently do not exist in sufficient numbers to support the effective delivery of ITS, carrying out the U.S. DOT's 5-year plan for building professional capacity is crucial to establishing the infrastructure to enable the vision of ISTEA. The plan specifically aims to do the following:

- Ensure that all transportation professionals and elected officials are aware of ITS, the benefits of deployment, and the Federal program.
- Identify Federal, State, and local staffs' ITS training needs and develop both general awareness and technical training programs to meet those needs.
- Provide for the continued advancement of the profession through university programs and other delivery mechanisms, such as distance learning, for students and transportation professionals.

Investing in the Next Generation of ITS

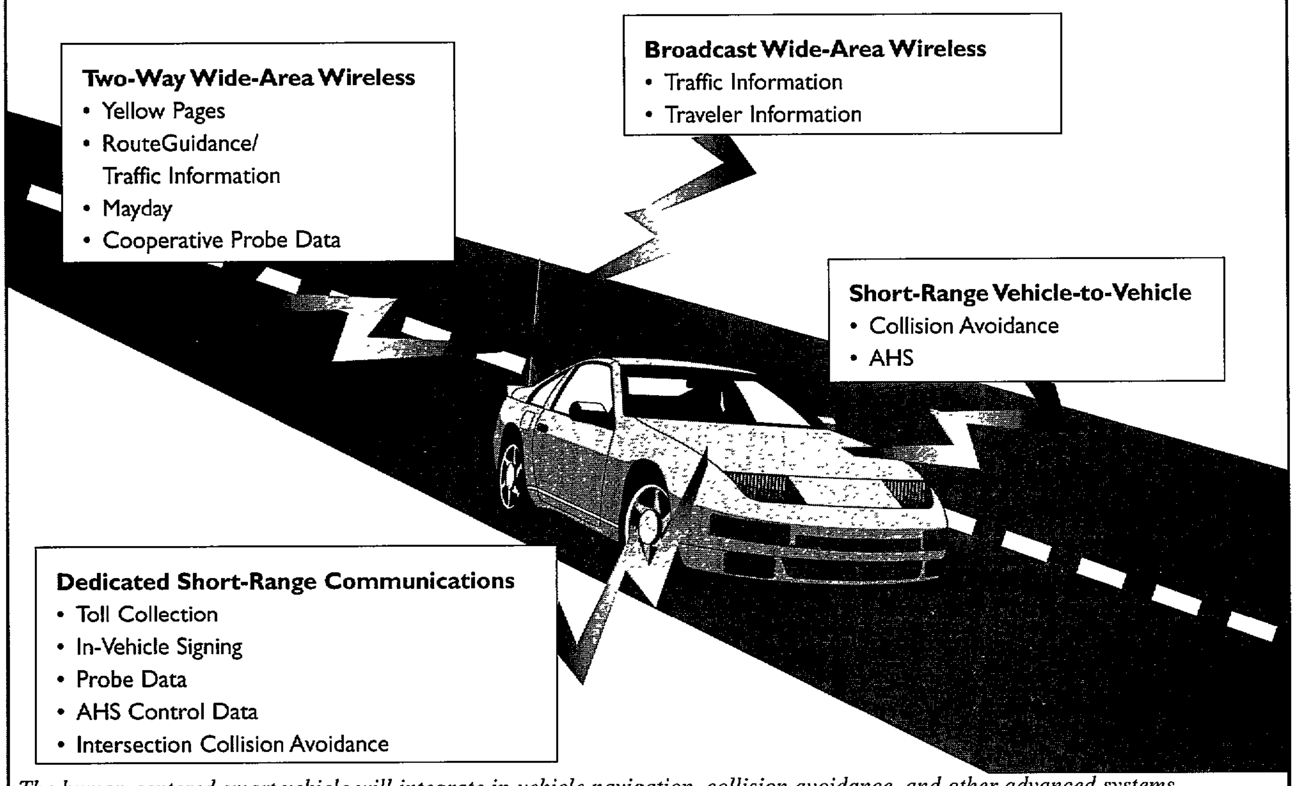
The long-range potential of ITS cannot be fulfilled without smart vehicles: automobiles, buses, and commercial fleets that can communicate with an intelligent transportation infrastructure to deliver information and options to drivers and passengers (see Exhibit IV-2). Research in this area must be done in collaboration with the industry that will eventually manufacture the technology. The risk of not investing in this research is threefold. First, the car of the future will largely be a "mobile computer," and the economic block (Europe, United States, or Japan) that develops the operating systems of this mobile computer will control the industry for a decade or longer. Second, without accelerated developmental research, current evidence suggests that smart vehicles will be very late (perhaps decades) in arriving on the market, if they ever do. This situation could result in an unnecessary loss of millions of lives and billions of dollars in accident-related costs. Third, individually developed systems without proper human-centered integration could actually degrade safety.

Many of the fruits borne by today's ITS deployments are being harvested from R&D initiated in the 1970's. Continued R&D is needed to provide the technological foundation for the solutions to tomorrow's problems.

Conclusion

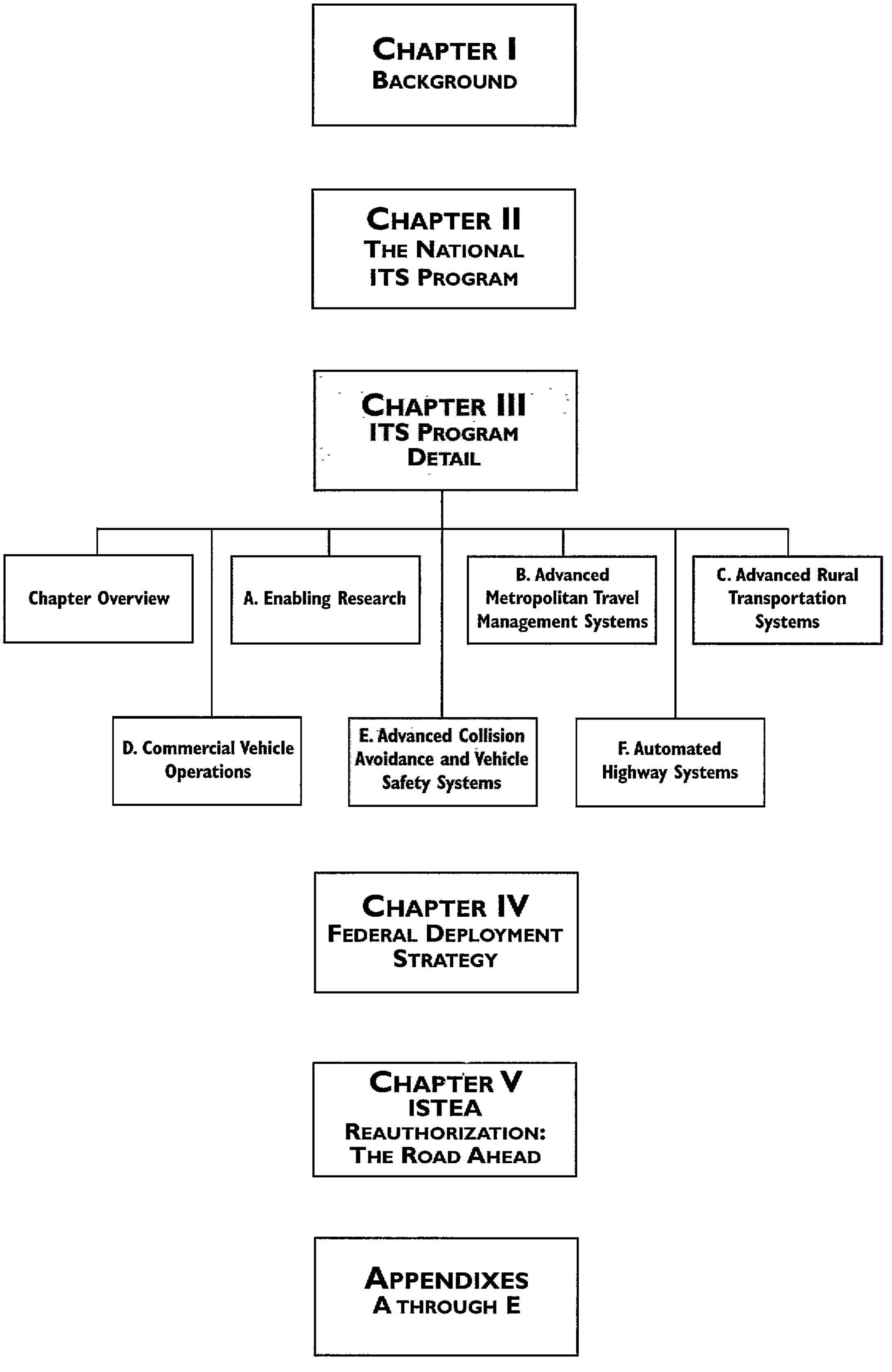
As it did in 1956, the Federal Government once more faces a remarkable opportunity to transform the Nation's transportation system. The U.S. DOT intends to lead, not mandate, the development of the ITS infrastructure-to facilitate deployment through incentives instead of imposing rigid spending requirements. U.S. DOT does not propose to work alone, but instead to encourage public sector agencies, with appropriate private sector support, to build this new infrastructure for the 21 st century. We envision an infrastructure that applies information technologies to meet local needs within a framework that establishes a national, interoperable system-a system that will open up business opportunities much as the Interstate highway did four decades ago.

EXHIBIT IV-2
THE SMART VEHICLE OF THE FUTURE



The human-centered smart vehicle will integrate in-vehicle navigation, collision avoidance, and other advanced systems.

As was also the case 40 years ago, we need a strategy of training and building professional capacity, developing standards, and providing incentives for States to cooperate in achieving a national vision. Working with its traditional partners and others, the U.S. DOT will move toward its goal of integrated and interoperable ITS to improve the safety, efficiency, mobility, and quality of life for Americans.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V. ISTEA REAUTHORIZATION: THE ROAD AHEAD

The national ITS Program stems from a strategic vision of how modern information, communication, and electronic technologies can enhance the safety and efficiency of surface transportation systems and the quality of life of the American public.

Working with a cross section of representatives from diverse fields, including transportation, electronics, and communications, the U.S. DOT has initiated and conducted the first phase of a national program to create an innovative, more capable, and cost-effective generation of surface transportation systems. But the transformation of ITS into a mainstream element of surface transportation planning and infrastructure investment has only begun. ISTEA launched a national ITS program that has amassed a formidable record of achievement. Its reauthorization, represented by the National Economic Crossroads Transportation Efficiency Act (NEXTEA), will present the opportunity to realize the benefits of that initial research and extend its horizon.

ISTEA launched a national ITS program that has amassed a formidable record of achievement. . . . NEXTEA will present the opportunity to realize the benefits of that initial research and extend its horizon.

This section presents the outline of a reauthorization agenda that emerged from numerous focus groups and listening sessions across the Nation. Three requirements for the reauthorization crystallized in those discussions: research and technology transfer, incentives to accelerate ITS deployment, and mainstream provisions for deployment.

ITS Reauthorization Agenda

Reauthorization presents an opportunity to focus the ITS Program on essential next steps. Although the U.S. DOT envisions a reduced Federal role, virtually all constituents agree that it must still provide critical research and technical assistance to State and local agencies, particularly in ITS implementation. A principal goal of the next phase of the ITS Program is to launch the deployment of integrated ITS infrastructure, develop the standards and the professional capacity to sustain it, and extend our research horizons, particularly in the integrated safety and information features of the intelligent vehicle.

Research and Technology Transfer

Continued funding is required to maintain the momentum of the ITS Program's near- and long-term research and technology agenda. As provided by the initial authorization, the U.S. DOT would continue to pursue high-priority initiatives, such as collision avoidance systems and advanced rural transportation concepts, as well as the next generation of advanced travel management and CVO systems. The research agenda would also support development of standards and the execution of the 5-year program for building professional capacity, as well as field operational tests and evaluations.

Specific program priorities would target the following:

- Human-centered smart vehicles that offer significant safety improvements and can communicate with an intelligent transportation infrastructure.
- Next-generation system capabilities for managing traffic and transit operations, including improved traffic management centers to enhance human effectiveness and productivity through sophisticated automation.
- Crash avoidance technologies for heavy vehicles.
- Development of an advanced driving simulator to support government and industry research into crash avoidance technology.
- ITS applications to make rail-highway grade crossings safer.

Exploratory research into potential rural applications of ITS, including road hazard and weather advisory, Mayday, and emergency response systems.

Funding of an AHS program plan through the year 2004, in fulfillment of the Federal pledge as a member of the National Automated Highway System Consortium.

INCENTIVES TO ACCELERATE ITS DEPLOYMENT

Two options have emerged for accelerating the deployment of ITS infrastructure. One option would provide small incentive awards to metropolitan areas, primarily to support the cost of system integration, after institutional willingness to adopt and finance an integrated system had been demonstrated. A second option would create a more traditional program that directly apportions funds to State and local agencies for ITS deployment. These funds would support both hardware procurement and system integration. Funding eligibility under either option would be contingent on conformance with the national ITS architecture and adherence to existing standards and protocols.

MAINSTREAM DEPLOYMENT PROVISIONS

Existing Federal highway, transit, and motor carrier investment program policies and regulations have been refined over many decades, but without improved system management or ITS in mind. The successor to ISTEA must explicitly state the eligibility of ITS deployment for mainstream Federal surface transportation funding. It should also pave the way for expansion of the capital planning process to include planning for ITS operations and maintenance.

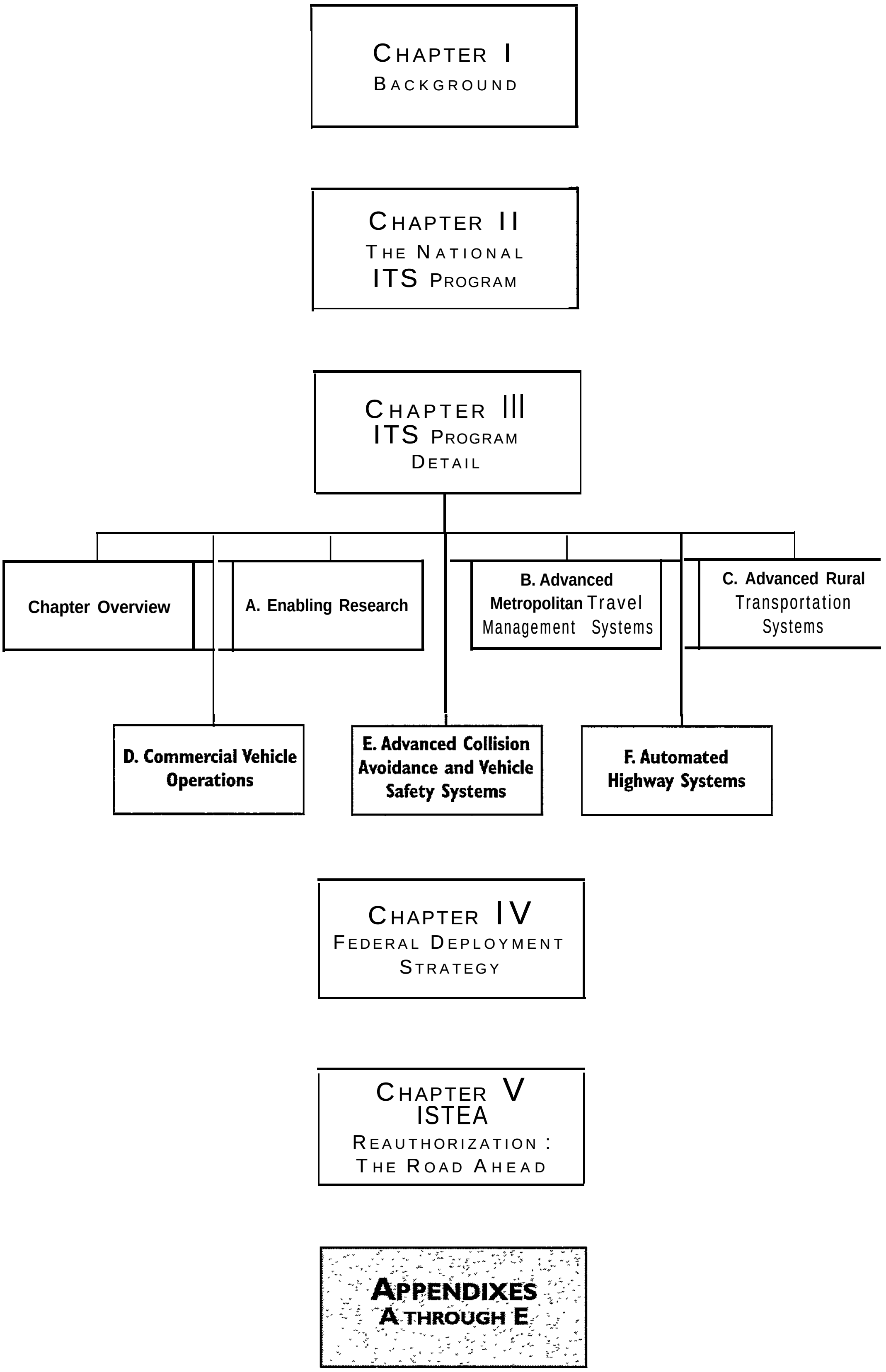
NEXTEA should also reconcile disparities between the highway and transit programs regarding the eligibility of ITS operating costs. For example, the National Highway System Designation Act allowed most highway funds to be used for ITS operations, yet corresponding provisions are lacking in the transit programs.

In addition, design/build contracting, life-cycle cost evaluation, and negotiated bid awards are often better suited to ITS deployment than the traditional low-bid approach used for road construction and transit vehicle acquisition. The next surface transportation authorization must sanction innovative procurement and financing approaches, including public-private partnerships.

CONCLUSION

A historic opportunity is at hand for Congress to dramatically improve the future of surface transportation. Tied to this opportunity is the prospect of improving the Nation's safety, productivity, and quality of life at a fraction of the cost of implementing antiquated solutions to national transportation challenges.

The ITS Program is at an important crossroads. Although the full potential of ITS has yet to be realized, enough has been learned in the past 5 years to verify the wisdom of forging ahead and nurturing the national ITS Program to full-ill ISTEA's promise of a safer, more efficient, and less costly intermodal transportation system.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