A REPORT TO CONGRESS

Surface Transportation Research and Development Plan

Third Edition

March 1996

A Report of the Secretary of Transportation
Pursuant to the
Intermodal Surface Transportation Efficiency Act of 1991
Section 6009(b), P.L. 102-240

A Report to Congress

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Third Edition

March 1996

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Surface Transportation Research and Development Plan

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EXECUTIVE SUMMARY

Surface Transportation Research and Development Plan

Third Edition

Introduction

Section 6009(b) of the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) requires that the Department of Transportation (DOT) develop an integrated National surface transportation research and development (R&D) plan that focuses on the research needed over the next decade. The congressionally mandated objectives of the plan are: 1) develop a range of technologies needed to produce convenient, safe, and affordable modes of surface transportation to be available for public use beginning in the mid-1990's; and 2) maintain a long-term advanced R&D program in order to provide for the next generation of surface transportation systems.

In January 1994, Secretary Federico Peña presented the Department of Transportation's *Strategic Plan*, establishing the following mission for the Department:

> *The Department of Transportation will "Tie America Together" with a safe, technologically advanced, and efficient transportation system that promotes economic growth and international competitiveness now and in the future, and contributes to a healthy and secure environment for us and our children.*

The Department's *Strategic Plan*, anticipating an era of "severe limitation on available resources", refocuses attention on DOT's core responsibilities and establishes seven strategic goals for implementation of the Department's mission. These goals emphasize strategic investment and prioritization of Departmental functions and projects, and stress the development and utilization of advanced transportation technologies as a means to address the challenges to and demands on the transportation system.

The third edition of the *Surface Transportation Research and Development Plan* presents the Department's strategic plan for maximizing the effectiveness of DOT R&D activities over the next ten years toward attainment of these goals.

In the near term, which for the purposes of this plan covers fiscal years 1996-1998, the Department's R&D agenda is shaped through a cabinet-level process for coordination of science, space, and technology policies throughout the Federal Government. In November 1993, President Clinton established the National Science and Technology Council (NSTC) as a cabinet-level council providing the principal means for the Administration to coordinate the Federal science, space, and technology enterprise. NSTC established nine interagency coordinating committees in areas of significant Federal R&D investment. The Committee on

Transportation R&D has established overall R&D objectives in six key areas, providing a structure for the Department's near-term activities:

- Aviation and Aeronautics
- Physical Infrastructure for Transportation
- Information Infrastructure for Transportation
- Next-Generation Transportation Vehicles
- Human-Centered Transportation
- Transportation System Assessment Tools and Knowledge

This plan focuses on the surface transportation research underway or planned within the six DOT operating administrations most directly responsible for surface transportation:

- Federal Highway Administration (FHWA)
- National Highway Traffic Safety Administration (NHTSA)
- Federal Transit Administration (FTA)
- Federal Railroad Administration (FRA)
- Research and Special Programs Administration (RSPA)
- Maritime Administration (MARAD).

Research under the purview of these organizations is covered by this document. In addition, departmental research conducted by the Office of the Secretary of Transportation (OST), the Federal Aviation Administration (FAA), and U.S. Coast Guard (USCG) is addressed when it correlates specifically to research being conducted on surface transportation issues. The plan also addresses planned activities of the Bureau of Transportation Statistics (BTS), which have direct relationships to surface transportation R&D.

Organization of the Plan

In order to emphasize the strategic long-term direction for the Department's research and development, the third edition of the Surface Transportation Research and Development Plan is structured as follows:

Section I introduces the plan, emphasizing its importance to the Department, summarizing the authority under which it is prepared, and summarizing its objectives and scope.

Section II presents the Department's strategic plan for surface transportation research and development over the next ten years, and contains four chapters (summarized in below).

Section III presents details of the Department's plans for its R&D programs over the next three years, and contains eight chapters (summarized below).

Section IV provides recommendations on options to consider to assure that Federal, State, and local contracting procedures encourage the adoption of advanced technologies developed through Federal R&D investment.

Summary of Plan Contents (Sections II-IV)

Section II, Chapter 1: Strategic Vision and Direction

As is discussed above, Secretary Peña has articulated a central mission for the Department of Transportation in the Department's *Strategic Plan*, which was issued January 1994. The Plan identifies resource scarcity as a key challenge facing the Department and the Nation, and refocuses the Department's efforts on its key responsibilities as the Federal steward of the Nation's transportation system. To implement the mission of the Department, the Secretary has identified seven strategic goals:

> *Goal 1. "Tie America Together" through an effective intermodal transportation system.*
>
> *Goal 2. Invest strategically in transportation infrastructure, which will increase productivity, stimulate the economy, and create jobs.*
>
> *Goal 3. Create a new alliance between the Nation's transportation and technology industries to make them both more efficient and internationally competitive.*
>
> *Goal 4. Promote safe and secure transportation.*
>
> *Goal 5. Actively enhance our environment through wise transportation decisions.*
>
> *Goal 6. Put people first in our transportation system by making it relevant and accessible to users.*
>
> *Goal 7. Transform DOT by empowering employees in a new team effort to achieve our goals.*

The third edition of the *Surface Transportation Research and Development Plan* aligns the Department's long-term R&D priorities with these strategic goals. The major long-term R&D thrusts identified in the Plan are built upon the foundation of the Department's near-term planned R&D programs. These programs have been shaped through internal DOT mechanisms like the Research and Technology Coordinating Council and also through the interagency National Science and Technology Council (NSTC).

In preparing this edition of the Plan, the Department has supplemented its ongoing outreach activities on overall research program design with solicitation of input specifically on the

R&D plan. The Research and Special Programs Administration (RSPA), which is responsible for developing the Plan, consulted with, and invited comment from, University Transportation Center (UTC) program contacts, and from a number of chairs of Transportation Research Board (TRB) committees.

Section II, Chapter 2: Transportation in the Next Two Decades

The Nation's surface transportation system will continue to evolve over the next two decades within the context driven by several important trends and issues. For example: The global economy is becoming increasingly competitive, placing increasing pressures on individuals and businesses, which in turn increases the importance of maximizing transportation efficiency while minimizing costs. The proportion of elderly persons in the U.S. population is increasing, and it will continue to do so over the next two decades, making it important that means of providing continued access and mobility for this group be identified. At the same time, internal migration of the resident population continues to cause increasingly dispersed travel patterns and even greater reliance on the automobile. Although increasing reliance on telecommunications technology may lead to some travel substitution, it has been argued that travel demand could actually be stimulated by such technology. At any rate, congestion is likely to persist in most areas of the country as they experience growth, and physical expansion of infrastructure will face serious obstacles. This increases the need to deploy an intelligent transportation infrastructure as a means to maximize the efficiency and safety of the existing system.

In reviewing these and other trends and issues, the Department has identified several key challenges and opportunities for surface transportation:

- Widespread Congestion and Limits of Transportation Capacity
- Pervasive Constraints Associated with Environmental and Societal Impacts, and Physical, Financial, and Human Resources
- Change as an Inherent Part of Economic Life
- Broad and Powerful Technological Capabilities
- A High Degree of Interdependence and Diffusion of Power among Economic and Social Institutions

It will be an increasingly challenging task to provide the transportation system capacity at acceptable service levels required to meet the Nation's needs in the future. The active pursuit and deployment of new technologies and operating practices must be supported if real progress is to be made. In order to fulfill its fundamental missions of investing in infrastructure, ensuring public safety, and maintaining National security, the Department intends to promote progress in a cooperative manner, to provide decision-making tools where

they are not yet available, and to establish standards where they are needed to ensure efficient implementation and consistency with accepted National goals and priorities.

Section II, Chapter 3: Research and Development to Meet Transportation Challenges

Innovation in transportation calls for a balanced and integrated approach that links parallel streams of research, development, test and demonstration, and implementation. This entire process must be based on a clear understanding of specific transportation objectives and institutional, regulatory and economic constraints. The translation of a tested and proven advance into revenue service or operational improvements often necessitates a major investment in providing users with sufficiently convincing evidence of its performance and probably benefits and with the knowledge needed to apply the innovation effectively.

The Department sponsors a range of research and development activity to support fulfillment of its core responsibilities, which are as follows:

- Establishing standards for safety and other key aspects of the transportation system, facilitating deployment of safe and effective transportation equipment and systems.

- Distributing funds to state agencies, transportation providers and other related institutions to plan, construct, and operate the transportation system.

- Interacting with other Federal agencies to carry out broader Federal mandates such as the Clean Air Act and National security policies.

- Providing law enforcement and traffic management systems for the Nation's airspace and waterways.

R&D is critical to the Department's ability to meet the multiple, and sometimes conflicting demands the Nation places on its transportation system, particularly in an era of scarce resources. As the National steward of the transportation system, the Department has a unique responsibility to work in partnerships with state agencies, transportation providers, and other related institutions to ensure that the Nation fully capitalizes on technological, operational, and institutional innovations.

Section II, Chapter 4: Strategic Long-Term Direction

Based on a consideration of the trends, issues, challenges, and opportunities discussed in chapters 2 and 3, the Department has identified sixteen major long-term DOT R&D thrusts essential for the fulfillment of the Department's central mission and strategic goals, as they are established in the Department's *Strategic Plan*. The basic goals of each of these thrusts, which fit within the indicated general groupings, are as follows:

Promotion of an integrated National transportation system that makes the most effective use of all modes

- Transportation System Assessment and Knowledge Base: Establish a comprehensive, intermodal, and multimodal transportation system assessment capability and knowledge base, including appropriate system-level performance measures, analytical tools, models and simulations.

- Intermodal Freight Transportation: Develop knowledge and understanding to foster and stimulate effective application of improved technologies and operational techniques at modal connections, and to resolve institutional impediments to improvements at intermodal terminals.

- Revitalization of the U.S. International Freight Transport Industry: Accelerate the identification, assessment and deployment of improved technologies and operations into global freight systems, especially their maritime transport elements.

Wise and efficient investment in the Nation's surface transportation system

- Improved Materials, Designs and Methods for Renewal Engineering: Stimulate and facilitate the effective use of innovative as well as improved conventional construction designs, structures, materials and methods in the rehabilitation, renewal and replacement of the Nation's highway system, and other components of the transportation system at large.

- Advanced Technologies for Inspection, Monitoring and Maintenance of Vehicles and Infrastructure: Stimulate and facilitate the effective use of advanced and automated inspection, sensing and testing technologies for monitoring and inspecting the Nation's transportation system.

Rapid and effective application of technological advances to transportation functions

- Application of Information Technologies to Transportation System Operations: Stimulate and facilitate the application of advanced information, management and control technologies and systems to operation of transportation systems, especially their surface elements, and dissemination of trip-related information to travelers and vehicle operators.

- Advanced Technology for Intermodal Public Transit Systems: R&D directed toward effective application of available technologies to transit vehicles and physical infrastructure can be focused on the following goals: improvement of the quality and effectiveness of transit vehicles and infrastructure; improvement of transit service and operations; stimulation of technology

development within the U.S. transit industry; expansion of domestic and world-wide markets for transit-related equipment; enhancement of the urban environment through improved mobility, reduction of traffic congestion and reduced transit vehicle emissions.

- Technical Foundation for High Speed Ground Transport Systems: Establish a technological foundation, including safety standards, sufficient to enable implementation of improved, higher-speed passenger ground transportation service by public and private bodies.

Prudent measures to enhance transportation safety and security

- Accident Avoidance: Reduce the occurrence of accidents in all modes of surface transportation through the development of an enhanced understanding of human performance and behavior, and through the application of human-centered technological aids and systems in design, construction and operation of transportation system elements.

- Accident Survivability: Reduce the occurrence of death and injury in accidents in all modes of surface transportation through enhanced understanding of the biomechanics of the human body and improved design and construction of vehicles and infrastructure.

- Safety Data and Analysis: Provide a strong statistical and analytical foundation of knowledge concerning surface transportation accidents and incidents in order to support safety advances by all elements of the transportation community.

- Security in Surface Transportation: Identify technological and operational means of enhancing the security of public surface transportation systems and facilities against crime and malicious attacks.

Harmonization of transportation policies and investments with environmental concerns

- Environmental Impact Data, Models and Knowledge Base: Further develop data, validated models and a comprehensive knowledge base to support analysis of transportation-related environmental impacts and alternative strategies by all levels of government and the private sector.

- Environmental Engineering and Technologies: Identify, develop, demonstrate, and foster the use of improved tools, technologies and methods to avoid and mitigate adverse environmental impacts of transportation.

Incorporation of the concerns and needs of the traveling public and the entire society into transportation policies and investments

- Accessibility for Persons with Personal Mobility Limitations: Assess and demonstrate technologies and concepts that enhance the accessibility of public transportation to the physically disabled, the elderly, and those with temporary disablements (e.g., broken limbs).

- Intermodal Transit System Innovation: Assess and demonstrate technologies and concepts that enhance the availability of public transportation systems to everyone.

Section III, Chapter 1: Relationship Between Future Plans and Current Activities

There are prominent relationships between the Department's near-term R&D activities and the long-term initiatives its has presented in Section II. In most cases, near-term activities form the technical foundation upon which a major long-term thrust will stand. To make these linkages more explicit, this chapter presents a formal map between the long-term thrusts and the Department's ongoing and/or planned near-term research activities.

Section III, Chapter 2: Physical Infrastructure

Infrastructure and materials research are a priority of DOT's *Strategic Plan* and this is reflected in the structure of the Department's R&D program. The Physical Infrastructure Subcommittee of the NSTC Transportation Committee has identified a number of crossmodal and generic R&D priorities, which include: nondestructive testing, high-performance materials, automation and robotics for renewal engineering, emergency response technologies, intermodal hazards reduction, and tools for maintenance and prioritization management.

The Department's near-term R&D priorities for surface transportation physical infrastructure include technologies and procedures associated with: operational efficiency, durability, performance, safety, environmental impacts, renewal and maintenance, real-time nondestructive inspection and monitoring of infrastructure condition and performance; improved design and construction concepts and practices, processes, structures, materials, resource use, and disposal of construction process wastes, recycling and reuse of byproduct and waste materials, as well as design and construction principles and technologies specifically relevant to intermodal connection points.

Section III, Chapter 3: Information Infrastructure

Parallel advances in such fields as electronics, communications, and information processing offer a unique opportunity to make profound improvements in the safety and economic efficiency of the Nation's surface transportation system. The Intelligent Transportation

System (ITS) program seeks to apply these technologies in a manner that will enable the public to use the Nation's surface transportation infrastructure in a manner that will help achieve multiple goals simultaneously, including: improved safety, increased efficiency of transportation operations, reduced environmental and energy impacts of transportation activities, enhanced economic productivity, and enhanced mobility for transportation users.

Emphasis in the area of surface transportation information infrastructure R&D is on a fully integrated, network-wide approach to traffic control; finalization of performance specifications for a wide range of collision warning and avoidance systems; successful demonstration of the feasibility of an automated highway system; development of an *ITS Deployment User's Guide*; development of a National strategy for deploying hazardous materials incident response capabilities; research into the performance of antilock braking systems of light vehicles; assessment of advanced information systems designed to improve vessel safety and efficiency; development of system standards for fixed traveler information message signs; testing of next generation kiosk and smart card concepts; and evaluation of advanced fleet management systems for transit.

The primary emphasis of the ITS program activities will expand to include deployment facilitation, especially as individual systems and components leave the laboratory and prove themselves in prototype and operational testing. This expectation is underscored by the Secretary's announcement in January 1996 of the *Operation Timesaver* initiative, through which seventy-five of the Nation's largest metropolitan areas are to be outfitted with key elements of the *Intelligent Transportation Infrastructure* (ITI), providing a concrete milestone on the pathway toward the Secretary's broader goal of a nationwide deployment of the technologies that comprise the ITI.

Section III, Chapter 4: Next-Generation Vehicles and Fuels

The manufacture, sale, and maintenance of transportation vehicles is one of the largest single segments of the U.S. economy, and aircraft exports help to improve the balance of trade for the Nation. At the same time, the transportation function is increasingly being expected to help meet important energy and environmental goals for our society. In response to these concerns, the Federal Government and DOT are increasingly becoming engaged in programs designed to apply state-of-the-art technological advances to transportation in order to meet combined safety, economic, energy, and environmental goals simultaneously. It can be anticipated that concern with the environmental and energy-related by-products of the transportation process, as well as continued economic competitiveness with other industrial and industrializing nations, will continue to exert significant influence on the search for technological improvements to transportation vehicles in all the modes.

The Department's R&D priorities for vehicles and fuels include the review of ITS technologies to identify near-term applications for improving motor carrier safety and productivity; evaluating the characteristics of reported crashes by different motor carrier operations, vehicle types, crash locations, etc.; evaluating production vehicles and developing

countermeasures for improved frontal crash protection; completing a final prototype of a crash dummy with innovative lower extremities; development of braking stability performance test procedures for trailers; development of advanced computer models to evaluate the crashworthiness of conceptual next-generation vehicle designs; publication of findings on improved rail roller bearing inspection; evaluation of safety of car tilt and brake systems for 150 mph rail travel; demonstration of communications-based train control in high-density freight and passenger corridors; completion of research on hull monitoring systems; continued implementation of the President's shipbuilding initiative; investigation of ship structural problems and pursuit of new technology and techniques for structural design, analysis, and fabrication; continued development of the Advanced Technology Transit Bus (ATTB); and the development of full-size fuel cells for passenger buses.

Section III, Chapter 5: Human-Centered Transportation Systems

Acting as operators, crew members, or passengers, people are essential components of all transportation systems. Their capabilities, decisions, and performance significantly affect the transportation system's overall safety and efficiency. Likewise, there is no doubt that reducing or mitigating human errors could improve safety: the majority of transportation accidents involve some form of human error. By contributing to safety and productivity, R&D in the area of human-centered technology supports National goals for economic growth, competitiveness, and job creation. Because human performance R&D often lacks private support, Federal investment and leadership is required. The objective of Federal efforts supporting the development of human-centered transportation systems is to ensure that needed data and methods are available to U.S. industries that design and produce advanced transportation technologies.

R&D priorities in the area of human-centered transportation include completion of an initial assessment of fatigue and loss of alertness associated with specific types of commercial motor vehicle (CMV) operations; determination of the crash risk for various blood-alcohol levels; focusing of the state and Federal maritime academies on human factors issues and accomplishing human factors research of direct utility to the marine industry; accommodating industry test and evaluation of the safe and practical use by local ship pilots of portable ship navigation technologies; and updating drug and alcohol implementation guidelines.

Section III, Chapter 6: Intermodal Systems Assessment, Design, Planning, Management, and Operations

System assessment has many aspects. The most basic requirement is to understand the range of elements that are a part of the transportation system and their relationships to each other. This process will then make it possible to determine which performance measures are needed to monitor the transportation system in operation, to evaluate the consequences of changes to the system, and to compare modes and geographic areas. The selection of performance measures in turn determines the specific types of data that need to be collected. This data is sometimes available directly as a result of various transactions, but often must be acquired

from survey, monitoring or measurement activities. Finally, an effective repertoire of tools, primarily models and simulations, is needed to add meaning to the raw numbers and enable useful analyses of the transportation system and its consequences to be conducted. Near-term emphasis in the area of system assessment includes policy and planning research, development of driving simulation capability in the U.S., data collection and analysis, and technology transfer. Such activities are also extensively supported by data collection and dissemination by the Bureau of Transportation Statistics (BTS).

Near-term R&D priorities in this area include evaluation of the State Infrastructure Bank pilot program; analysis of financing, energy, and environmental issues likely to arise in reauthorization legislation; achievement of intermediate operating capability of TRANSIMS (Transportation Analysis and Simulation System); beginning construction of a National Advanced Driving Simulator (NADS); completion of a nationwide five-year cooperative fatal accident reporting agreement; collection and coding of National Accident Sampling System (NASS) data; identification of injury mechanisms and associated outcomes in motor vehicle crashes; obtaining and disseminating state-level safety databases; analysis and publication of results from the FY 1997 National Occupant Protection Use Survey; analysis of potential sealift planning strategies for different mobilization scenarios; creation of an electronic file of all special crash investigations; expansion of the transit-related curriculum on a variety of subjects related to finance, planning, management, technology, etc.; provision of training and technical assistance to rural transit operators in each state; conducting "Bridges to Work" demonstrations helping disadvantaged unemployed inner-city residents to join and remain in the workforce; development of technical assistance capabilities to enhance mobility for disabled and low-income passengers in rural areas; estimation of transit's condition, performance, and short- and long-term investment needs; demonstration of best-practice in innovative transit finance and turnkey construction; development of a comprehensive resource document on transportation applications of advanced materials; comparison of resources dedicated to each mode versus fatalities; and analysis of impacts of removing legal barriers to truck and bus operations between Mexico and the U.S..

Section III, Chapter 7: *DOT Investment in University Research, Education, and Cooperative Initiatives*

Since World War II, universities and collaborative research partnerships have been the intellectual centerpiece of Federal policy for research, education, and innovation in all policy areas. Federal research and development grants and contracts have been integral to new discoveries, education of new researchers and the training of operators so to provide a steady stream of ideas to improve the Nation's security, health, and industry. DOT invests strategically in and partners with state and local governments, transit properties, universities, and research and training institutions to ensure that the transportation system maintains an adequate knowledge base and a pool of transportation professionals to operate and manage a safe, competitive, and sustainable transportation system. DOT relies particularly on universities because of their unique resources, capacity and qualifications in the area of

knowledge-building, education and technology transfer, and their ability to bridge all sectors of the transportation enterprise.

The Department's near-term priorities in this area include evaluating proposals and selecting programs for the University Transportation Centers (UTC) program; funding promising research efforts through the University Research Institutes (URI) program; through AASHTO (the American Association of State Highway and Transportation Officials), solicit and administer research on behalf of the various State departments of transportation under the National Cooperative Highway Research Program (NCHRP); through the Transit Cooperative Research Program (TCRP), continue support for special long-range projects and programs; award Dwight David Eisenhower Transportation Fellowships to students and faculty at institutions across the U.S.; completing state research on quality assurance in highway design, construction, and maintenance; and seeking proposals for the Department FY 1997 Small Business Innovation Research (SBIR) program.

Section III, Chapter 8: DOT R&D Facilities and Administrative Support for R&D

In order to carry out its responsibilities for the management of DOT-funded R&D, and the actual implementation of a number of key activities, the Department devotes a portion of its funding and personnel to administration of these resources. In addition, the Department operates a number of physical facilities that support DOT R&D activities, and these will require some upgrading and refurbishment in the near term.

Section IV: Contracting Procedures

DOT experience confirms the premise that Government contracting practices can have a substantial impact on the adoption of advanced technologies. To develop a better understanding of these impacts, the Department is conducting a number of studies and experimental programs addressing important aspects of Government contracting. Because of the additional authorities granted to state and local agencies by ISTEA, the number of grantees and subgrantees can be expected to increase during the coming years. This plan provides an overview of current contracting practices, summaries of recent changes in legislation and regulations, and brief descriptions of relevant studies and task force efforts that are currently in progress or have been completed since the last edition of the plan.

SECTION I: INTRODUCTION

Surface Transportation Research and Development Plan

Third Edition

Secretary Federico Peña presented the Department of Transportation's *Strategic Plan* in January of 1994, articulating the following mission for the Department:

> *The Department of Transportation will "Tie America Together" with a safe, technologically advanced, and efficient transportation system that promotes economic growth and international competitiveness now and in the future, and contributes to a healthy and secure environment for us and our children.*

In doing so, the Secretary underscored the challenges facing the Department: "In an era of severe limitation on available resources, and an era of National deficit reduction, there are not enough transportation dollars to meet all of these needs. We are compelled by the public trust to ensure that our National transportation infrastructure does not deteriorate; that our investments improve the condition of our environment; and that our decisions drive forward our National economy, and are a catalyst for improving the safety and quality of life for our citizens. Strategic utilization of our resources is critical to carrying out this public trust."

The Department's *Strategic Plan* also establishes seven strategic goals for implementation of this mission. These goals emphasize strategic investment and prioritization of departmental functions and projects. They also stress the development and utilization of advanced transportation technologies as a means to address the challenges identified above while pursuing the overall mission of the Department.

With respect to surface transportation, the challenge of resource scarcity is at least as great for R&D efforts as it is for overall departmental activities. The fraction of overall surface transportation sector expenditures devoted to R&D activities has historically been significantly lower than for most domestic industries, even those that could be characterized as low-technology. Moreover, legislative earmarking has played a significant role in establishing Federal R&D priorities. It is therefore imperative that, while operating within such constraints, the Department strategically prioritize its R&D activities in a way that achieves the greatest long-term progress toward the Department's mission, and that it maximizes coordination of these activities both within and outside the Department in order to make the most efficient use possible of Federal resources.

In this edition of the *Surface Transportation Research and Development Plan*, the Department establishes sixteen key strategic 10-year thrusts that were arrived at through the Department's careful consideration of the most important long-term trends and issues affecting the evolution of the U.S. transportation system, and the Department's mission and goals. These

thrusts represent a set of cohesive priorities for R&D throughout the surface transportation system, and reflect the Department's current and future emphasis on integration and coordination of governmental activities. Indeed, the Department's near-term R&D activities, which are presented in the plan for the next three years, are strongly coupled to the longer-term thrusts and the underlying societal goals, and are prioritized in a coordinated fashion within DOT.

Authority

This is the third in a series of congressionally required plans submitted by the Secretary of Transportation to the Congress pursuant to Section 6009(b) of the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA). The second edition of the plan was submitted in March 1995.

Plan Objectives and Congressional Mandate

ISTEA requires that an integrated National surface transportation research and development (R&D) plan be developed that focuses on surface transportation systems needed for the next decade. The congressionally mandated objectives of the plan are: 1) to develop a range of technologies needed to produce convenient, safe, and affordable modes of surface transportation to be available for public use beginning in the mid-1990's; and 2) to maintain a long-term advanced research and development program in order to provide for the next generation of surface transportation systems. In addition, ISTEA requires that the plan include the following:

> *"(A) Details of the Department's surface transportation research and development programs, including appropriate funding levels and a schedule with milestones, preliminary cost estimates, appropriate work scopes, personnel requirements, and estimated costs and goals for the next three years for each area of research and development.*
>
> *(B) A ten-year projection of long-term programs in surface transportation research and development and recommendations of the Research and Development Coordinating Council of the Department of Transportation and the plan of the National Council on Surface Transportation Research.*
>
> *(C) Recommendations on changes needed to assure that Federal, State, and local contracting procedures encourage the adoption of advanced technologies developed as a consequence of the research programs in this Act* [ISTEA]."

Scope

Surface transportation R&D, broadly defined, is conducted by a number of Federal organizations (e.g., DOT, EPA, DOE), by State and local government agencies, by academic institutions, and by the private sector. Within that context, this plan focuses on the surface transportation research underway or planned within the six DOT administrations with direct responsibility for surface transportation:

- Federal Highway Administration (FHWA)
- National Highway Traffic Safety Administration (NHTSA)
- Federal Railroad Administration (FRA)
- Maritime Administration (MARAD)
- Federal Transit Administration (FTA)
- Research and Special Programs Administration (RSPA).

Other departmental research, including that conducted by the Federal Aviation Administration's (FAA), the U.S. Coast Guard (USCG), and the Office of the Secretary of Transportation (OST) is addressed when it correlates specifically to research being conducted on surface transportation issues. In particular, FAA's Aviation Human Factors Program, discussed briefly in Section III, is specifically related to the human factors programs being conducted in FRA, NHTSA, FHWA, FTA, MARAD, and USCG. Other FAA research and technology programs are also related. The Aviation Security program remains a top priority, and the Airport Pavements program continues efforts to improve airport pavement in order to accommodate the next generation of very large aircraft. These efforts are detailed in the FAA's 1995 Plan for Research, Engineering, and Development published in December 1994. The *Surface Transportation Research and Development Plan* also discusses activities of the Bureau of Transportation Statistics (BTS), as these have a very direct role in supporting the Department's system assessment efforts.

The near-term section of this plan focuses on research underway or planned in FY 1996, 1997, and 1998. In response to the directive in ISTEA, the plan provides details of the surface transportation R&D programs, including funding levels, milestones, and personnel requirements. The plan's long-term outlook offers insight into the course the Department's surface transportation research program will pursue into the 21st century. The plan's final chapter on contracting provides an overview of current contracting practices, summaries of recent changes in legislation and regulations, and brief descriptions of relevant contracting studies and task force efforts that are currently in progress or have been completed since the last edition of this plan.

Consistent with the Secretary's *Strategic Plan*, this edition of the R&D plan places greater emphasis on a strategic vision for long-term R&D activities. As in the two previous editions, the Department has relied extensively on its ongoing outreach activities in establishing R&D priorities. For this edition of the plan, comments specific to the plan have been obtained through a number of processes discussed in Section II. The Department has

supplemented its ongoing outreach efforts related to R&D prioritization through a 2-day symposium on long-term challenges and opportunities for transportation, a request for suggestions from University Transportation Center program contacts regarding the plan, and informal discussions about the plan held at the January 1996 TRB annual meeting.

Plan Organization

This plan is divided into the following sections related to surface transportation R&D:

- *Section II* establishes a strategic vision and direction for surface transportation, establishes a context for that vision by examining a number of key future trends and issues, presents an overview of the Department's process for establishing R&D priorities, and presents the Department's strategic plan for sixteen key long-term R&D thrusts related to surface transportation. The plan emphasizes long-term integration and coordination of departmental R&D efforts in implementing these core thrusts.

- *Section III* outlines the Department's near-term (FY 1996-1998) surface transportation research program in five major areas, discusses related university and cooperative research activities, and gives an overview of administrative and facility planning associated with these programs. Relationships between the Department's near-term R&D programs and the long-term thrusts identified in Section II are explored in the second chapter of Section III.

- *Section IV* discusses contracting procedures affecting the Department and its grantees.

Changes From the Last Edition

Several changes have been made from the last edition. These include the following:

Organization of the Plan: The second edition of the plan organized the Department's R&D activities in 12 chapters, each of which presented both the near-term perspective for each major research area and the long-term outlook. As noted above, this edition presents a long-term vision for surface transportation and a strategic plan for long-term R&D activities in one section, and an overview of near-term activities in a following section. The plan presents sixteen major long-term R&D thrusts, which are strongly keyed to directions established in the Department's *Strategic Plan*. The third section describes the Department's near-term R&D programs, and consists of eight chapters that rely heavily on the framework established by the Transportation Committee of the National Science and Technology Council (NSTC).

Transit Research: FTA's FY 1997 budget has been restructured. This edition of the plan discusses FTA's near-term R&D activities within the framework established by the NSTC Committee on Transportation R&D, rather than grouping these activities in one transit-specific chapter.

SECTION II

STRATEGIC PLAN FOR SURFACE TRANSPORTATION RESEARCH AND DEVELOPMENT

CHAPTER 1

STRATEGIC VISION AND DIRECTION

Introduction

Many complex issues and forces will shape the transportation needs of the Nation, and the constraints within which those needs must be satisfied, in coming decades. The DOT long-term surface transportation research and development program has been structured to respond effectively to needs within the broad mandates of national transportation and technology policies, as they bear on the explicit mission responsibilities and functions of the Department, as articulated in its *Strategic Plan*. In response, DOT has generated broad long-term R&D thrusts, guided by the Administration's technology policy and the vision of future transportation developed by the National Science and Technology Transportation (NSTC) and the Department's Research and Technology Coordinating Council.

That R&D program addresses the current and future condition and performance of the National transportation system, and the assessment of the principal societal demands and forces that will act on that system in the foreseeable future. The plan develops specific long-term programmatic thrusts through consideration of the level and nature of the Federal interest and responsibility in relevant areas, and the likelihood that specific objectives can be realized by exploiting new technologies or concepts.

This chapter focuses on the broad vision and goals for transportation established by the Administration, the Secretary of Transportation and the NSTC.

The President's Technology Policy

The Administration's technology policy, *Technology and Economic Growth: Producing Real Results for Real People*, which was signed November 8, 1995, states:

> *"...Government has an indispensable role to play in advancing new technology development -- by ensuring a strong base of fundamental science, by providing a business environment that encourages innovation and investment, and by investing in research that is critical to the economy and the social needs of the Nation, but that cannot attract adequate private support."*

The President continues to make technology policy a key element of his economic strategy. In turn, transportation is a significant factor in both the technology policy and the Administration's economic strategy. The President's technology policy states that "a competitive growing economy requires a transportation system that can move people, goods, and services quickly and efficiently. To meet this challenge, each transport sector must work

effectively both by itself and as part of a larger, connected whole. Technologies that increase the speed, reliability and cost-effectiveness of the transportation sector will also increase the economy's competitiveness and ability to create jobs."

The National Science and Technology Council

In response to a key recommendation of the National Performance Review, President Clinton, in November, 1993, established the National Science and Technology Council (NSTC) as a cabinet-level council providing the principal means for the President to coordinate the Federal science and technology enterprise. NSTC provides a cabinet-level process to coordinate science, space, and technology policies throughout the Federal Government. Interagency budget planning, essential in R&D due to the widespread need for cooperative efforts in many projects, was identified as a major NSTC function. This role is of particular importance in enhancing the efficiency of R&D activities in these times of fiscal constraint.

Through the NSTC, the White House focuses on ensuring that the Government's $75 billion annual R&D budget fully reflects critical National priorities in both basic and applied research. In order to prepare coordinated and balanced R&D strategies and budget guidance for accomplishing these goals, NSTC established nine interagency coordinating committees in areas of significant Federal R&D investment. One of these committees, established by the Secretary and co-chaired by the Deputy Secretary of Transportation and the NASA Associate Administrator for Aeronautics, addresses transportation R&D. An early task of that committee was the development of a vision for transportation in the next century.

Vision and Strategic Goals

The vision and goals driving transportation R&D must account for the central role of transportation in the Nation's quality of life, economic vigor, and long-term environmental sustainability, providing the personal mobility and movement of goods that are critical to the functioning of our society. This underlines the great potential for benefits from successful innovation in operations and technology, and the importance of transportation decisions at all levels being based on sound and comprehensive knowledge and understanding. Technological advances of recent decades have created the opportunity for significant improvements, just at the time political, economic, and social forces are generating demands for greater mobility at reduced environmental and resource costs. Effective exploitation of these opportunities to meet the growing needs requires a clear vision of the future we wish to create.

The vision developed by the NSTC Transportation R&D Committee is that of *a sustainable and seamless intermodal transportation system that effectively ties America together and links it to the world: a system based on strategic investment in infrastructure and a dynamic and*

fruitful alliance between the transportation and technology industries, and which provides efficient, safe and secure transportation fully satisfying the needs of individuals, businesses and the National economy while enhancing our environment and supporting world leadership in transportation technologies.[1]

The NSTC Transportation Committee identified the building blocks for achieving this vision as being knowledge of the system and its operations, a sound physical infrastructure for transportation, wise application of information technologies to infuse that physical infrastructure with intelligence, and a broad array of technological alternatives on which to draw in meeting specific transportation system needs. The path to realization of the vision requires Government and industry working together to achieve four broad objectives:

- Consistently wise and effective strategic and tactical decisions and policies based on comprehensive knowledge and assessment of system condition, performance and operations, and of impacts and implications of alternative choices and courses of action.

- The best possible performance of the Nation's transportation physical infrastructure, obtained through:

  Improved means of renewal, rehabilitation, expansion, operation, maintenance and management,

  Creation of an information infrastructure that overlays the physical infrastructure to revolutionize virtually all aspects of transportation operations and logistics.

- Major improvement in the overall performance characteristics of vehicles of all types, and expansion of the range of alternatives available for meeting transportation needs.

- Reestablishment and improvement of the position of the U.S. as a technological leader and primary exporter of transportation-related equipment and services.

Ongoing performance of private-sector and Federal R&D activities are fundamental to achievement of these goals. Some topics fall largely to the private sector; others may involve objectives or industries that virtually preclude large private research investments. Federal activity complements private sector R&D, and is neither intended to nor capable of supplanting it. Rather, there are explicit Federal functions which cannot be addressed effectively by the private sector. Necessary Federal R&D includes stimulating and supporting development of information, scientific and engineering knowledge; applying new and emerging technologies; creating innovative procedures, methods and practices; and

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[1]NSTC Committee on Transportation R&D, Strategic Planning Document, March 1995, p.2.

assuring rapid deployment of the most effective technological responses to our transportation needs.

The Department of Transportation's Strategic Plan

In January 1994, DOT Secretary Frederico Peña presented the Department's *Strategic Plan*, which articulates DOT's mission, identifies the major challenges facing America's transportation system, and establishes seven key goals for the Department as it faces those challenges in fulfilling that mission:

> *Goal 1. "Tie America Together" through an effective intermodal transportation system.*
>
> *Goal 2. Invest strategically in transportation infrastructure, which will increase productivity, stimulate the economy, and create jobs.*
>
> *Goal 3. Create a new alliance between the Nation's transportation and technology industries to make them both more efficient and internationally competitive.*
>
> *Goal 4. Promote safe and secure transportation.*
>
> *Goal 5. Actively enhance our environment through wise transportation decisions.*
>
> *Goal 6. Put people first in our transportation system by making it relevant and accessible to users.*
>
> *Goal 7. Transform DOT by empowering employees in a new team effort to achieve our goals.*

As is discussed in Chapters 3 and 4 of this section, the Department's *Strategic Plan* provides the overall framework and objectives for research and develop activities addressed in this edition of the *Surface Transportation Research and Development Plan*.

Outreach to the Transportation Enterprise

The Department gathers input from a variety of constituents to help establish its R&D priorities through a wide range of both ongoing and special activities. Collaboration within the Department and with external customers is pursued to ensure that these priorities reflect the Department's mission and goals, and that they are pursued in the most efficient manner possible by reinvigorating what works well, eliminating what is not necessary, and reinventing that which could work better.

A number of R&D advisory committees have been established which meet on a regular basis to review R&D plans and priorities. Each of the operating administrations use such processes to develop R&D programs and budget proposals, which are the starting point for this integrated Departmental plan. However, the typically modal focus of these efforts calls for additional broader outreach efforts.

In March of 1995, the Transportation Research Board (TRB) and the NSTC jointly sponsored a two-day *Forum on Future Directions in Transportation R&D*, at which breakout sessions were held with the explicit purposes of developing a framework for R&D priority-setting and gaining the distinct perspectives of industry, State government, local government, the research community, and other key stakeholders. Additional breakout sessions were held to establish R&D priorities using the framework developed at the forum, taking into account the perspectives observed. This forum provided key input for this edition of the Department's R&D plan. Interactions with users and providers of transportation services, and with leaders in the academic and research communities, are vital to the development of concepts and goals for transportation systems of the future. Without reality testing of this sort, it is not possible to form policies or examine priorities for R&D programs within DOT. A basic understanding of the forces that drive the supply and demand for transportation is also important: demographic trends, economics, and technological progress.

On behalf of the Secretary, the Research and Special Program Administration's (RSPA's) Volpe National Transportation Systems Center organizes and conducts a continuing outreach with transportation providers, users, planners, consultants, manufacturers, state and local governments, and universities in order to gather and share basic data for use in integrated long-range transportation and transportation-related R&D planning and decision making. These outreach activities serve a number of purposes and take a wide variety of forms.

In October 1995, the Volpe Center conducted a 2-day symposium *on Challenges and Opportunities for Global Transportation in the 21st Century*, at which a number of long-term trends for global transportation were discussed by a wide range of participants including, for example, representatives of the World Bank, the automotive industry, the electric power industry, academia, the freight industry, and the Congressional Budget Office (CBO). Among the topics covered were the following: global demand for transport, the role of information technology, transportation system investment in an era of limited public spending, the role of transportation in environmental pollution and energy consumption, the evolution of urban forms, the outlook for advanced vehicle technologies and alternative fuels, opportunities for reducing transportation accidents and fatalities, and the enhancement of transportation security. These discussions helped to establish the context presented in Chapter 2 of this section, within which R&D priorities must be established.

In January 1996, Volpe Center staff held informal discussions related specifically to the Department's strategic plan for long-term R&D at the TRB 1996 Annual Meeting. The Department relied on the comments and suggestions received there, and subsequently in writing, in developing this edition of the plan. Early in the development process, RSPA also

solicited input based on the second edition of the plan from University Transportation Center (UTC) program contacts.

CHAPTER 2

TRANSPORTATION IN THE NEXT TWO DECADES

The strategic goals presented in the Department's *Strategic Plan*, and the long-term R&D thrusts presented in this report are logical responses to a set of trends that are shaping transportation and the global environment in which it is evolving. The Department developed this strategic plan for its R&D activities by identifying opportunities to use updated technologies and practices to satisfy the multiple demands on the transportation system, within the context resulting from current and anticipated trends and issues affecting transportation over the next 10-20 years.

Key Trends and Issues

Increasingly Competitive Global Economy

It is generally accepted that this Nation is part of an increasingly competitive global economy. Laborers and professional workers in the U.S. face increasing competition from their peers in both developed and developing nations. For example, hourly compensation costs in 1994 for manufacturing production workers in the U.S. were three times as high as in the newly industrialized Asian economies (Hong Kong, South Korea, Singapore, and Taiwan), and nearly seven times as high as in Mexico.[1] Businesses are under increased pressure to reduce costs in order to remain competitive with their peers. In recent years, transportation outlays have decreased notably as a percentage of gross domestic product (GDP) since the 1970s, driven in part by sizable reductions in inflation-adjusted fuel costs. The Consumer Price Index (CPI) for transportation has tracked closely with the total CPI for the past 25 years. The total per-mile cost (in constant 1990 cents) to operate an automobile, after reaching a low of 33 cents per mile in 1985, increased to nearly 43 cents per mile by 1992--still nearly 2 cents/mile lower than in 1975. Increased competition in the global market place will lead to further pressure by U.S. citizens and businesses for low-cost transportation.

Per-Capita GDP Increase
1985-1993

France	-3.4%
U.S.A.	10.5%
So. Korea	82.4%
China	80.3%
Taiwan	69.2%
Indonesia	45.1%

At the same time, economic growth in selected regions (e.g., Asia) is providing the base for the development of newly emerging upper and middle classes which enjoy a larger percentage of disposable income than previously experienced in most of the developing world.

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[1]On the other hand, hourly compensation costs in 1994 for such workers were 15% and 25% higher in Europe and Japan, respectively, than in the U.S.

In the U.S., some important economic trends are those toward growth of the service sector, an ever-increasing presence of women in the paid workforce, increased reliance on temporary employment and contract workers, and increases in the number of people who run businesses at home and people who telecommute to work. Some of these expectations are emphasized by the following recent quantitative trends and projections:

- Service sector employment in the U.S. grew at an annual rate of 2.3% between 1979 and 1992, and is expected to continue growing at a 2.0% annual rate through 2005. By comparison, nonagricultural goods production employment declined at an annual rate of 1.0% during 1979-1992, and is expected to grow at an annual rate of only 0.2% through 2005.

- The male participation rate in the U.S. labor force decreased by about ten percent between 1960 and 1994. During the same period, the female participation rate increased by more than fifty percent, and the participation rate for married women nearly doubled. Moreover, while participation rates have been dropping slightly since 1990 for both men and women in general, they have continually increased for married women.

Changing Demographics, Increasing Demand

Between 1960 and 1994, the average size of households in the U.S. decreased significantly--from 3.33 to 2.67 persons. Given the baseline travel required to maintain a household unit, this helps to explain the much more rapid increase in travel than in population. Between 1960 and 1991, while the U.S. population increased by about 40%, highway travel nearly tripled. There are several demographic trends for the future that warrant close attention, the most important of which are as follows:

First, and most important, the elderly are the fastest growing age component of the U.S. population, and mid-range Census projections indicate that the population growth rate between 1995 and 2025 will be nearly ten times as great for Americans 55 and older as it will be for those between 25 and 54 year of age. This is a continuation of trends observed over the past 35 years. In 1960, for example, about 32 million Americans, or 18% of the total population, was 55 years old or older. By 1991, that total had risen to nearly 53 million, or 21% of the total population, including more than 7 million who were 80 years old or older. By the year 2020, between 70 and 80 million Americans, or nearly one-fourth of the population, could be over 55 years old. Because of associated reductions in average visual acuity and increases in average reaction time, for example, this could have profound implications for the safety of the Nation's transportation system, and R&D is needed to characterize implications regarding operator performance, and to identify technological opportunities and suitable means of providing continued access and mobility.

Second, although women continue to increase in prominence in the U.S. paid workforce, salaried women, more often than their male peers, shoulder the bulk of the responsibility for

day-to-day management of U.S. households. For example, NPTS data show that women in urban households with children 6-15 years of age make 21% more trips per day than men in the same households. NPTS data also show that 45% of all trips occur as a part of trip chains, and that women are significantly more likely than men to form such chains (i.e., run errands). Because trip chains may be more dependent on single-occupancy private vehicles than trips directly to the workplace and back home, this has important implications for the surface transportation system, especially in light of the increased presence of women in the paid workforce.

Changing and Emerging Demand Patterns -- Passenger and Freight

The migration of the population within the U.S., combined with migration from abroad and with the rapid suburbanization of homes and jobs, have been linked to:

- substantial population and employment growth in the west and south;
- concentrations of migrants from abroad in a limited number of states;
- major growth in suburb-to-suburb commutes;
- major growth in reverse (i.e., urban core to suburb) commutes; and
- increased distances between home and all trip destinations.

These patterns, which vary in specific manifestation from one region to the next, have profound implications. Employees who both work and live in low density places create scattered travel patterns--they do not travel along highly concentrated corridors, and they have few viable alternatives to the private car when they travel. Employees who live in the core of metropolitan areas but work in the suburbs also create nontraditional commutes and may have limited travel options. Overall, these population and land-use trends accelerate the travel patterns linked to the growth of the service-based economy. They lead to:

Average Characteristics of Urban Commute Trips

Year	Length (mi)	Time (min)
1983	8.28	17.81
1990	10.14	18.88

- longer work trips;
- longer nonwork trips;
- more scattered origins and destinations; and
- greater dependence on single-occupancy private vehicles.

Overall, it appears that there will be continued trends toward longer worktrip commutes, dispersed and generally lower density workplaces, new and decentralized employment locations, and different and variable employment schedules. These changes in travel patterns, if they persist, may lead to longer peak periods, greater dispersion of demand and destinations, temporal and geographic changes in congestion patterns, greater challenges for fixed route/schedule transit and other alternatives to single-occupancy vehicular travel. This is already reflected in home-to-work transportation trends from 1980-1990, which show a

significant increase in solo driving (up from 64.4% in 1980 to 73.2% in 1990), significant declines in carpooling (down from 19.7% to 13.4%) and walking (down from 5.6% to 3.9%), and smaller declines in public transit usage and other means (e.g., bicycling). On the other hand, more people worked at home in 1990 (3.0%) than in 1980 (2.3%).

U.S. Freight Outlays
1980: 7.9% G.D.P.
1993: 6.3% G.D.P.

Low-cost global communication and transportation networks have resulted in a global manufacturing marketing enterprise that, in turn, stimulates further progress in those networks. Very often the differential transportation costs are too small to offset an overseas production cost advantage. Similarly, U.S.-made components and products now compete in markets throughout the world. In an interdependent global economy there is a continuing growth in worldwide merchandise imports and exports. For example, U.S. oceanborne trade is expected to grow at an average annual rate of 4.5 percent between 1994 and 2005. Just-in-time goods movement with the goal of minimum inventories is resulting in an increase in the number of trips made by parts suppliers and the final assemblers' deliveries to purchasers, and is placing increasingly stringent cost and reliability requirements on the global transportation enterprise. At the same time, a freight transport system that operates so leanly raises some concern with respect to handling anomalous peak flows associated with, for example, a major natural disaster or a large-scale military conflict.

Transportation/Telecommunication Interaction & Tradeoffs

The creation, distribution, and use of information has become ever more central to the life of modern societies. More than half of the U.S. workforce is often described as consisting of "information workers." In recent decades, more and more opportunities have been found for "tele-substitution" or "virtual transportation"--the use of communication of information in ways that substitute for the physical transportation of individuals and even some goods (e.g., newspapers). One of the current manifestations of that early perception is telecommuting, which replaces daily trips to and from a customary workplace with the use of telecommunications services to access organization information resources and communicate with co-workers and others.

The degree to which telecommuting will be adopted, the specific forms it will take, and the magnitude of the public benefits actually obtained will depend largely on attitudes of people toward their work and workplace, the adaptability of corporate culture, the nature of the work performed, the actual productivity benefits for employers and gains in quality of life for workers, and the specifics of changes in their travel behavior. Not surprisingly, there is a high level of uncertainty about the future course of telecommuting and its impacts on transportation.

However, telecommuting is only one of many ways in which information flows are being substituted for individual travel. The availability of information-based substitutes in situations where transportation is burdened by congestion, inconvenience, or high cost could

conceivably enable tele-travel to eliminate a significant amount of actual transportation services, and subsequent environmental impacts. On the other hand, a variety of effects associated with telecommunications advances could stimulate travel and transportation demand. Examples include more decentralized residential patterns, increases in home delivery services, ability to work and communicate while driving, and improvements in the level of transportation services (e.g., small package delivery services) based on the application of information technology. Further, in many cases the act of traveling has an attraction in its own right, apart from the associated transportation function.

Increased Travel and Tourism

Despite incredible poverty in some places, there is growing prosperity throughout the world. The growth in disposable income is fueling new demand for travel and tourism. Between 1985 and 1993, temporary visitation by foreigners increased by over 150% for pleasure, and by about 65% for business. As world tourism becomes an increasing share of transportation demand, resulting in the dramatic growth of international passenger travel and straining the capacity of existing surface and air transportation facilities, many nations will be required to expand their transportation infrastructure.

On the average day worldwide, an estimated 3.4 million passengers take off from 16,000 airports, on over 600 domestic and international airlines that serve thousands of destinations. A doubling or tripling of international air travel will place major new demands on international airports and air traffic control systems. Within the next 20 years, it is anticipated that the United States air traffic control systems, airlines, and airports will have to accommodate 1 billion passengers a year.

Given that most of these passengers will not be staying at airports, this will place new demands on the surface transportation system, which will be faced with greater numbers of visitors who may not speak English or be familiar with local driving regulations, but will expect access, mobility, and service.

Continued Infrastructure Maintenance/Renewal Requirements

In direct expenditures alone, transportation-related activities account for an annual investment of about $1 trillion for transportation goods and services, almost 20 percent of the U.S. Gross Domestic Product. About 15 percent of these expenditures are for construction, operation, and maintenance of transportation systems, and more than 80 percent of this is devoted to maintaining our aging transportation infrastructure.

In many sectors of transportation in the U.S., usage of existing infrastructure is rising, physical condition of facilities has deteriorated, vehicle speeds are reduced due to congestion, and/or modern standards of facility efficiency are not being met.

The Department currently estimates that the average annual investment required from 1994 to 2013 to maintain the current (1993) overall quality of the existing highway, bridge, and transit infrastructure will be more than $60 billion ($1993). Improving these systems in an economically efficient manner is estimated to require an average annual investment of nearly $87 billion.

Investment in the waterborne transportation system is a blend of public and private money. The industry is, for the most part, privately capitalized. It is anticipated that continued investment, probably in excess of $100 billion over the next decade, will be required to replace aging tonnage, expand and upgrade shipyard facilities, and to advance technology, equipment and training programs.

Traditional funding mechanisms are being used in new ways and for new purposes, and entirely new funding mechanisms are being simultaneously developed, with options such as investment banks and regional pooling of Federal funds being contemplated. Experiments have been recently conducted using increased private sector infrastructure capital funding and greater reliance on user fees. However, private investors may be deterred somewhat by the prospect of Government regulation of what are perceived by some observers as monopolistic enterprises.

Among the important questions regarding financing are the following: Are the existing combinations of mechanisms in the U.S. for raising infrastructure funds adequate to generate appropriate spending levels? Would it be desirable, for example, to shift significant amounts of such infrastructure from tax to toll financing, and/or from public agency to private enterprise operation? Are there sectors of the U.S. transportation systems where innovative designs and materials would be more cost-effective, in spite of higher front-end costs, than financing new developments using traditional materials?

Deployment and Utilization of a Sophisticated Information Infrastructure

Increasingly, applications of information technology are being seen as a promising means to increase the effective capacity of many elements of the Nation's transportation system and achieve higher levels of system performance. Modern sensing, communication and information technologies can support optimization of the use of urban highways at rush hour, dispatching of transit buses, management of truck fleets, control of aircraft, management of harbor traffic, planning and dispatching of maintenance crews, and many other applications. Electronic data interchange can bridge the gaps between modes to help make trips more seamless. This can permit trucks to cross borders without stopping; eliminate toll booths on highways; provide electronic fare collection in transit systems; smooth both intra- and intermodal scheduling and transfer operations for highway, rail, and maritime freight; and provide motorists with alternative routes to avoid congested points. Advanced technologies, including space-based satellite navigation systems, can also enable the utilization of sophisticated methods of pricing transportation services and access (such as to urban highways). Partial or even full automation of vehicle control on a large scale, based on

continuous exchange of information with the roadside infrastructure and with other vehicles, is envisioned as a future possibility that could have dramatic potential for increasing highway capacity.

However, realization of the full potential of these technologies and applications requires a degree of system-level information technology performance, including reliability, availability, convenience and response time, that will require coordinated efforts by many parties and inherently raises numerous complex questions and issues.

Continued Importance of Surface Transportation to Environmental Quality, Energy Expenditures

Worldwide, transportation has long been a major focus of concerns about fossil fuel consumption, urban air quality, and the global climate. It is also a focus of similar concerns about solid and hazardous waste disposal, and the loss of natural habitats and open civic space. Cars, trucks, buses, and other vehicles contribute significantly to global petroleum demand and carbon dioxide emissions, and are also major sources of carbon monoxide and of volatile organic compounds and nitrogen oxides - precursors of tropospheric ozone and acid rain. Motor vehicles' share of oil consumption and emissions will undoubtedly increase as the world's population grows and becomes increasingly urbanized.

U.S. trends indicate continued progress toward reducing nonattainment of the carbon monoxide and ozone National Ambient Air Quality Standards (NAAQS). However, EPA must periodically revisit the stringency of these standards, and recent medical evidence indicates that a more stringent ozone standard, perhaps as low as 0.060 ppm (the current standard is 0.125 ppm), could be required depending on the degree with which public health is to be protected. Many states continue to have significant difficulty developing plans to achieve the current ozone NAAQS, and transportation-related emissions are a significant part of the problem.

U.S. Transport-Related Emissions
(million tons)

	NO_X	PM_{10}	CO_2
1970	9.26	1.24	
1980	11.44	1.39	417
1990	10.66	1.76	477
1992	10.34	1.84	477

In addition, renewed concerns and recent scientific data have led to consideration of a more stringent NAAQS for fine particulate matter. A focus on smaller particles implies a greater role of Diesel engines (e.g., buses and trucks)--historically, sources such as fugitive dust have been viewed as dominant due to referencing to a more inclusive (i.e., larger) particle size.

Finally, current projections indicate that, without intervention, greenhouse gas emissions from personal motor vehicles in the U.S. will increase by roughly 40-70% between 1990 and

2025. Increased highway speeds associated with higher speed limits could lead to even greater increases. Transportation (all modes) accounts for about one third of U.S. carbon dioxide emissions, and the U.S. is responsible for about one fifth of global greenhouse gas (GHG) emissions.

Although the magnitude of expected global warming and the extent of subsequent impacts continue to be debated, world leaders, including then-president George Bush, committed in writing in 1992 to the stabilization of greenhouse gas concentrations. In 1993, President Clinton reaffirmed U.S. commitment with a detailed *Climate Change Action Plan*. However, there are significant challenges to achieving rapid reductions of transportation-related emissions, and U.S. new vehicle fuel economy, after improving in the 1970s and early 1980s, has stagnated. In addition, the significant shift of the consumer new vehicle market toward pickups and sport-utility vehicles has reduced the fuel efficiency of the Nation's fleet as a whole.

U.S. Average New Vehicle Fuel Economy (mpg)

Year	Autos	Small Pickups
1976	17.2	23.9
1982	26.3	28.1
1988	28.5	26.1
1992	27.7	25.0

As the world vehicle population has grown, so has oil consumption. For the most part, the world fleet runs on oil. According to the U.S. Department of Energy (DOE), consumption of oil has risen steadily since the mid-1980s, due primarily to the rapid expansion of transportation in the developing countries. This trend should continue as long as oil prices remain stable. Of course, there is concern among some that oil prices may become less stable within the next couple of decades if there is a resurgence of monopolistic supplier behavior, and that the short-term price elasticity of demand in the U.S. is such that even a brief (e.g., 2-year) supply curtailment could lead to a significant drain on the U.S. economy. This persistent concern regarding dependency of the U.S. transportation sector on imported petroleum products is reflected in the ongoing emphasis on the potential diversification of transportation fuels, and in the particular interest in recoverable domestic fuels (e.g., natural gas).

On the other hand, significant transitions will have to occur if the long-term goals of stabilizing the global climate, reducing regional and urban pollution, and reducing economic sensitivity to energy costs are met through vehicles that employ revolutionary technologies and/or renewable low-carbon fuels for which supporting industries (such as refueling, maintenance, and repair) are not yet in place. Wherever there are established infrastructures, questions regarding responsibility for sunk costs (i.e., money that has been already spent to develop those supporting industries and infrastructures) will arise. Access to capital required to go through transitions will be important, and workers in a number of industries will need to be retrained. These are issues that will be particularly important in developed countries such as the U.S., where the significant sunk costs tend to reside.

Continued Concern with Personal and System Security

The safety and security of travelers is at once a major public concern and a principal responsibility of National and state transportation agencies. The overall historical trends in U.S. transportation fatality rates per unit of exposure show a decline of at least 50% in the rate of accidental deaths between 1950 and 1990. These results are highly encouraging. They have generally been achieved by the concerted and focused efforts of many parties, including Government agencies, providers of equipment and services, private groups and individuals. However, it is not clear to what degree it will be possible to continue the improvements made in the recent past, and this gives rise to a number of important questions. Will fatalities gradually begin to creep upward again, driven by rising VMT (vehicle miles travelled) and, perhaps, newly-increased speed limits? Will new vehicle and traffic management technologies, accompanied by better understanding of the driving task and human capabilities, lead to motorists, cars and road systems that can maintain the decline in accident and fatality rates?

The security of travelers can be threatened by terrorist or other malicious actions regardless of means of transportation. Although attention has generally focused on aviation, recent domestic and international incidents have heightened concern about security threats to railways and transit systems. Despite the typically very low level of actual risk (per unit of exposure), public perception and concern make improvement of transportation security a high priority for governments. The need for joint international efforts is especially critical in this sphere.

It is very challenging to truly provide a high level of security without seriously compromising freedom of movement, convenience, privacy, and cost. Questions such as the following arise: What will it cost to make transportation secure? Who should pay for transportation security? Where can technology solve security problems? What kinds of non-technical means (e.g., procedures and training) are needed? How can countermeasures be more selectively applied? What kind of impact will increased security have on transportation operations?

Deaths of 15-24 Year-Old Persons in 1992 in the U.S.

10,305	Motor Vehicle Accidents
8,019	Homicide, Lgl. Intervention
4,693	Suicide
3,357	Other Accidents
1,809	Cancer
968	Heart Disease
578	HIV Infection
4,819	All Other Causes

Emphasizing Risk-Based Regulatory Processes

In many regulatory arenas, there is a new emphasis on moving from approaches typified by universal performance standards to ones that rely on a characterization of relative risk. In some cases, this may not actually represent a major philosophical shift, but rather a perhaps significant extension of long-standing efforts to quantify and document the costs and benefits of regulations under consideration. In others, there may be a more fundamental questioning

of established practices--for example, the nationwide applicability of minimum standards for environmental quality. In general, it is anticipated that such emphasis on risk-based regulatory practice will provide the most risk-reduction benefits for the least overall cost. However, there are a number of issues to be addressed in making such changes. First, the information needed to make more explicit and thorough risk-based decisions may be significant, and new efforts may be required to collect and interpret data. Second, in making programs more flexible, it may be necessary to develop new performance measures, verification techniques, training mechanisms, and enforcement protocols.

Fulfilling Congressional Mandates

Many key National goals and concerns have been embodied in major legislation adopted over the past twenty-five years, and the accompanying regulatory and administrative activities *(See Table 1)*. Yet the existing inventory of information and tools for use in evaluating transportation needs and developing the best responses to these needs is often inadequate to provide the desired solid foundation for wise policies and efficient implementation.

Table 1: Illustrative Legislative Mandates

National Environmental Policy Act (NEPA) -- 1969
Clean Air Act Amendments (CAAA) -- 1970, 1977, 1990
Hazardous Materials Transportation Act -- 1975
Clean Water Act -- 1977
Port and Tanker Safety Act -- 1978
Act to Prevent Pollution from Ships -- 1980
Surface Transportation Assistance Act -- 1982
Shipping Act -- 1984
Aviation Safety and Capacity Expansion Act -- 1990
Americans With Disabilities Act -- 1990
Oil Pollution Act -- 1990
Intermodal Surface Transportation Efficiency Act (ISTEA) -- 1991
Energy Policy Act -- 1992

The continuous challenge--to make the best and most cost-effective transportation investment and operational decisions possible--can be met only when decision makers have available a solid and robust capability for transportation system assessment. This capability in turn has many components: a broad understanding of the economic, financial and institutional context in which transportation takes place; a comprehensive base of data and information; viable analytical tools, models and techniques; and meaningful measures of all important aspects of system performance and the entire range of externalities associated with transportation activities.

Summary: Key Challenges for Surface Transportation

DOT has identified several key challenges and opportunities for surface transportation. These define the environment in which future transportation systems will evolve, and therefore provide the focus of the Department's strategic planning for major long-term R&D thrusts. Chapters 3 and 4 of this Section will identify the relationships between these challenges, the Department's strategic goals as established in its *Strategic Plan*, and its strategic plan for R&D for the next ten years.

Widespread Congestion and Limits of Transportation Capacity

Transportation system capacity is another "resource" often in short supply. Demand for transportation services are typically increasing faster than population, with congestion an increasing reality in many modes. The time required for expansion of transportation physical infrastructure is substantial--often 20 or more years elapse between initial serious discussion of new or increased facilities and operational use, and in some cases the project may never come to pass. When combined with the enormous costs which can be associated with infrastructure expansion in a period of worldwide financial constraints, the result is often an extended lag between awareness of a need and effective action in response. Since the time for the response itself is inherently lengthy, this dynamic virtually guarantees that supply will be many years behind demand. For any activity or locality experiencing significant growth, infrastructure capacity as perceived by most users will thus be marginally adequate at best, and often characterized by one or more serious bottlenecks.

Pervasive Constraints Associated with Environmental and Societal Impacts, and Physical, Financial and Human Resources

Along with technical advances and rapidly growing scientific knowledge has come better understanding of the cost paid for a polluted environment and awareness of the fragility of our entire ecosystem. The growth of populations and economies has sharply intensified the burden we place on that ecosystem, while simultaneously emphasizing the relatively new realization that natural resources are not unlimited. The global spread of democratic political structures and greater insistence on the recognition of perceived individual and community rights increasingly challenges the degree to which land or other resources needed for the claimed greater good for the many can be obtained at the expense of the few who occupy it or depend upon it for their livelihood. These constraints also exacerbate debates over the proper allocation of the costs, burdens and benefits of change, as well as over what changes should be made.

Change as an Inherent Part of Economic Life

The combination of a global, highly competitive marketplace with continued application of powerful advanced technology leads to constant change in the economic environment to a degree not previously experienced on such a broad scale. Strategic business decisions must

therefore be made in a climate of substantial uncertainty. At the same time, any failure to develop long-term vision and commitments will leave nations and companies at the mercy of such changes, unable to take advantage of new opportunities and prey to obsolescence.

Broad and Powerful Technological Capabilities

The factors discussed above derive in part from the incorporation into business and private life of a steady stream of technology applications, many of which provide expanded functionalities, create new products and services, require a wide range of resources, and make possible alternative approaches to the organization and management of economic activity. Typical of this process are the changes associated with combinations of computer and satellite communications technology. For example, it is now technically possible to track the location of and communicate almost instantaneously with a person or a vehicle virtually anywhere in the world. Largely due to advances in transportation, components and raw materials can be acquired in one continent for assembly in another continent of a product to be sold in a third, with the choice of each dependent only on economic considerations.

A High Degree of Interdependence and Diffusion of Power among Economic and Social Institutions

Numerous economic and technical factors have stimulated the development of an elaborate global web of inter-relationships among businesses. At the same time, increased concern over environmental and societal impacts, coupled with a need to ensure an appropriate framework for National and international economic activity, have linked the private and public sectors to a degree far removed from that of the much simpler world that existed not too long ago. One consequence of these links is that organizations and institutions (and individuals) are now continually affected and constrained by the actions or views of other entities throughout the society. The requirement to prepare an environmental impact statement for many activities previously undertaken without a moment's thought is symbolic of this changing social compact. The "post-industrial" society is one in which power has been greatly diffused among many players, so that, with few exceptions, no one organization can act in an unconstrained manner. Major initiatives can only be accomplished effectively when they are recognized to be a cooperative venture, in which all parties with the will and energy to make it happen, as well as those concerned about the direct and indirect consequences, find ways to understand and deal with one another. Modern management theories stress the development of cooperative and collaborative relationships to supplant those that have been historically competitive.

Role of DOT in Meeting Transportation Challenges

It will be an increasingly challenging task to provide the transportation system capacity at acceptable service levels required to meet the Nation's needs--passenger and freight, personal and business. This challenge is further complicated by financial constraints, and the

necessity to control or eliminate adverse societal impacts. The task can be accomplished only by working with all transportation stakeholders to exploit fully the potential of new technologies and concepts. The Department of Transportation has both specific mandated responsibilities and a broad general stewardship role that warrant its playing a leadership role in stimulating, guiding and facilitating the realization of a National transportation system fully responsive to the needs of the 21st century. The Department recognizes the pivotal role in this process of the private sector, and must facilitate innovation initiated by these players, and provide leadership for the public and private sectors in all modes of transportation. DOT's involvement in R&D, as discussed in the next chapter, is based on the need to develop specialized equipment needed for DOT operations, to support policy formulation, to provide objective information supporting the development of standards, and to conduct research addressing National needs that may not otherwise be met in a timely and/or efficient manner.

The Department actively pursues new technologies and new operating practices as means to address the trends and issues discussed above. However, as options become available, difficult choices must be made, and new technologies and practices must be deployed if real progress is to be made. In the U.S., state and local governments have most of ultimate responsibility for these implementation issues. In order to fulfill its fundamental missions of investing in infrastructure, ensuring public safety, and maintaining National security, the Department must continue to promote progress in a cooperative manner, to provide decision-making tools where they are needed but not yet available, and to establish standards where they are needed to ensure efficient implementation and consistency with accepted National goals and priorities. In working to increase the visibility of its R&D program, Secretary Peña has emphasized mechanisms to ensure that these challenges are met.

CHAPTER 3

RESEARCH AND DEVELOPMENT TO MEET TRANSPORTATION CHALLENGES

The Challenge

As set out in the DOT *Strategic Plan*, the Department's mission is to "'Tie America Together' with a safe, technologically advanced, and efficient transportation system that promotes economic growth and international competitiveness now and in the future, and contributes to a healthy and secure environment for us and our children." This responsibility is all the more challenging in an era of severely limited resources and numerous constraints associated with societal concerns and impacts. The broad means by which DOT will meet its mission responsibilities are embodied in six of the overall goals of the DOT Strategic Plan. In condensed form, these goals call for the following:

- Promotion of an integrated National transportation system that makes the most effective use of all modes
- Wise and efficient transportation system investments
- Rapid and effective application of technological advances to transportation functions
- Wise and efficient measures to enhance transportation safety and security
- Harmonization of transportation policies, investments and operations with environmental concerns
- Incorporation of the concerns and needs of the traveling public and the entire society into transportation policies and investments

Research and development, broadly defined, is a necessary element in the success of each of these undertakings, and particularly the third. A broad foundation of data, knowledge and understanding concerning both transportation and the technologies on which it is based, is required for wise decisions in all the areas noted above. Beyond that, the stimulation and fostering of innovative technologies and methods in transportation is particularly important in the current dynamic environment. In many areas current needs are being met only marginally or worse, and the means by which rising demand can be met in the future will clearly have to include major improvements over current ways. Similarly, there is a clear need to find new more effective and less burdensome means of carrying out Federal regulatory responsibilities. Finally, full U.S. participation in the global economy necessitates continuing international harmonization of standards, practices and regulations as an aid to National competitiveness.

Moreover, DOT R&D represents only a portion of U.S. transportation research activities. Equipment manufacturers are continually improving their products in response to market forces, just as carriers constantly seek better technology, operations and practices in order to provide better and more economical services. State and local government agencies with transportation responsibilities also explore, within often-limited resources, how best to carry out their missions. However, to a large degree, many of these parties face financial constraints and exist within an industry structure that severely limits incentives for any R&D but that which offers immediate and low-risk returns -- typically highly focused and short-term in nature. A substantial portion of DOT research is conducted in partnership with these elements of the transportation community, combining their understanding of the need and constraints with a the typically longer-term Federal perspective and greater access to funding.

Fortunately, these challenges, and the associated necessity for continuing innovation, arise in an era richly endowed with a wide range of steadily-advancing technologies and tools that, effectively applied, have great promise for resolving current or anticipated problems. Innovation is seldom a smooth process, and realization of significant change in transportation systems--tightly linked to their environment and characterized by very long-lived infrastructure and vehicles--is complicated and difficult. In recent years, those people and organizations trying to manage and implement beneficial advances have become increasingly sensitive to the complexity of the process of innovation, and the role played in that process by research and development. The relationship between innovation and research is critical in shaping the nature of the R&D performed by DOT and the manner in which it is conducted.

The Innovation Process

Until recently, the commonly used model of innovation assumed a high degree of independence and isolation between its discrete successive stages, and had clear beginning and end points. This process has generally been seen as driven by perceived advantages of technical advances ('technology push'), but the competitive nature of the modern world has led to increasing emphasis on the pull of market forces as an alternative primary motivation. Innovation was perceived as occurring through a simple linear and sequential process that begins with basic research, passes through stages of applied research and development into test and evaluation, and finally yields a product or process design and actual manufacture or implementation.

Students and practitioners of innovation now recognize that this paradigm, originally shaped by experience in developing specific new products and weapon systems, is overly simplistic and should not guide R&D policy. A more realistic picture is now becoming accepted that reflects the continuous nature of the innovation process, and the strong linkage that must exist between and among the various successive stages. The process is iterative and ongoing, yielding a stream of improved technologies, products, and services, with no specific endpoint.

As an illustration, two staples of U.S. transportation--the motor vehicle and the airplane--have been evolving in this manner throughout the twentieth century, with the innovative process still robust. Sometimes driven by technology push--the automatic transmission or the jet engine--and now responsive primarily to large global markets and societal requirements for safety, fuel efficiency and environmental friendliness, these technologies continue to show steady and dramatic improvements in function and cost-effectiveness. R&D, prototype design, test and evaluation, and implementation all continue to occur simultaneously, each element affecting the future course of the others.

These examples not only show the role of R&D in bringing about innovation, but also demonstrate the need to see research as an ongoing activity linked closely to development and testing, evaluation, demonstration, and performance in the real world. Ultimately, virtually all development is evolutionary in nature, and even the early stages of R&D must be driven by some sense of need for a product and the societal requirements and values that will determine its acceptance. The transistor -- the basis of much of the information age now taking shape -- was developed not as a serendipitous outcome of undirected solid state physics research, but rather from a specific program based on the recognition that the high power consumption and heat generation of vacuum tubes might best be overcome through examination of the properties of electronic conduction in semiconducting materials. Similarly, the need to achieve extremely low automobile emissions or petroleum independence drives focused basic research in areas such as combustion and energy storage.

Consequently, innovation in transportation calls for a balanced and integrated approach that links parallel streams of research, development, test and demonstration, and implementation, all based on a clear understanding of specific transportation objectives and institutional, regulatory and economic constraints. The translation of a tested and proven advance into revenue service often necessitates a major investment in providing users with sufficiently convincing evidence and with the knowledge needed to apply the innovation effectively.

The R&D Role of the Department of Transportation

Basic DOT Responsibilities

As articulated in the Department's *Strategic Plan*, basic responsibilities associated with DOT's mission fall into four broad categories:

- *Operation of Federally-Provided Transportation-related Services* -- providing traffic management and other services for the Nation's airspace and waterways.

- *Public Investment in the Transportation System* -- distributing funds to state agencies, transportation planners and other institutions to plan, construct and operate the U.S. transportation system, and, in partnership with states and localities, to shape its development.

- *Setting Standards* -- Setting standards for safety and other key aspects of the transportation system and enforcing those regulations. This also includes participation in the development of voluntary standards, and encouraging the development and deployment of effective safety systems.

- *Spokesman for Transportation in the Federal Government and the World* -- interacting with other Federal agencies to carry out broad mandates such as clean air and National security policies, and working with other nations toward the international harmonization required for trade competitiveness.

These four roles are explicit elements of a broader fifth mission: the responsibility to serve as the Federal steward of the transportation system:

- *Stewardship of the Transportation System* -- The Department of Transportation is the Federal steward of the Nation's transportation system and speaks for transportation in the Federal Government. It actively promotes the adequacy, health, efficiency, and robustness of the Nation's transportation system and the industries and infrastructure on which it depends, and the ability of that system to serve the U.S. economy and meet National needs, now and in the future.

R&D to Support DOT Missions and Responsibilities

As the National steward for the transportation system, the Department sponsors a range of research and development activity to support specific missions and the broader responsibilities indicated above. This R&D is critical to the Department's ability to address the multiple, and sometimes conflicting demands on the Nation's transportation system, particularly in an era of scarce resources.

Operational Services: This role is predominantly associated with operation of the Nation's air traffic control system and a spectrum of services provided by the U.S. Coast Guard, including provision of maritime safety, marine search and rescue, and management of oil spill prevention and cleanup. These are major and critical DOT responsibilities, and they offer a range of opportunities for spinoff (to and from) the surface transportation system.

Public Investment: The Department is extensively involved in planning and shaping public investment in the transportation infrastructure (vehicles, physical plant, control and management information) through trust fund grants. For example, more than $70 billion is spent annually by all levels of government on the Nation's highways alone, about one-fifth representing Federal funds. With this level of expenditure, very high payoff is obtained from R&D that reduces the cost and extends the performance and lifetime of roadways and other transportation infrastructure. Further, when the primary users of new technology or methods are public sector organizations that draw on Federal funds, such as highway departments or transit authorities, the process of information dissemination and education concerning improved technologies and methods may need to extend well beyond the

conventional definition of technology sharing. In addition, the magnitude and long-term consequences of transportation investments necessitate that it be guided by comprehensive knowledge and tools for assessing the costs, benefits and effectiveness of alternative courses of action and levels of investment, and for assuring balanced investment.

Safety Standards: Many of the Department's numerous and varied surface transportation safety responsibilities involve development and promulgation of regulations, standards, and specifications. Motor vehicle crashworthiness and other regulations, for example, have been a major cause of the dramatic reduction in the U.S. highway death rate. Fulfillment of regulatory responsibilities typically requires research to understand accident causes sufficiently to identify and assess alternative approaches to their elimination or mitigation while minimizing economic and other adverse impacts on affected parties. In addition, rigorous cost-benefit analyses, long a part of DOT regulatory processes, are necessary to assure that a regulation or standard is warranted, and that the proposed approach is the most cost-effective alternative. R&D can also foster the development of tools and procedures to reduce costs borne by the Government and for the affected parties in certification, inspection and enforcement activities associated with regulations.

Associated with mandated regulatory functions, the Department uses many other means to enhance safety and security in transportation, including public outreach and education, aggressive enforcement, promotion of alternatives to the command-and-control regulatory paradigm, and collaboration with safety organizations and cooperation with state and local governments to promote new safety-related technology and practices. Research and development activities are necessary to provide the necessary knowledge base for evaluation of alternatives and implementation of all of these approaches.

Spokesman within the Federal Establishment and the World: Some of the most difficult and contentious issues currently facing the U.S. and the world are inextricably linked to transportation. Governmental decisions in these areas that affect the performance of the transportation system can have substantial impact on the Nation's economic health, and global competitiveness, and on the quality of life of all Americans. Environmental concerns such as urban air pollution, preservation of wetland ecological systems, and global warming already pose major constraints in operation and expansion of transportation systems, may ultimately require dramatic changes in the nature of those systems--particularly in propulsion system and fuels--that will affect the entire transportation community and many aspects of society external to transportation. The Department of Defense is heavily and increasingly dependent on the civil transportation system for normal operations and in responding to international missions. Transportation is often a key element in coping with natural disasters and other emergency situations. Often the Department is explicitly involved in collaborating with other agencies to carry out National policy.

The steady increase in the globalization of world trade, as reflected in treaties such as the General Agreement on Tariffs and Trade (GATT) and the North American Free Trade Agreement (NAFTA), carries with it both formal and implicit needs to assure international

harmonization of transportation-related equipment, standards and practices. (This concern is particularly evident in the area of information technology applications that involve electronic linkages between vehicles and highway infrastructure.) The Department must also play an active role in representing transportation interests in international agreements, such as global environmental standards and radio frequency spectrum allocations.

Since the transportation system can be significantly affected by decisions made throughout the Federal Government, it is particularly important that the Department be in a position to articulate the impact on transportation providers and system users of the actions of other agencies, and be sure that those organizations are aware of ways in which they may be affected by events and trends in the transportation sector. Such policy considerations must recognize the transportation system as a whole, from the standpoint of its users.

Ongoing research is an essential concomitant of this role. The Department can speak effectively and authoritatively only on topics for which it is fully informed concerning the relevant technical, economic, institutional and other considerations. Further, impacts of external factors can be appreciated and assessed only on the basis of a rich and comprehensive understanding of the components and workings of the National system and its many elements.

Stewardship: The Secretary of Transportation and all elements of the Department have a broad responsibility for the adequacy of the National transportation system for personal, business and National security uses, to establish a clear vision and framework to guide its future evolution, and to promote the health of the industries that comprise the transportation community.

Surface transportation in the U.S. is largely in the hands of state and local governmental bodies, the private sector, freight shippers and consignees, and individual travelers. It is these parties that must ultimately implement and accept innovative technologies and methods. However, for many aspects of transportation, those are often not the entities with the resources and capabilities to conduct independently either the R&D or the extensive evaluation process needed before major commitments to change can be made.

Circumstances vary across the modes and the transportation community as a whole, but in general the most effective role for DOT has been found to lie in research that clarifies problems, objectively identifies and evaluates alternative responses, assesses basic feasibility of new technologies, and characterizes their potential performance. Development of new products is typically best accomplished by private firms, in some cases drawing upon cooperative efforts with DOT, particularly with regard to objective test and evaluation.

An important aspect of stewardship, strongly emphasized by the Secretary, is the active use of Federal research and technology initiatives to stimulate innovation in transportation. Although development of advanced transportation technology and improved operations is largely the responsibility of the private sector, focused Federal investment in research,

development, test, evaluation, and technology dissemination can have great impact for areas in which market-driven R&D efforts are impeded by technological and other uncertainties as well as institutional impediments.

Benefits of Transportation R&D

The principal benefits of Federal transportation R&D lie in five broad areas:

- Personal Mobility and Access
- National Economic Health
- Cost Efficiency of the Transportation System
- Public Safety and Security
- Environmental Sustainability

These are the primary parameters that measure the performance, in the broadest sense, of the Nation's transportation system.

Personal Mobility and Access. Effective, reliable, low-cost and convenient personal transportation is central to the quality of life in the United States. Some important components of mobility include uncongested urban and intercity travel, seamless and efficient intermodal transfer, and an overall high level of access to employment, goods and services, particularly for people living in rural areas and for elderly and disabled individuals.

National Economic Health. A high-performance freight and passenger transportation system, operating in harmony with global markets, is critical to economic well-being both as an enabler of business activity and in markets for transportation goods and services. The cost, quality and availability of transportation services have a strong impact on the efficient functioning of U.S. businesses and the accessibility of goods and services; growth of global markets for transportation-related products; creation of new products, services and markets, and of associated employment; improvements in transportation productivity; enhancement of intermodal connectivity; and general job creation and economic growth.

Cost Efficiency of Transportation. Taxpayers and users, through Federal, state and local governments, make very large annual expenditures to operate, maintain, renew and improve the public portions of the Nation's infrastructure--highways, ports, transit systems, airports and rail and marine passenger systems. Very often, the funds available are not sufficient to provide a transportation system of the quality that the Nation needs and desires. Reduction of these costs through privatization and improved planning, operation, and technology, can

yield a better-performing system and may reduce the burden imposed on some public funding mechanisms.

Public Safety and Security. A high level of personal safety and physical security is essential for domestic and international travelers and freight, crews and operating personnel, and the general public, and for cargoes being carried. Concerns over safety and security limit personal mobility, adversely affect carriers, and diminish the attractiveness of transit.

Environmental Sustainability. The importance of environmentally sustainable economic development has been emphasized by President Clinton. Transportation is intimately involved in shaping our physical environment (air quality, land use, noise) and in our use of scarce and irreplaceable resources, such as land and petroleum.

Technical Areas of Opportunity

There are few technical disciplines which are not currently experiencing continuing significant advances. As a technology "consumer," the transportation sector can benefit from many of the new capabilities, components and tools now becoming available. Four stand out as particularly appropriate to transportation applications. All are closely related to areas that have been identified by the White House Office of Science and Technology Policy as National Critical Technologies in which the U.S. is considered strong, but which warrant greater effort in their application to the production of goods and services.

Materials

New 'high-tech' materials, as well as improved variants on conventional materials, offer many opportunities for beneficial application to transportation infrastructure and vehicles. Often these enable new and improved structural designs and manufacturing or construction methods.

Information Technologies

Communications: The availability and use of electronic digital information exchange, exemplified by the Internet and years of use in, for example, maritime transportation, is increasing dramatically. This advance, which is at the heart of the National Information Infrastructure initiative, is making it easier for both individuals and organizations to acquire and disseminate data and software tools, and to establish new cooperative mechanisms.

Computer Systems Advances and GIS: The performance of computers continues to increase at a high rate, while prices are dropping dramatically. Techniques for combining data from a wide variety of sources, such as monitoring networks, historical data bases and maps, are also becoming more advanced. For example, the data collected as part of traffic management systems -- whether for maritime, aviation or surface transportation -- provide a

new source of information on vehicle volume and movements which can be used in performing other assessments and analyses of transportation operations.

Tagging and Locating Technologies: Based largely on satellite-based communications and positioning networks such as the fully-functional (without user charges) Global Positioning System (GPS), it is now possible to track vehicles and cargoes anywhere in the world with impressive accuracy--accuracy that will improve dramatically as a precision signal is made available to the public. In addition to facilitating effective fleet management, systems of this type can yield large and highly detailed transportation data as well. "Smart card" technologies and the use of bar codes and hand-held bar code readers also offer the ability to track movements, such as passage through an electronic toll gate or across borders.

Advanced Sensor Technology: Particularly with respect to environmental impacts, new sensing devices hold great promise. Technologies such as light reflection and absorption, tunable infrared laser differential absorption spectroscopy, fourier transform infrared spectroscopy, and differential optical absorption spectroscopy, are being widely tested and used to monitor air quality on a localized real-time basis. Weather monitoring on a "mesoscale" basis also is becoming practical. Satellite and airborne sensing technologies are just reaching the point at which they might be used both for environmental observations as well as for capturing data on such topics as aggregated vehicle flows.

The rapid development and interrelationship of computer, sensing, communication and navigation technologies, including the "Information Highway" concept, is having a powerful impact throughout the U.S. economy, and across the spectrum of transportation operations. In many areas, these applications remain to be implemented or are only in their infancy.

Data and Modeling

Associated with the advance in information technologies is the capability to create very sophisticated computer models, coupled to very large (in some cases real-time) data bases to support a wide range of planning, analysis, design, evaluation, implementation and system operation decisions.

Understanding of Human Performance

Many issues of transportation system safety, performance and acceptability relate to the interaction of the system characteristics with human performance characteristics and behavior. The accumulated knowledge in this area from various transportation and other fields, as well as the increasing availability of research simulators and instrumentation capabilities, makes this a discipline that offers a high potential for application to transportation operations.

Implementation as an Essential Element of R&D

It can be a very lengthy and expensive process to carry out convincing evaluation and demonstration of innovative approaches and materials for transportation infrastructure, vehicles and operations. Implementation or deployment can often be greatly delayed, or even aborted, by uncertainties of users as to life-cycle cost, long-term performance, safety, security or other attributes of an innovative technology. The facilitation of deployment of technological advances, including creative applications of existing technologies to solve problems and increase productivity is therefore critical to reaping the benefits of innovation. Particularly where areas that involve major public investment, as in infrastructure construction and maintenance or urban transit, activities to facilitate and encourage technology deployment can be of as much importance as technology generation. As the Federal steward of the Nation's transportation system, the Department has a unique responsibility to work in partnership with state agencies, transportation providers and other transportation-related institutions to plan, construct, and operate the system. This includes addressing challenges to implementation and deployment of improvements to the system that are made possible through R&D efforts.

CHAPTER 4

STRATEGIC LONG-TERM DIRECTION

The steady growth of both domestic and international transportation demand is anticipated to continue indefinitely into the 21st century. Coupled with economic, physical, and environmental constraints on expansion of system capacity, this will necessitate that the Nation focus on maximizing the performance of the existing transportation system through seamless linkages among modes, overlay of an information infrastructure on the physical transportation infrastructure, and application of other technological and operational advances.

Exploitation of new technologies will be central to meeting these challenges. System maintenance, renewal and operation must be carried out in as efficient and cost-effective a manner as possible. The growth rate for travel will carry the implication of a significant rise in the already-unacceptable number of transportation fatalities and injuries. Continuation of past safety improvements are mandatory if this is to be avoided. Failure to address the local and global environmental consequences of transportation-related activities would ultimately have highly damaging impacts on system operation and performance, including the ability to provide critically-needed capacity expansion and congestion relief.

Realization of the Department's vision and strategic objectives requires a research and development program that focuses on topics associated with these challenges and allocates scarce resources according to the merit of priority areas. DOT has shaped its major long-term R&D thrusts in response to the needs, issues and challenges that will face the transportation community. Each thrust is centered primarily on a specific strategic goal; most have several distinct elements, and will also contribute significantly to the realization of multiple objectives.

To a large degree these thrusts are based on and will incorporate existing R&D activities. The descriptive framework provided in this plan does not imply any particular new approach or process for implementation. Rather, the manner in which each thrust area is pursued will be established on the basis of existing related efforts and in harmony with them.

Typically these thrusts represent the R&D component of a broader overall Departmental effort associated with each goal. In some areas, such as data analysis for policy support, some activities described here may not conventionally be described as R&D or included in the research portion of budget submissions. Sixteen thrusts, cutting across all surface transportation modes, have been identified:

- Promotion of an integrated National transportation system that makes the most effective use of all modes

  Thrust #1: Transportation System Assessment and Knowledge Base

Thrust #2: Intermodal Freight Transportation

Thrust #3: Revitalization of the U.S. International Freight Transport Industry

- Wise and efficient investment in the Nation's surface transportation system

  Thrust #4: Improved Materials, Designs and Methods for Renewal Engineering

  Thrust #5: Advanced Technologies for Inspection, Monitoring and Maintenance of Vehicles and Infrastructure

- Rapid and effective application of technological advances to transportation functions

  Thrust #6: Application of Information Technologies to Transportation System Operations

  Thrust #7: Advanced Technology for Intermodal Public Transit Systems

  Thrust #8: Technical Foundation for High Speed Ground Transport Systems

- Prudent measures to enhance transportation safety and security

  Thrust #9: Accident Avoidance

  Thrust #10: Accident Survivability

  Thrust #11: Safety Data and Analysis

  Thrust #12: Security in Surface Transportation

- Harmonization of transportation policies and investments with environmental concerns

  Thrust #13: Environmental Impact Data, Models and Knowledge Base

  Thrust #14: Environmental Engineering and Technologies

- Incorporation of the concerns and needs of the traveling public and the entire society into transportation policies and investments

  Thrust #15: Accessibility for Persons with Personal Mobility Limitations

  Thrust #16: Intermodal Transit System Innovation

Neither research nor transportation lend themselves to rigorous compartmentalization. These thrusts have important overlaps and links to one another, as well as to other research conducted within the Department, elsewhere in the Federal government, and throughout the transportation community. However, each component has a primary focus that makes the above categories a useful framework for describing the dominant long-term efforts that comprise DOT's surface transportation R&D.

The list above could have been substantially longer. Improvement is highly desirable in many aspects of transportation, and interesting and attractive innovative technological and operational concepts abound. However, it is clear that DOT research over the next ten years must be conducted in a climate of severe fiscal restraint. Ongoing consideration of the broader transportation R&D context will be essential, and will encompass important activities throughout the Federal Government, academia, the States, and industry. The topics identified here all pass rigid criteria of high potential impact in areas important to transportation and the Nation, necessity for a substantial Federal role, and contribution to central Departmental responsibilities and policies.

The distinctions between R&D and the numerous related activities necessary to bring beneficial innovations to fruition are not sharply drawn in this document. In many cases, demonstration and evaluation of new technologies and operational concepts are the most critical elements in stimulating widespread adoption. Aggressive technology sharing and dissemination efforts may be required to overcome uncertainties or unfamiliarity on the part of the ultimate users. Many users, including state or local governments, are risk averse, and need clear understanding of the technology under consideration and convincing evidence of benefits and advantages.

The descriptions of long-term programmatic thrusts described here focus research and development. However, each is merely one element of a broader DOT initiative that typically includes major demonstration and technical assistance elements as a key means of fostering adoption and implementation of innovative systems and operations. Often those deployment activities are supported under R&D funding categories.

The R&D thrusts set forth above do not comprise the whole of DOT surface transportation research. The Department's basic mission responsibilities necessitate a substantial body of additional ongoing research to support specific short-term functions and mandates. Many of the near-term research and development activities described in Section III of this plan will necessarily extend into a long-term timeframe, evolving as appropriate to future challenges and priorities. Some of these ongoing efforts will be integrated into one of the major R&D thrusts or are closely related, but others--typically more modest in scope and magnitude, or of short-term duration--will be coordinated with other research but will be performed independently. Dissemination and implementation of results will use both existing Departmental mechanisms and new processes based on electronic (e.g., CD-ROM, Internet) document distribution and exploitation of partnerships with the appropriate elements of the transportation community.

Indeed, several of the long-term activities described below are based upon work already initiated, and in some cases specifically called for under ISTEA. These initiatives typically have explicit long-term goals and at least initial strategies for meeting those goals. In accordance with the President's technology policy and the guidance of the National Science and Technology Council, DOT is currently working closely with other Federal agencies and the Nation's transportation community to shape a coordinated and comprehensive long-range research and development program responsive to the challenge of the 1990's and beyond.

Some of the sixteen long-term thrusts described below, such as those addressing applications of information technology, are inherently intermodal in nature or have applications cutting across modes. Others are based on highly specific topics and Federal responsibilities, such as development or revision of particular modal safety regulations. As such, they are relevant to only a single mode of transportation. However, even in those cases, the initiatives will be carried out in a manner that emphasizes use of cross-modal resources, technology transfer with related topics concerning other modes, and exploitation of synergies associated with particular program elements elsewhere in the Department or Federal establishment.

Programmatic Long-Term Thrusts

Goal 1: Promotion of an Integrated Intermodal National Transportation System

Goal 1 Overview

It is widely accepted that the Nation needs a seamless transportation system in which each mode is used in the most effective manner and the connection between modes is rapid and efficient. Achievement of this goal has three components: understanding of the transportation system as a whole, and how the elements relate to one another; improvement of the connectivity among modes; and the financial health of the participating agencies and industries.

The NSTC Transportation Committee emphasized the importance of system-level knowledge and perspective, and ongoing comprehensive transportation system assessment. This includes data, analyses, and assessments of all of the various aspects of transportation and how they interrelate in both the National and the international transportation systems.

The Intermodal Surface Transportation Efficiency Act of 1991 states that 'The National Intermodal Transportation System shall consist of all forms of transportation in a unified, interconnected manner...' The Department's *Strategic Plan* includes the specific objective of a system '...that integrates all modes and emphasizes connection, choices, and coordination of transportation services...' To a very large degree, those people and organizations responsible for the various elements of the transportation system naturally focus their attention on the particular mode which they operate, maintain and renew. The value of

intermodal connectivity is particularly visible in passenger transportation, although many institutional and economic impediments limit progress in this area. However, for freight movement, the challenge is quite different and less visible, but substantially greater in impact.

In an economy that is increasingly service-oriented and based on 'just-in-time' operations, rapid and highly reliable shipment is a necessity. But goods shipments cannot, by themselves, compensate for connectivity gaps in the way that human passengers can. Seamless goods movement requires not only a suitable physical infrastructure, but also efficient exchange of myriad elements of information--still often involving a flow of paper--at every interface. In the context of ever-growing but financially burdened urban areas, it is difficult for planning agencies to formulate and implement transportation investment policies that achieve good balance and integration between passenger and freight movement, and between transportation and other public needs. Further, the institutional complexity is much greater, particularly--due the globalization of trade--with respect to shipments passing through ports and across state and National borders.

The vigor of the National and global transportation systems depends on the condition of each mode. Concerns about institutional economic health predominate in the area of maritime transport. The U.S. maritime industry--shipyards and as well as ship operating companies and ports--plays an important role in both the global and domestic economy, as well as being critical to meeting National security requirements. U.S. shipyards were virtually out of the business of building merchant ships by the late 1980's, but, with various forms of Federal support, are now aggressively competing for entry into domestic and international markets, thereby contributing to job growth and regional economic health.

The efficiency and land and sea accessibility of U.S. ports are critical elements of the transportation system, with strong impact on the health of the entire economy. ISTEA explicitly notes the importance of port access in the metropolitan transportation planning processes, but the severity of land-use issues, the many institutions involved, and frequently greater interest of the public in passenger transportation often thwart attempts to facilitate land goods movements in and out of ports. Revitalization of U.S. maritime transport is a necessary building block to achieving the goal of an effective integrated system that links America to the world, and technology advances may offer important opportunities to lower regulatory, border crossing, and other barriers to maritime transport.

Thrust #1: Transportation System Assessment and Knowledge Base

Rationale and Focus: Transportation decisions, whether made in the public or private sector, must address a steadily widening range of considerations: safety and environmental impacts; economic effects for various segments of the population and the economy, National energy and petroleum consumption, land use and living patterns, international agreements, and global competitiveness and balance of payments. These decisions must be viewed from a long-term perspective as well as addressing immediate concerns. Each year more and more

stakeholders are involved, and the technical realities and uncertainties in each issue become more complex. National goals, embodied in legislation such as ISTEA, ADA and the CAAA, place heavy burdens on state and local agencies for planning and decision making in technically complicated areas. Information and tools for use in assessing and meeting these challenges often are difficult to obtain or simply do not exist.

Transportation data is the starting point for building the necessary knowledge base. Programs and organizations throughout DOT have extensive and often detailed knowledge of specific transportation functions, technologies, operational practices, and other characteristics. However, it is much more productive to link these resources into an integrated whole, creating a system assessment capability and knowledge base that all programs, as well as users across the transportation community, can contribute to and draw upon. The establishment under ISTEA of the Bureau of Transportation Statistics represents the foundation and framework for this initiative.

The Department has also identified related long-term R&D thrusts, discussed later in this chapter, in the areas of safety data and analysis; and environmental impact data, models, and knowledge. Although these can be considered components of an overall system assessment and knowledge base R&D thrust, they are identified with distinct and high-priority challenges. Particular focus on these areas during long-term planning of surface transportation R&D is therefore warranted.

System assessment consists of at least five key elements: performance measures, data, analytical tools, technology assessments, and awareness of current and anticipated trends that affect transportation. Research in these areas will facilitate a balanced long-term response to many of the issues and challenges identified in this report (e.g., economic and demographic shifts, increased and altered demand, environmental and energy constraints).

Performance Measurement: Traditionally, supply and demand have been the most important transportation system indicators. However, they are too narrow, imprecise, or even misleading to be fully satisfactory by themselves as the basis of important investment and operational decisions. Explicit performance and impact indicators are also necessary in order to provide important information on how efficiently and effectively the system is functioning to meet user needs, as well as to describe the effect that these activities are having on other aspects of life such as energy usage, land use patterns and the environment. Much of the transportation-related legislation of the past twenty-five years has expanded the importance of assessing system impacts and, where necessary, mitigating the negative effects.

Performance measurement is becoming increasingly important to decision-making in characterizing the full social costs and benefits of transportation. Performance measurement topics warranting special attention include determining the costs to the economy of traffic congestion, the health effects of vehicle emissions, motor vehicle crashes and accidents, and vehicle energy consumption. It is important to establish the proportion of other impacts that can be specifically attributed to transportation, as opposed to other contributors.

Data Collection: While more and better data is needed, a crucial first question is: why is the data being collected? What data is needed? In what format would it be the most useful? Answering these questions will allow collection efforts to be prioritized, coordinated, and focused more effectively. With consistently defined data, collection will be more efficient and the data will more likely be comparable. By establishing commonly accepted data collection goals at the start, users can also specify the degree of precision and geographic scale desired.

Once the need is identified, data can often be acquired in the course of business or agency operations, or as an overlay on those operations. For example, broad measures of transportation such as passenger-miles, ton-miles and accident and injury/fatality rates can be estimated with reasonable accuracy. However, even in these cases many critical parameters and characteristics remain incomplete. Information such as a traveler's total trip distance, the purpose and total duration of the trip, and intermediate stops are not captured without special survey-type efforts. Similar difficulties confound attempts to understand specific freight movements, particularly when multiple modes and/or providers are involved.

In addition, the categories of information needed can go well beyond the traditional definition of 'transportation' activities. For example, the dramatic reduction of communications costs and the explosion of related services and products can have a major impact on some categories of travel, including home-to-work commuting and even travel for shopping. Similarly, changing demographic and economic characteristics of the Nation and the world have a profound impact on long-term decisions for vehicle and infrastructure planning and investment. Increasing concern over transportation's relationship to quality of life, equity issues, and environmental and energy impacts all create demand for new data.

Thus, today's needs require new and more intelligent data collection efforts. Creativity, continual movement forward, and exploitation of new technologies are all assisting. There is a continual need to improve our ability to synthesize and integrate the various data elements into a more comprehensive view of transportation activities and the full range of their consequences.

Tools - Models and Simulation: Data and information are only one aspect of system assessment. Without analytical models and simulations of how the transportation system works, it is not possible to determine the likely consequences of any change, such as a specific infrastructure investment or a new regulation. This is not only important from the "off-line" standpoint of prospective planning--it plays a key role within the context of iterative "on-line" system optimization and validation.

Improvements and needs in this area are many. Models and simulations with a strong scientific and engineering content are needed to assess the environmental and energy impacts of alternative investment and operational decisions. This is equally true of economic and financial models covering transportation investments and operations, models integrating land use and transportation, and models of institutional arrangements.

For example, a new generation of "activity-based" planning models are supplementing "trip-based" ones, for they look at the reasons for travel and not just the fact that it occurred. These are being developed to help manage future transportation demand, understand transportation's effects on the spatial distribution of the economy, link transportation models with air quality models, and determine whether human needs are being met. As with data, the models created must be appropriate to their audience and usage--in their complexity, assumptions, and scope. For instance, increased accuracy is not always favored when the trade-off is decreased applicability.

Technology Assessments: While the basic technologies on which transportation systems are founded tend to change slowly and in an evolutionary manner, scientific and engineering advances are now so pervasive that long-term planning and major transportation decisions must be based as much on choices expected to be available in the future as on the current situation. In some cases, enabling technologies such as computers and satellite navigation and communication, transportation operations can be nearly revolutionized in a relatively short period. The Department can fulfill its responsibilities only by continually monitoring global progress in technologies affecting transportation, particularly where other nations are in the lead, and disseminating that information to the transportation community. For some topics, this process may require a substantive ongoing research program having the primary purpose of maintaining a public reservoir of knowledge and expertise in a field that is of substantial potential importance, regardless of its immediate priority to the Nation.

Trends and Projections: The inherently very long lifetime of transportation vehicles and infrastructure--sometimes measured in centuries--necessitates an especially forward-looking perspective in transportation planning and investment. The knowledge base needed thus includes not only facts concerning the current condition and performance of the transportation system, but continuing examination of the likely consequences of current trends and sophisticated projections of realistic future scenarios that bear on the future supply and demand of transportation services and systems. As an example, the technology driven trend toward tele-substitution could have dramatic long-term effects, replacing some types of travel while stimulating others.

Basic Goal: Establish a comprehensive transportation system assessment capability and knowledge base, including appropriate system-level performance measures, analytical tools, models and simulations.

Principal Participants: All parts of the Department must be actively involved in this program, which will include extensive outreach to government agencies, trade associations, transportation planning organizations, academia, and other organizations. As a newly created steward for transportation data, BTS will be an important focal point for activity in this area.

Benefits: The basic benefit of the system assessment capability established in this program will be a substantial improvement in the foundation for policy formulation and long-term planning, investment, and operation. The benefits will be particularly great for all levels of

government, but will also be substantial for the private sector and the research community. Establishment of a sound basis for decisions and policy should greatly increase the likelihood of achieving timely resolution of major contentious issues in transportation. This will facilitate a balanced long-term response to many of the issues and challenges identified in this report (e.g., economic and demographic shifts, increased and altered demand, environmental and energy constraints).

Thrust #2: Intermodal Freight Transportation

Rationale and Focus: Driven by parallel trends of global trade and freight containerization, an increasing fraction of higher-value freight is moving intermodally--by ship across the ocean, by truck, rail and barge inland. The seamless movement of goods from origin to destination, rapidly and reliably, is now widely recognized as a necessity for economic efficiency and global competitiveness. A similar capability is required to support military deployments, largely dependent on the civil transportation system, anywhere in the world on very short notice.

One of the most critical elements in achieving this objective is rapid and efficient transfer between ship and train or truck at ports. But the process is complex. Many container ships can carry several thousand containers, and time is of the essence in the loading and unloading process. This is a natural application of highly sophisticated information technology for tracking containers throughout their journey, and particularly in and around ports and when crossing borders. In addition to increasing basic operational efficiency, the electronic processing of shipping 'documents' (information coded into a chip attached to the container) opens a broad vista of improvements.

The nodes linking modes of transportation typically are characterized by the overlapping of many interests and jurisdictions: shipper, carriers, port authorities, city and state governments, Federal customs offices, etc. Institutional and informational connectivity is often a much greater problem than physical connectivity between modes. There are no stakeholders likely to perceive sufficient direct benefits, and having sufficient funds, to conduct the R&D necessary fully to understand the underlying processes and means by which improvements can be accomplished. However, the large societal benefits potentially available--including the impact on National economic health--necessitate a strong Federal leadership role in shaping research of this nature, particularly given the continuing trend toward a high degree of interdependence and diffusion of power among economic and social institutions.

Basic Goal: Develop knowledge and understanding to foster and stimulate effective application of improved technologies and methods to modal connections, and to resolve institutional impediments to improvements at intermodal terminals.

Principal Participants: R&D in intermodal freight transportation will involve close partnerships with port operators, shipping lines, rail and trucking companies, state and local authorities.

Benefits: Further improvements in the flexibility, efficiency, reliability, and cost of freight transportation to, from, and within the United States.

Thrust #3: Revitalization of the U.S. International Freight Transport Industry

Rationale and Focus: International freight transport is critical to this country's participation in the global marketplace. Access to foreign markets is heavily dependent on surface transportation, in particular maritime transport--a key goal identified in the Department's *Strategic Plan* is the implementation of a maritime revitalization strategy. Total oceanborne foreign trade in 1994 had a value of $566 billion, up 13% from the previous year. This trade has been expanding at approximately 7% annually since 1985, and is estimated to increase in coming years at almost a 10% rate. Almost 80% is containerized, facilitating efficient transfer to rail, highway or barge inland transport. Commercial sealift is the primary means of deployment of military assets abroad. Sufficient surge capacity, including readiness for conversion from civil to defense functions of ports and a portion of the commercial fleet, is therefore essential to National security. It is thus important to the Nation that there be a U.S. merchant fleet capable of competing internationally on a cost and service basis. An efficient and effective port system is also essential to U.S. participation in the international transportation system.

In spite of the importance to this country of the maritime portion of the transportation system, US-flag vessels carry only 4% of this trade, and U.S. shipbuilding had declined nearly to zero when a new initiative breathed some life back into that industry. The U.S. has 342 ports, but almost 90% of the total trade was handled by the largest fifty. Access to ports by rail and highway is a serious issue in many cities, with freight considerations often under-represented in the transportation planning process. Financial limitations also play a major role, particularly in expensive undertakings such as raising highway bridges to permit operation of higher-clearance double-stack container trains. From the water side, environmental constraints and related issues focused on disposal of dredged material have posed serious problems for many deep-water ports and can limit access by deep-draft ships.

Between 1982 and 1993, the number of U.S. shipyard jobs declined by approximately one third--a loss of about 60,000 jobs. Further severe decline is possible. Technological advances in ship designs and shipbuilding productivity will be a critical element in restoring the health of this critical sector of the U.S. economy. Similarly, advanced technologies and operating systems are needed to enhance shipping productivity, efficiency in ship and terminal operations, and service quality. Strong Federal participation and leadership, including focused R&D to stimulate and foster industry innovation, is a necessary element of revitalizing the U.S. maritime industry.

Basic Goal: Accelerate the identification, assessment and deployment of improved technologies and operations into maritime transport.

Principal Participants: This R&D will be based on leveraging a small Federal investment through close partnerships with port operators, shipping lines, shipyards and other stakeholders.

Benefits: Revitalization of the productivity, efficiency and overall competitiveness of U.S. maritime carriers, shipyards and ports. Provision of surge capacity essential to National security.

Goal 2: Wise and Efficient Transportation System Investment

Goal 2 Overview

The DOT Report to Congress *1995 Status of the Nation's Surface Transportation System: Conditions and Performance* develops estimates of the Nation's current investment needs for highways, bridges, and transit systems. It indicates that an annual investment of approximately $57 billion would be required from all sources just to maintain current conditions, with $80 billion required to provide a higher level of service by correcting existing deficiencies. Actual investments in 1993 by all levels of government totaled only $40 billion. The need to 'do more with less' is nowhere more apparent than in maintaining the Nation's physical infrastructure for surface transportation.

Central to the surface transportation infrastructure is the almost 4 million miles of paved roads and highways and 575,000 bridges that carry 90% of passenger-miles traveled and nearly one-third of the tons-miles for domestic freight. The annual maintenance cost of this infrastructure, borne largely by states and municipalities, is about $80 billion, and its health and performance is essential to the economic well-being and vitality of the Nation. It must be incrementally restored, renewed, preserved and strengthened. Many elements also require capacity expansion if the growing transportation needs of our Nation are to be served.

More than 80% of total travel occurs on the 22% of the system--850,000 miles--that is eligible for funding through the federal-aid highway program. This program is financed by the Federal Highway Trust Fund, with annual receipts of approximately $17 billion, largely from fuel, heavy vehicle and tire taxes. The first federally financed highway, was completed in 1840, and stewardship of the highway system has been an explicit Federal responsibility since establishment of the predecessor to the Bureau of Public Roads (now the DOT's Federal Highway Administration) in 1893. In November, 1995, the National Highway System Designation Act designated 161,000 miles of highway as being of importance to the economic, defense and mobility interests of the entire Nation.

Public transit, critical to the health and viability of many large cities and to the mobility of their residents, shows similar underinvestment, with $12 billion needed annually to improve conditions and performance, and less than $6 billion available. More than 60% of Federal capital investment in public transit is related to system physical infrastructure. Utilization of new technologies and development of new methods, including tunneling and more-efficient cut-and-cover construction, could have substantial impact on the investment required for system renewal and expansion.

The 1995 Strategic Implementation Plan developed by the National Science and Technology Council's Interagency Coordinating Committee for Transportation R&D defined renewal of the physical infrastructure of our Nation's transportation systems as a high priority area for Federal research and development. Reduction of the backlog of needed rehabilitation and renewal of existing transportation infrastructure poses a challenge that will continue well into the next century. Meeting the critical need to improve the performance of transportation infrastructure, in terms of capacity, life-cycle cost, safety, reliability, and environmental impacts, will result in improved transportation service, mobility, and access for all.

Ongoing research and technical advances of the last few decades now offer the potential to improve significantly the efficiency with which transportation infrastructure in general and roadways in particular are designed, constructed and maintained, thereby yielding important economic and performance benefits. In addition, R&D during the next 10 years will include continuation of a long-term program to evaluate performance of different types of paving surfaces under a wide variety of conditions. Specific elements of the infrastructure investment and renewal thrust, directed toward port, rail, transit and other applications, as well as highways, include improved materials, designs and methods for renewal engineering and use of advanced technologies for inspection, monitoring and maintenance of physical infrastructure and vehicles.

Thrust #4: Improved Materials, Designs and Methods for Renewal Engineering

Rationale and Focus: The Department's *Strategic Plan* establishes as a goal the support for "the use of advanced materials in manufacturing and constructing transportation equipment and facilities. As is discussed in Chapter 2, there are currently substantial transportation infrastructure maintenance and renewal requirements in the U.S., presenting a challenge yet also an opportunity to utilize improved technologies and practices. However, the methods, tools and materials used in transportation infrastructure construction and maintenance change very slowly. It is limited in part by the desire of system owners and managers to avoid the risk of unknown consequences years or decades later, and by the importance in most decision processes of minimizing initial cost. Another constraint is that the supply industries involved may anticipate limited markets and low profits for innovative products, and often exhibit little motivation toward performance of advanced R&D.

However, in other sectors of the economy, various forces have provided a strong incentive for innovation in sophisticated new materials, structural design concepts, and innovative tools and techniques. The challenge in coming years will be to build on this inventory of advances to develop specific transportation-related applications, demonstrate their effectiveness and long-term viability, and reduce their costs to a competitive level. Portions of the Nation's highway system are nearing their design life. Much of the transit system infrastructure has already exceeded its nominal life, thereby imposing high maintenance costs and periodic service disruptions. These factors warrant aggressive examination of the most efficient and practical means to renew transportation infrastructure of all types.

There is also a continuing need for R&D in the context of conventional technologies. Materials used, construction practices, climate and traffic can all vary dramatically, and surface lifetime is normally measured in decades. Establishing the most cost-effective approaches to construction and maintenance of this infrastructure is a complex problem. Intensifying the challenge is the need to find means of infrastructure renewal that minimize motorist delays, congestion and other adverse impacts associated with construction activities on operating systems, such as urban interstate highways.

In response to the need for better information on this topic, the 1987 reauthorization of the Surface Transportation Act established the Strategic Highway Research Program, including as a major element a Long Term Pavement Performance Program (LTPP). The purpose of LTPP was to collect uniform, comparable data on pavement condition, climate, traffic, and load conditions from many road locations over a twenty-year period.

The LTPP is the largest pavement performance research project ever undertaken. It now involves periodic data collection and condition monitoring of approximately 2,500 inservice pavement test sections, located throughout the U.S. and Canada, over a 20-year period. As the data collection and data base development progress, the scope and depth of the data analyses will be expanded to establish the relationships among pavement performance and design, materials, construction, maintenance, traffic, environment, and geographic location.

The very large annual public investment in highway and transit infrastructure, and the many obstacles to private sector or state performance of long-term applied research in this area, require that there be a substantial Federal R&D investment to maximize the cost-effectiveness with which trust fund resources are expended, and to assure the best possible health of the Nation's surface transportation system.

Basic Goal: Stimulate and facilitate the effective use of innovative as well as conventional construction designs, structures, materials and methods in the rehabilitation, renewal and replacement of the Nation's highway system, and other components of the system at large.

Principal Participants: This program will be a implemented though partnerships involving Federal agencies, states, the private sector, and universities.

Benefits: Acceleration of the use of improved knowledge, new materials, designs and processes will improve safety and reduce life-cycle costs of highway infrastructure, permitting a more effective response to the current backlog of infrastructure maintenance and renewal requirements and an improved road system for users.

Thrust #5: Advanced Technologies for Inspection, Monitoring and Maintenance

Rationale and Focus: Transportation infrastructure inspection and maintenance is a rich field for application of the broad and powerful capabilities of non-destructive inspection and testing devices. These findings are valuable both during and after the construction process, and for incorporation into maintenance procedures. New sensing techniques and computer-based analysis tools offer the potential of major improvements in the efficiency and effectiveness of inspection processes. "Expert systems" and other artificial intelligence concepts are increasingly being applied to these types of activity. These and other innovative approaches offer benefits in terms of safety, infrastructure lifetime, and optimized maintenance practices.

One concept is that of "smart structures" in which roads, trackage, highway and railroad bridges and tunnels, ships, shipyards, ports and other facilities have a network of embedded sensors. These sensors can continually provide detailed information as to the structure's condition throughout its lifetime, under normal as well as abnormal circumstances. Large potential benefits are also anticipated from automated highway maintenance systems, based on digital imaging and sensing, sophisticated data analysis, and advanced robotics.

Technologies that support reduced maintenance costs and extended facility service lifetimes offer large annual savings in public expenditures for highway and transit infrastructure. Impediments to private sector or state performance of long-term applied research in this area are such that a substantial Federal R&D investment is needed to realize the potential benefits, thereby assuring the best possible health of the Nation's surface transportation system.

Basic Goal: Stimulate and facilitate the effective use of advanced and automated inspection, sensing and testing technologies for monitoring and inspecting the Nation's highway and rail transportation system.

Principal Participants: The Department will work closely in partnerships with the technology community, highway departments, transit authorities and railroads in advancing inspection system technologies.

Benefits Fewer service interruptions, more efficient maintenance and renewal of transportation infrastructure, and reduced likelihood of catastrophic failure.

Goal 3: Rapid and Effective Application of Advanced Technologies to Transportation

Goal 3 Overview

A highly visible characteristic of the contemporary world is the continuing incorporation into government, business and private life of a steady stream of new technologies, many of which provide expanded functionalities, create new products and services, and make possible alternative ways of organizing and managing economic activity. Just as for other societal activities, transportation is benefiting greatly from this phenomenon. But the pace at which this evolution can occur is inherently limited. Transportation system concepts that are both new and practical are rare, and even incremental improvements can require many years of refinement and deployment before the results are felt.

Long-range transportation R&D inherently requires a distant time horizon. Infrastructure construction can easily require 20 years or more from initial planning to initial operational status. The transportation infrastructure investment timetable contrasts markedly with many private sector investment schedules, which can in some cases be measured in months. Transportation systems and elements -- roads, railroads, harbors, ships, aircraft, transit cars -- generally have a very long service life, best measured at least in decades. The time and effort required to bring about transportation innovation is a daunting obstacle for the private sector, which normally has a very near-term decision and investment horizon. This consideration often warrants public R&D investment to explore new concepts, bring them to the point that they can be evaluated, and demonstrate their advantages convincingly.

One clear reality of the late 20th century is the power of technology and the advances that can be achieved when it is applied properly to the right problems. The personal vehicles, transit cars and aircraft being manufactured 30 or 40 years hence, and their supporting infrastructure, can be expected to offer a dramatic advance in performance and cost, based on refinement and innovation affecting almost every component. But the magnitude and pace of improvements in the next century will depend on the investment of energy, imagination and public and private resources made in the 1990's.

Most of the long-term R&D thrusts discussed in this chapter involve some degree of creation or advancement of technological advances, focused on relatively specific desired outcomes. Those described below represent research in which the new technologies have the potential to induce particularly substantial innovation, and for which the Federal role lies largely in encouraging and facilitating public sector applications of private sector technical advances. Three topics are included here: transportation applications of information technologies (focused on fostering an intelligent transportation infrastructure), advanced propulsion and other technologies for public transit, and technologies to facilitate deployment of high-speed rail systems.

Thrust #6: Application of Information Technologies to Transportation System Operations

Rationale and Focus: The rapid development and interrelationship of computer, sensing, communication and navigation technologies, including the Intelligent Transportation Systems (ITS) concept, is having a powerful impact across the spectrum of transportation operations. Originally nurtured by space- and defense-related R&D, and now driven largely by global business and consumer markets, this revolution is proceeding rapidly in the private sector. Public sector applications, particularly in transportation, are for the most part only in their infancy, but are seen as having great near- and long-term promise. One important and highly visible area singled out in ISTEA and currently being actively addressed is applications to traffic management on urban roads, where congestion often exacts a high societal cost in terms of time, accidents, air pollution and quality of life for all those affected by it. Another important application is railroad positive train control. More generally, the efficiency of transportation system operations, whether on land, sea or in the air, is also critical to the productivity and overall health of the entire economy. In many cases resolution of these problems by construction of physical infrastructure is either not financially feasible, or not a practical possibility.

A large part of the answer to this dilemma is to overlay an information infrastructure on the physical transportation infrastructure--to infuse the system with intelligence. The result will be a system in which information technologies and ready access to many types of information are integrated into virtually all elements and functions to enable greater efficiency and improved performance. The basic paradigm reflected here is to use intelligent systems to obtain greatly improved performance from the basic infrastructure that exists. In addition, the availability of spatial positioning data from the Global Positioning System (GPS) provides a major new resource which can be incorporated into this process.

Private sector applications of information technology, particularly in portions of the freight sector, have been well ahead of public sector deployment. This illustrates the importance of parallel efforts by the technology and transportation communities, including all levels of government, the private sector, academia, and individual shippers, carriers and travelers. Still, much can still be done within the freight sector to ensure full utilization of information technologies.

In response to the opportunity offered by information technologies, Secretary Peña announced in January, 1996, the National goal of building "an Intelligent Transportation Infrastructure (ITI) across the US, to save time and lives and improve the quality of life for Americans." DOT's Operation Timesaver initiative (discussed in Chapter 3 of Section III), involving deployment of key ITS elements in 75 major metropolitan areas, will be both an illustration and an important component of ITI.

The ITI reflects a vision of a establishing a communications and information infrastructure that will enable the realization of a 21st century transportation system, characterized by major improvements in passenger and freight mobility, safety, and environmental

compatibility, all at a cost far less than could be achieved in any other way. The larger result will be substantial benefits to the traveling public, the National economy, and the cost-effectiveness with which Federal transportation funds are invested.

As recognized in ISTEA, and embodied at present in the DOT ITS (Intelligent Transportation Systems) program, there are many ways in which Federal R&D, conducted in close partnership with state, localities and technology providers, can substantially accelerate the speed and effectiveness with which this multi-faceted revolution proceeds. Federal research is necessary to stimulate deployment by assessing the best ways to use these technologies and objectively demonstrate and evaluate the benefits obtained. With the important exception of work focused explicitly on vehicle crash avoidance, treated described subsequently under the Safety strategic goal, the topics discussed below represent the four major federal R&D areas central to fostering the realization of an intelligent National transportation system:

1. Traffic Control and Management and Traveler/Operator Information: The many factors -- economic, environmental, physical, and other -- that constrain expansion of transportation system capacity have motivated intense interest in the potential to obtain better system performance through improved management of traffic, including providing vehicle operators with better information on which to make trip decisions. Public safety and the environment also benefit along with travelers and shippers. It has been estimated that establishment of the ITI is ten times as cost-effective as attempting to meet the urban needs with highway construction, with ten billion dollars of ITI investment potentially achieving benefits that would require 100 billion dollars to obtain through new roads and other facilities.

A particular focus of efforts in this area lies in applications addressing urban traffic management and traveler information systems, particularly for highway vehicles and transit fleets. Actual development of technology is appropriately occurring in the private sector, but without a major Federal role in supporting, guiding and facilitating deployment, including evaluation and demonstration of technical and operational alternatives, implementation of potentially valuable innovations will not occur at the rate necessary for a successful response to current urban transportation problems. Rural areas can also benefit greatly from applications of intelligent transportation. Examples include collision notification systems, traveler information, weather monitoring and public transportation. Similarly, innovative approaches to railroad signal and control systems and management of vessel traffic in port areas offer great promise, although the specific technologies and operational concepts may differ substantially from the highway case.

2. Automated Highway System: Use of vehicle-highway communications sufficient to perform driving functions, and advances in collision-avoidance technologies (discussed below as an element of long-term safety R&D) have given credence to the concept of automated highways. ISTEA calls for a demonstration in 1997 of prototype elements of an automated highway system -- a first step in the very

long-term effort to realize automatic operation of vehicles at high speed and close headways, thereby dramatically increasing capacity and safety. Functions to be demonstrated include lateral and longitudinal control, lane changing, and various malfunction-management capabilities. This goal will require overcoming many technical and societal challenges, but appears technologically feasible. The Department has entered into a cooperative public-private partnership with industry, state government, and academia to further develop the concept.

3. Intermodal and Crossmodal Freight Transportation: Advanced information technologies are also coming into use for fleet management. Real-time tracking of vehicles and cargoes permits a much higher level of optimization than has previously been possible, with continuous matching of resources to demand and adjustment to changing circumstances. A similar application with impressive potential is the use of electronic data transfer between commercial vehicles and roadside at state and National borders, with large consequent benefits in terms of efficiency and service levels. Tagging and tracking technologies can also play a critical role in controlling the movement of containers in intermodal terminals. All of these applications involve extensive and complex interactions among multiple public and private institutions. Federal participation in structuring, facilitating and evaluating innovative concepts and demonstrations can significantly advance the rate of implementation and the speed with which substantial benefits accrue to the entire economy.

4. Positive Train Control: Advances in Positive Train Control can bring about both improved safety and efficiency for freight and passenger (urban and intercity) railroad operations. Positive Train Control utilizing digital data link communications and GPS positioning systems can result in significant reductions in the probability of train collisions and overspeed accidents. A strong Federal role in encouraging and coordinating the development of standards for Positive Train Control will be important to assure the full realization of potential safety benefits including more reliable train detection at grade crossings) available from these expanded capabilities.

Effective and rapid exploitation of the opportunities to be found in transportation applications of information technology will require a substantial and ongoing public-private research and development effort associated with enabling technologies, system configuration and architecture and standards. Creation of effective systems requires not only the basic technology, largely a private-sector responsibility, but also development of a strong enabling framework. Some of the critical topics that call for long-term Federal participation in their resolution them are listed below.

Wired Communications Infrastructure: A powerful communications infrastructure, based in large part on conventional wire and fiberoptic cables, is central to the effective application of information technologies throughout transportation. Many complex technical, economic and institutional questions arise as to how best to provide publicly-owned or commercially-leased local capabilities. Traffic

management and related functions will be a major force in shaping urban public data communication requirements, often integrated with other public organizations including schools, libraries, hospitals and government offices. Federal participation can significantly assist in resolution of these issues.

Wireless Communications Infrastructure: Similarly, increased use of wireless communication throughout the society and economy will require wise allocation and efficient use of electromagnetic spectrum and sophisticated mobile data communications technologies. Resolution of these issues will require a solid technical foundation and cooperative efforts by all parties.

Evolution and Enhancements in Positioning Systems: Many important transportation applications use the highly-accurate DoD Global Positioning System (GPS) for position-finding and navigation. Augmentation to improve precision for civil use is now being pursued. Many technical as well as financial and institutional issues must be resolved to assure that this system evolves and is managed in a manner that fully reflects the growing needs of its dominant user, civil transportation, and effectively supports functions of surface modes.

Digital Spatial Database: GPS position information is of limited value unless it can be related to digital maps based on a common reference coordinate system, with that map accurately representing facilities such as roads, waterways, airport runways, etc. A high degree of commonality and precision is required, including standards for data interchange and identification of transportation-related elements.

Weather Information Requirements and Integration: Weather information, sometimes on a very localized and short-term scale, is of great importance to the operation of transportation systems, and will play a key role in the value of some information technology applications. Appropriately-detailed forecasts can occur only if the requirements are well-defined, made known to the National Weather Service and others, and if means are developed for information interchange and dissemination.

Data Exchange Standards and Protocols: The basic protocols for electronic data interchange are being addressed by appropriate trade and technical organizations, with the federal government playing an important role in facilitating the process. However, the pace of technical change associated with this subject will necessitate ongoing efforts to assure continuing hardware, software and data compatibility and interoperability.

Assessment of Congestion, Safety, Economic, Energy and Environmental Benefits: The rate at which innovative traffic management technologies are applied will depend in part on the confidence that implementors--often state or local governments--have in the public benefits offered, and in their ability to estimate those benefits in a particular context. Confirmation of the high cost-effectiveness of ITI applications

compared to construction of physical infrastructure will be of great importance in furthering these systems. Assessments of this nature can be complex, and typically require a significant R&D and evaluation component in initial deployment efforts.

Evolution of System Design Principals, Configurations and Software: The just-developed National ITS architecture provides an effective framework for proceeding with system surface transportation implementations. However, the rapid pace of evolution and use of information technologies throughout transportation will call for ongoing refinement and extension of that foundation, and will force public and private organizations to contend with continually changing alternatives in making major transportation system investments. Development and realization of strategies for dynamic traffic management, combining sophisticated sensor arrays and calling for substantial computing capacity, will require continuing public and private R&D. The degree to which computing capacity is best centralized or distributed among subsystems will be highly specific to each implementation, but federal participation in characterization of alternative generic configurations and development of design tools will assist significantly in wise decisions. Similarly, development and evaluation of dynamic traffic management and control software, with appropriate incorporation of human participation, will be an ongoing challenge as implementation efforts grow in complexity and come to play a dominant role in urban traffic operations.

System Reliability and Vulnerability: Increased complexity of ITS systems and greater dependence on them will require a high level of reliability and robustness, including "graceful degradation" in the face of subsystem failures or extreme circumstances. Similarly, a transportation system permeated with information technologies could have significant vulnerabilities to terrorist and other malicious attacks focused on introduction of false information into the system or interference with computer and communication system operation. Coordinated federal research in these areas, drawing extensively on expertise from non-transportation applications, will benefit the entire IT community, and particularly the public sector.

Human Factors in System Design and Operation: As electronic information sources become more and more a part of traffic management and vehicle operation, many safety issues arise. How should the human role in operation of traffic control centers be organized? How should information be displayed to controllers? How can warnings and critical information best be provided to operators? At what point do operators become overloaded and unable to accept or act upon the information? What is the potential for misunderstanding or reliance on a defective system? It is important that these issues be clarified prior to widespread deployment.

Basic Goal: Stimulate and facilitate the application of advanced information, management and control technologies and systems to the operation of surface transportation systems and dissemination of trip-related information to travelers and vehicle operators.

Principal Participants: DOT will work closely, often through consortia and partnerships, with local and state governments, trade and professional groups, and affected users in exploring new technologies, developing standards, facilitating resolution of major issues, and conducting enabling research.

Benefits: Accelerated introduction of advanced information technologies into the nation's transportation system with resultant substantial benefits to the economy and the traveling public. These benefits will include reduced congestion and less time spent in urban travel, ready availability of travel-related information, reduced air pollution, fewer accidents, and elimiNation of delays for freight moving across state and National borders and other points requiring exchange of information. Information technologies will also greatly reduce the public cost of enhancing highway and other system capacity.

Thrust #7: Advanced Technology for Intermodal Public Transit Systems

Rationale and Focus: The U.S. transit industry has seen little change in the technologies available to it during the last decade, and energy consumption remains the single largest rail system operating cost after labor. Technological advances are required to reduce these costs, to improve system safety and security, to improved the ability of transit vehicles to accomodate disabled individuals, to improve environmental characteristics, and to reduce overall life-cycle costs. However, technology development has been stagnant while weak market conditions have resulted in financial difficulties for transit equipment suppliers and the withdrawal of many firms from the market.

The limited financial capacity of the transit operating industry, its suppliers and the state and local governments which support it precludes their undertaking unassisted major technology development projects. After two decades of declining transit R&D, the transit industry needs a major infusion of advanced technology. While capital investment is needed to stimulate the market and provide for needed service, innovation is needed in parallel to maximize the return on these investments.

Technology available in military, commercial and consumer markets has shown dramatic advances (e.g., train control and communications, propulsion systems, Computer Aided Design or CAD tools, composites), but the transit industry generally continues to procure systems based on technologies developed twenty or more years ago. To provide higher-quality and more economical service to the public, the transit industry must take advantage of the availability of new materials, subsystems, communications and design concepts. Examples include application of advanced materials to transit rolling stock and introduction of propulsion systems offering improved environmental and energy characteristics.

Federal support is necessary if work of this type is to be fostered to the degree warranted by potential benefits. In particular, support for the development of clean and quiet low-floor buses and automated passenger train location and management technologies will be important to the improvement of transit service in the U.S.

Basic Goal: R&D directed toward effective application of available technologies to transit vehicles and physical infrastructure can be focused on the following goals:

- Improve the quality and effectiveness of transit vehicles and infrastructure;
- Improve transit service and operations;
- Stimulate technology development within the U.S. transit industry;
- Expand domestic and world-wide markets for transit-related equipment;
- Enhance the urban environment through improved mobility, reduced traffic congestion and reduced transit vehicle emissions.

Principal Participants: Private industry's role will be to design and develop needed technology, and work jointly with the participating transit property to demonstrate and deploy it. Close cooperation and coordination between transit properties and the manufacturers will help ensure a ready market for the final technology product. The public transit agency's role will be to define needed systems and equipment, define performance specifications, and provide for demonstration and deployment at the property. DOT will provide overall guidance and oversight, and will work closely and coordinate all phases of the initiative with the National laboratories, transit authorities, and private manufacturers.

Benefits: This initiative will yield the following benefits:

- Advanced train control and communications systems will allow for greater capacity and safety, better asset utilization, and improved customer service and schedule reliability.
- Clean propulsion systems for transit buses will result in significant improvements in urban air quality, helping cities to meet air quality standards.
- Development of advanced composite materials will result in lighter, more efficient and accessible buses and railcars.
- Use of computer-aided design technologies for buses and railcars will reduce the design cost of new equipment and yield customer-responsive new designs.
- Technology advances will stimulate the domestic transit manufacturing and supplier industry, increasing production and enhancing prospects for export sales.
- Overall, the development of advanced technologies will result in major improvements in the quality of transit service provided in the U.S. while

increasing the competitiveness of the U.S. supplier industry in the world market.

- Advances will, in many cases, be transferable to other transportation modes (e.g., airport service equipment, Coast Guard vessels, heavy trucks, etc.)

Thrust #8: Technical Foundation for High Speed Ground Transport Systems

Rationale and Focus: The Department's *Strategic Plan* establishes as a goal the promotion of "high speed rail as a viable transportation option in select corridors." During the last decade, active consideration of high speed ground systems has grown, driven partly by the "technology push" of advanced passenger trains developed abroad. But "market pull" has also played a role. Congestion and delays at major airports, as well as environmental and energy/petroleum consumption issues have stimulated considerable interest in providing an alternative to the airplane and the motor vehicle for intercity travel. The primary market for rail service is generally perceived to consist of trips of 100 to several hundred miles in length. Continued progress in this area will be important to the Nation's ability to meed the challenge of increased demand and tourism in such markets.

The financial feasibility of high speed ground transportation corridor operations has been explored in depth by many states and regional consortia during the last decade. Although financing has proven to be a key obstacle, many believe that high speed ground transportation ultimately will be a necessary part of the National transportation system in at least several U.S. corridors. Current planning efforts in several states focus largely on incremental speed improvements based on relatively low-cost enhancement of existing rail infrastructure.

A wide variety of proven high speed passenger rail rolling stock is available as a result of past development activities, largely conducted overseas. However, specific adaptations to the needs of U.S. service will be required, necessitating explicit research activities. For example, most high speed passenger train technology uses electric propulsion. Virtually the only portion of the U.S. rail system currently electrified is along the Northeast Corridor. While existing rights of way and track can form the basis of many other intercity corridors, the cost of electrification is daunting, particularly when potential demand is modest or uncertain. Further, this constraint makes it very difficult to initiate even trial service on an experimental basis.

Many routes might well prove viable for higher-speed trains, in the range of 100 to 125 MPH or faster, but a non-electric, high-acceleration locomotive is required. Diesel-electric and gas-turbine-based designs have been considered in the past, but a fully satisfactory locomotive for this type of U.S. service has so far been unavailable. Development of state and regional rail corridors can proceed only with availability of suitable rolling stock, but hardware development is beyond the financial capabilities of those bodies, and industry typically does not see a sufficiently large or assured market to undertake the needed R&D

independently. Federal participation in development, test and demonstration is therefore necessary to establish a technological context in which public and private bodies can proceed to implement new rail services of the type needed.

Regardless of the rolling stock used, passenger rail systems operating at speeds above those addressed by existing U.S. standards are now being planned by states and public-private consortia for application in this country. This will necessitate research to establish Federal standards relating to the safety of high speed rail systems.

Two other elements are also critical to the viability of U.S. high-speed intercity rail systems: advanced train control, and means to eliminate the hazard of grade crossings on high-speed lines. Signal and control technology is required that will maximize the capacity of a rail line for mixed (commuter, freight, intercity passenger) service and assure safety at significantly lower cost than conventional systems. Where highways cross rail lines, the cost of grade separation is often very large, and local land use or other circumstances may not even permit that solution. Innovative barrier systems or warning devices that provide nearly the same level of safety would be an important step in advancing the introduction of high-speed rail corridors. The Department must also monitor offshore progress in this area (e.g., higher speed magnetic levitation systems) in order to anticipate potential new opportunities.

Basic Goal: Establish a technological foundation, including safety standards, sufficient to enable implementation of improved, higher-speed passenger ground transportation service by public and private bodies.

Principal Participants: The Department will work closely with equipment suppliers, Amtrak, and state and regional bodies in defining the needed rolling stock characteristics and in shaping and implementing a program of development, test and evaluation.

Benefits: Improved transportation service in high-density markets. Reduced demand pressure on congested airports. Widening of options available to cope with trends toward increased demand and tourism, and emerging demand patterns.

Goal 4: Prudent measures to Enhance Transportation Safety and Security

Goal 4 Overview

Maintenance and enhancement of the safety of the Nation's transportation system is the most central mission of the Department. Personal and system-level safety and security remain a chief concern of U.S. citizens, and long-term R&D in this area is essential as the Nation continues to emphasize risk-based regulatory processes. Every major element of DOT has explicit safety responsibilities, and the Department is particularly sensitive to cross-modal opportunities for increased safety and security. Most of the DOT effort specific to surface transportation focuses on highway safety, which accounts for more than 90% of all

transportation deaths and injuries. In addition, DOT also has a key role in assuring safety and protection from malicious acts in rail, pipeline, air and waterway and maritime transportation. Prevention and mitigation of land- and water-based freight-related accidents is important not only from the standpoint of deaths and injuries, but also to prevent major financial and environmental losses.

Consideration of potential safety benefits and impacts is naturally included in virtually all Department R&D. However, some research is motivated totally by the potential to achieve significant safety advances, or to minimize the cost and operational impacts of measures necessary to reduce transportation-related risks to people and goods.

Many approaches can be enlisted in the service of safety: education, formulation and enforcement of laws, vehicle and infrastructure regulations and design standards, and technological innovation. Whatever the mechanism, research is typically a necessary element in defining specific problems and opportunities, shaping and implementing strategies, and in assessing benefits and costs of alternatives, including those that have already been implemented. Emerging issues, such as global harmonization of vehicle standards and adoption of cooperative risk management practices as a partial replacement for direct regulation of vehicles, infrastructure and operations, raise new questions that can only be answered with expanded knowledge.

Safety-oriented research has many elements. The areas of major emphasis in the Department's long-term program in R&D to improve surface transportation safety and security can be described in terms of four broad topics:

- Accident Avoidance
- Accident Survivability
- Safety Data and Analysis
- Security in Public Transportation

Thrust #9: Accident Avoidance through Technological Advances and Improved Understanding of Human Performance

Rationale and Focus: The first priority in safety is prevention -- stopping accidents before they occur. The great majority of transportation accidents involve at least some degree of operator error brought on by fatigue, inattention or incapacitation. Significant safety challenges arise from the expected growth of the older segment of the population. These users and operators may have diminished night vision, and some degradation of other physical abilities needed for safe vehicle operation. Other issues relate to restrictions imposed on commercial drivers and other operators. An appropriate response to these concerns can

be resolved only on the foundation of solid understanding of human characteristics as the relate to vehicle operation.

Technical advances, particularly in information technologies, now offer many possibilities in terms of devices to warn operators of unsafe circumstances, and to suggest or even initiate corrective actions. The Intelligent Transportation System program discussed previously specifically includes elements intended to assure full exploitation of these opportunities. Additionally, innovative means of inspecting and monitoring the condition of vehicle and infrastructure components, periodically or while in operation, can make it possible to take corrective action before an accident occurs.

A wide variety of R&D activities are thus associated with the topic of accident avoidance. For conciseness, they are discussed here in two broad groups: human performance and applications of advanced technology:

Human Performance: Research directed toward better understanding of operator performance in transportation systems now offers great promise. As these results are incorporated in vehicles, highways and overall system design and operation, and accompanied by new technological aids to provide information and alerts to operators, dramatic safety benefits will result. Greater knowledge of how and why operational errors occur also facilitates working with service operators and equipment suppliers to manage and reduce risk with minimal regulations, and to assure that introduction of new vehicle technologies and operator aids, including wayside-vehicle traffic advisories, do not carry with them unanticipated safety hazards. New simulator capabilities, such as that now being completed for motor vehicle operator research, will add substantially to understanding of operator behavior and decision-making, and assist in evaluation of the human-machine interface.

The complex effects of fatigue and stress are often in question when accidents occur. Understanding of these topics in the context of operations in each mode of surface transportation, and how they relate to operational and management practices, is necessary to guide the actions of private system operators and governmental regulators.

Accident Avoidance Technologies: An important use of advanced information technology applications in transportation is the deployment of devices to improve operator awareness, warn operators of hazardous circumstances or imminent threats, or initiate responses to hazards.

The Intelligent Transportation System (ITS) program, for example, includes a substantial component that seeks to exploit these possibilities. The ability to exchange information between vehicles and wayside, whether by on-board devices or variable message signing, will be an inherent part of the traffic management and traveler information systems discussed previously, and will be important from a safety

perspective. However, there is an important additional category of opportunities that relates to purely vehicle-located systems. Examples include means of providing night vision aids, "smart cruise control" that maintains a safe distance from the vehicle ahead, collision warnings or automated braking, devices to detect vehicles in a the blind spots that can occur on each side of a car, and sensors to detect that operator alertness has dropped to a hazardous level.

Beyond the obvious safety import of such technologies, these concepts can also contribute to the reduction of congestion and its environmental consequences. Programmatic thrusts in this area include evaluation and demonstration of the effectiveness crash avoidance technology, assurance that no ITS in-vehicle systems compromise safety, and facilitation of commercialization of safety applications. Other topics discussed previously also have significant safety elements. For example, improved train control systems, whether for transit, commuter or intercity operations, are key to achieving high capacity and operating efficiency without compromising safety.

While most familiar in the highway context, these technologies and concepts are being applied to all modes of transportation, including air and rail operations, 'smart ships,' and vessel tracking systems to prevent incidents. Opportunities for sharing information and research developments in accident avoidance technologies between modes are particularly fertile. Special situations like railroad-highway at-grade crossings could benefit from a wide range of technological countermeasures. Many technical, behavioral, economic and other issues arise in determining to what degree such technologies may actually prove to be cost-effective safety devices, but the promise is sufficient to warrant long-term efforts to assess these approaches and take steps to implement their widespread use if found sufficiently beneficial.

Many accidents are associated with failure of specific components, such as railcar wheels, track failures, or structural elements of bridges. Properly focused research can provide high payoff in identifying failure modes and mechanisms, suggesting design and construction improvements, providing better ways and devices for detecting problems prior to final failure, and predicting potential risks associated with new operational environments (e.g., greater speeds and vehicle weights, electrification of rail lines).

Development and use of test facilities and simulators is commonly a necessity for the specialized types of research needed for real understanding of the fundamental causes of accidents and preliminary evaluation of countermeasures.

Basic Goal: Reduce the occurrence of accidents in all modes of surface transportation through the application of human-centered technological aids and systems in design, construction and operation of transportation system elements, and the development of enhanced understanding of human performance and behavior.

Principal Participants: The department will work with the technology community, vendors, transportation companies and the automobile industry in assessing and exploiting new devices and systems that assist operators in avoiding accidents. Human performance R&D will draw on all appropriate Federal agencies, as well as academia and industry.

Benefits: A safer transportation system, with reduced deaths, injuries, suffering and property loss, accompanied by a diminished transportation burden on the U.S. health care system. Reduced transportation vehicle repair costs and, potentially, reduced insurance premiums (e.g., automobile insurance).

Thrust #10: Accident Survivability - Crashworthiness and Biomechanics

Rationale and Focus: For the foreseeable future there will continue to be millions of highway crashes every year, largely involving personal motor vehicles. Other surface transportation accidents are much less frequent, but kill or injure many people in ways that can be minimized. In addition, freight-related accidents (e.g., derailments, tanker vessel groundings) are sporadic but sometimes cause major financial and/or environmental losses. Improvement of vehicle crashworthiness and accident survivability therefore remains an urgent priority. Advances in basic understanding and modeling of biomechanics and accident dynamics will pay large safety dividends in all modes of passenger transportation, and will permit performance of regulatory missions in a manner that minimizes the cost and burden placed on all parties.

Although this area has benefited greatly from extensive research over the years, knowledge of the biomechanical properties of the human body and the details of crash dynamics is still far from complete. However, the opportunity now exists to make a major breakthrough in this area. Recent advances in computer modeling and related disciplines, coupled with improved instrumentation and experimental capabilities and medical imaging technologies can now greatly increase our ability to understand and analyze the detailed mechanical interactions that occur during a crash and design increasingly effective countermeasures. Advances in this area, though primarily focused on highway vehicles and physical infrastructure, are equally important in improving rail and transit safety. An additional benefit of this type of research is establishment of a solid foundation for performance-based cost-effective safety regulations and design standards and guidelines.

It can be the case that vehicle designs focused on crashworthiness may accentuate aggressiveness in terms of the consequences for the vehicle it strikes. This could particularly be the case for ultralight vehicles using ultrastiff structures. The complex but critical topic of vehicle aggressivity and fleet compatibility will be an important component of future crashworthiness research. Given the global nature of the automobile industry, this will necessarily require a high level of international cooperation and give added impetus to the importance of harmonizing vehicle safety standards.

Basic Goal: Reduce the occurrence of death and injury in accidents in all modes of surface transportation through enhanced understanding of the biomechanics of the human body and improved design and construction of vehicles and infrastructure.

Principal Participants: This work will involve close partnerships with academia and the affected industries.

Benefits: A safer transportation system, with reduced deaths, injuries, suffering, accompanied by a diminished transportation burden on the U.S. health care system.

Thrust #11: Safety Data and Analysis

Rationale and Focus: Whatever the Federal role in a particular area of transportation safety, ongoing collection and analysis of safety data for all modes is essential to identifying emerging problems, assessing effectiveness of current activities, and providing information and guidance to individuals and organizations as to how best to promote safe transportation. Comprehensive and accurate accident data identifying causal and contributory relationships including those of human factors origin is particularly important in assuring the cost-effectiveness of regulatory actions.

Basic Goal: Provide a strong statistical and analytical foundation of knowledge concerning surface transportation accidents and incidents in order to support safety advances by all elements of the transportation community.

Principal Participants: Federal data collection and analysis draws extensively upon cooperative efforts with states and localities, as well as partnerships within the transportation and insurance industries.

Benefits: More effective shaping and implementation of transportation safety programs, resulting in a safer transportation system. Improved ability to implement risk-based regulatory processes.

Thrust #12: Security in Surface Transportation

Rationale and Focus: Recent events have made it clear that surface transportation systems, in particular public transportation systems, are highly vulnerable to malicious attacks, whether by vandals, deranged individuals or terrorists. The relatively low frequency of such incidents over the last decade provides no assurance that serious threats will not materialize with little or no warning. In addition to the potential for loss of many lives, public perception of a threat can significantly reduce ridership even when the actual risk is minuscule. Transit systems, buses, and passenger railroads which serve very large numbers of travelers cannot be protected through highly localized access-control methods associated with commercial aviation. However, given a clear understanding of the nature and reality of

the problem, there are many countermeasures available to system operators to deter or prevent incidents, mitigate their consequences, and reduce the anxiety of their riders.

Effective planning, management and implementation of emergency response procedures similarly depend on a sound understanding of the nature of the possible threats and the characteristics of various response strategies; focused R&D is a necessary step in creating this understanding.

New technologies may hold promise for crime reduction and counter-terrorism in transit. FTA is the formal sponsor of an interagency chemical weapon detection test in one or more subway system(s). The National Security Council's (NSC's) Technical Support Working Group is providing funding and program support. In addition, the DOT Office of Intelligence and Security is collaborating on independent research that may lead to one or more patent applications for new approaches to ensuring track integrity and avoiding collisions.

Recent attacks on transit systems in the United States and overseas demonstrate the need to have effective security technologies to ensure the safety of the riding public. There is a need to identify and assess the vulnerabilities of U.S. urban transit systems to terrorism. Following such an assessment, an effort should be made to identify technological and procedural solutions that have the potential to make mass transit systems a less desirable target.

Resources to conduct technological security projects have been limited given the legislatively determined mandates of FTA's R&D program. The main thrust of FTA's efforts have been to provide continuous promotion of transit safety and security through technical guidance to the transit community. Transit systems collect and disseminate information on safety and security concepts, identify and implement best practices, and follow system safety and security guidelines. These actions aid in the design of their safety and security procedures and provide a means by which to compare local actions that address this issue. The FTA encourages transit authorities to develop and implement both a system safety and security program plan which covers passengers, vehicles, and facilities. This will ultimately aid in the reduction of incidents or accidents involving people or property.

Basic Goal: Identify technological and operational means of enhancing the security of public surface transportation systems and facilities against crime and malicious attacks, improve emergency management planning.

Principal Participants: DOT will work closely with public transit authorities and public and private experts in security matters in addressing this challenging area.

Benefits: Improved personal and system-level safety and security, and more rapid and incident-specific response to emergencies.

Goal 5: Harmonization of Transportation with Environmental Concerns

Goal 5 Overview

The construction, maintenance and use of transportation facilities and vehicles carry with them a wide range of environmental impacts. The many and complex interactions between transportation and environmental quality carry with them serious challenges and conflicts that the Department has a clear role in addressing. Major transportation infrastructure investments invariably raise many questions concerning a wide range of possible environmental impacts.

Most large urban areas are struggling to achieve cleaner air, even while highway traffic continues to increase. Concerns with environmental impacts of infrastructure construction in some cases greatly delay or even preclude much-needed expansion of capacity and congestion relief. Noise associated with transportation, particularly near airports and highways, is a continuing topic of controversy. Port authorities cannot carry out needed dredging due to concerns over disposal of the waste materials; port and air terminal ground access problems, associated in part with concern over societal impacts, can constrain the efficiency and performance of the entire system.

National and international environmental policies, regulations, legislation and executive orders can impose constraints and requirements on transportation that may have serious consequences for the movement of people and goods, but which are not readily perceived by those outside the transportation community. Transportation-related decisions by state and local governments often raise contentious issues made even more difficult to resolve by a lack of credible and objective technical information.

Assessment of environmental impacts, and of proposed regulatory and other strictures, is a process often hampered by inadequacy of the data available and the models for predicting outcomes. In many transportation-related areas, DOT's participation in the necessary research is essential if the transportation perspective is to be fully appreciated and represented in formulation of policy and laws, and if the transportation community is to be made aware of future demands it will have to meet.

Better information and analytical tools can lead to more informed discussion of issues, but will not necessarily lead to 'transportation-friendly' decisions. It is also necessary to develop technologies and strategies that prevent or mitigate adverse environmental impacts. Market forces, often driven by regulations, can generate needed advances effectively in some areas, such as the private motor vehicle. However, particularly in situations involving public sector ownership or operation, Federal participation and leadership is necessary to stimulate and foster improvements.

Two types of R&D are needed in this area: an expanded environmental knowledge base, and advances in environmental engineering and technologies.

Thrust #13: Environmental Impact Data, Models and Knowledge Base

Rationale and Focus: Assessment of environmental impacts, and of the cost-effectiveness of countermeasures, is in most cases a very difficult process. For example, urban air pollution depends in part on vehicle emission characteristics, emissions associated with other activities and by natural phenomena, patterns of travel, weather and climate conditions, and very complex atmospheric chemistry and physics. Moreover, it is often not possible to predict accurately the travel behavior changes that may be associated with a particular change, whether involving road construction, traffic control, or demand management. Even more fundamental, the health consequences of particular types and levels of pollution remain a subject of debate and research.

As a result, many uncertainties surround the environmental aspects of major transportation investment and regulatory decisions. This can be a an especially serious problem for local government planning bodies who often lack the sophisticated tools and technical staff to deal with the complexity of the issues. Problems can also arise in the degree to which environmental regulatory agencies appreciate the transportation impacts of their decisions. Since the consequences for transportation system performance, public health and overall quality of life can be severe, it is critical that DOT conduct a wide range of research activities focused on clarifying all aspects of major transportation-related environmental issues. This topic also has a large international component. International agreements to limit emissions of carbon dioxide and other gases could have profound consequences for domestic transportation. Rules agreed to by the International Maritime Organization (IMO) on, for example, criteria air pollution emission rates, will affect all shipping to and from U.S. ports.

It is therefore necessary to develop the data and analytical models sufficient to provide a comprehensive environmental knowledge base to support decisions, policy formulation, and transportation investments in all modes.

Basic Goal: Further develop data, validated models, and a comprehensive knowledge base to support analysis of transportation-related environmental impacts and alternative strategies by all levels of government and the private sector.

Principal Participants: The Department will work closely with EPA and other responsible Federal agencies as well as state and local environmental authorities, National Laboratories, the private sector and academia in advancing knowledge in this area.

Benefits: Improved ability to respond strategically to environmental objectives, and to prospectively characterize the implications of those objectives.

Thrust #14: Environmental Engineering and Technologies

Rationale and Focus: Given the existing framework of environmental legislation and regulation, and the simultaneous need for transportation system renewal and--in some cases--expansion, satisfactory resolution of conflicts between transportation and the environment often requires technical advances. For example, currently-available means for disposing of dredging spoil are often not adequate, and major ports risk reduction of their capabilities if sufficient depth cannot be maintained. Other problems relate to wastes and emissions generated by ships in ports. Highway runoff, including de-icing materials, can threaten local water supplies. Wetland rehabilitation may be a requirement for facility construction to proceed. Effective means are needed for cleanup and remediation when spill incidents occur, whether on land or water. In addition, means to improve prevention of waste generation, air pollution, runoff, and spills will be important.

The complexity and subtlety of environmental impacts is such that the technologies and strategies needed can require many years for full evaluation. The Department has a central role in this process not only with respect to the infrastructure-related examples presented above, but also in the assessment of technologies developed to mitigate vehicle-related environmental impacts. For example, the Department must be able to evaluate the potential safety implications of technologies reducing vehicular fuel consumption, which range from advanced structural composites to high-speed flywheels.

In its *Strategic Plan*, the Department has established a number of objectives in this area: support for commercialization of the "Clean Car Initiative", support for the use of advanced materials, introduction of low emission and alternative-fueled vehicles into the DOT fleet, vigorous implementation of marine pollution agreements, and aggressive implementation of the President's Global Warming Initiative.

Many of the concerned parties are state and local government units, and a wide range of suppliers and vendors may be involved. In addition, R&D in these areas may be difficult for the private sector to tie directly to a reliable short-term financial return. It is therefore not a need that can be left entirely to the private sector; a strong Federal role is required in some areas to assure successful innovation in technologies to prevent, mitigate and remediate environmental problems.

Basic Goal: Identify, develop and demonstrate and foster the use of improved tools, technologies and methods to avoid and mitigate adverse environmental impacts of transportation.

Principal Participants: In this area DOT will work closely with appropriate Federal and state agencies (e.g., U.S. EPA, state-level transportation and environmental agencies) and affected industries (e.g., transportation vehicle manufacturers), as well as with academic specialists.

Benefits: More effective and efficient means of minimizing adverse environmental impacts associated with transportation. Reduced air pollution, waste generation, runoff, and spills from the transportation system. Improved methods for disposal and remediation of transportation-related waste and pollution.

Goal 6: Incorporation of the Needs of the Traveling Public into Transportation

Goal 6 Overview

Mobility is a central part of daily life including access to work, education, recreational, social, and religious activities and those outlets necessary to support basic needs. Mobility is the linchpin to full living and participation in society. The automobile in particular, and the infrastructure that supports it, provide a level of individual mobility that is unparalleled. To a very large degree the personal motor vehicle is assumed in land use patterns and commercial development plans.

However, the auto may not be available to all Americans, or may not be the most viable, safest, nor most affordable transportation alternative. Many Americans, due to physical disability, age, location, or economic capacity do not have use of an automobile, and can thereby be denied access to key life activities. Public transit, where available, may have barriers to its full use, making it less than an equitable alternative to the auto. These constraints include physical barriers to access, reduced or no service to certain locations, or lack of coordination with other service providers.

Research in support of this goal will be essential to meeting the challenges posed by changing demographics, increased demand, and changing and emerging demand patterns. Such R&D can be divided into two major long-term thrusts: accessibility for persons with disabilities, which will result in physical and system-level improvements that are specifically designed to improve the mobility of Americans with physical disabilities; and transit system innovation, which will yield more generalized improvements to transit system accessibility and utility for *all* Americans.

Thrust #15: Accessibility for Persons with Personal Mobility Limitations

Rationale and Focus: Billions of dollars are invested annually in the Nation's transportation system infrastructure. Access to this system for all Americans is a chief priority, and the Americans with Disabilities Act (ADA) of 1990 requires equal access in public accommodations and transportation. Policy equity and economic productivity goals demand that Americans with disabilities be able to access the system to live full lives and to meaningfully contribute to society. The long-term trend toward aging of the population makes this an even more crucial issue.

Over 45 million Americans have a disabling physical limitation or medical condition. Persons with disabilities are often very dependent on public transit. In its *Strategic Plan*, the Department has established the goal of ensuring "mobility in all transportation modes for those Americans with disabilities." Technical advances in structures, planning, and facilities construction promise to greatly improve access to transportation for the physically disadvantaged. In addition to technical improvements, the development of planning guidelines and regulations to assure the use of appropriate elevators, walkways, doors and other facility components may greatly improve the mobility of disadvantaged persons by enabling the use of public transit services.

Pursuant to the DOT regulation implementing the ADA (49 CFR Parts 27, 37, and 38), every public transit operator must make their rail, bus, and demand responsive service accessible. With capital funding assistance from FTA, transit operators have already equipped 60% of the transit bus fleet with lifts or ramps.

As our population ages, the portion that has difficulty carrying out basic life activities will likely increase. The implications for transportation services are becoming more clear as this trend progresses. The HHS Administration on Aging provides funding for transportation services under Title III of the Older Americans Act. Most senior citizen centers, nutrition and medically-related programs, both in rural and urban settings use demand-response transportation systems. In a demand-response system, the elderly must phone in a request to receive a ride to service programs.

As programs not primarily engaged in transportation, the ADA rules that aging service providers must ensure that their transit systems, and not necessarily the entire fleet of vehicles, are accessible when viewed in their entirety. This translates into providing comparable service to older persons with or without a disability. Eligibility is more of a concern with the elderly use of paratransit services on fixed routes. Because public transit systems are being required to operate paratransit services without additional funding, they may restrict the number of paratransit users. This could affect the older transportation population.

The program that has been developed by the Federal Transit Administration to assist the agency with the Americans with Disabilities Act is entitled Project Action (Accessible Community Transportation in Our Nation). The objective of the program is to assist in the improvement of access to transit services that will enable many of our Nation's more than 45 million people with disabilities to take better advantage of opportunities in employment, education, housing, and recreation. The program is a National research and demonstration activity designed to involve National and local organizations representing public transit operators, the transit industry, and persons with disabilities in the development of cooperative model programs promoting greater access to mass transportation.

Basic Goal: Assess and demonstrate technologies and concepts that enhance the accessibility of public transportation to disabled individuals. Better accommodation of changing demographics and transit-related mandates.

Principal Participants: The Department will work with the special needs community, technology community, transit properties, and state/regional transportation providers in identifying and promoting new approaches to improved access for the physically disadvantaged.

Benefits: Improved access to jobs, health care, education and other life activities to the physically disadvantaged.

Thrust #16: Intermodal Transit System Innovation

Rationale and Focus: It is today technologically possible to deploy "smart paratransit" systems that use ITS technologies (e.g., cellular communications, digitized maps, and computer-optimized dispatching) to maximize the utility and convenience of demand-response highway-based transit (e.g., passenger vans). Real-time ridesharing is one example of transit system innovation encouraged through FTA's Advanced Public Transit Systems (APTS) program. Such systems provide improved mobility to Americans with physical disabilities that limit their access to automobiles and/or current transit systems.

These systems may also offer the even broader promise of improving the utility, convenience, and affordability of surface transportation systems for *all* Americans. Key related goals established in the Department's *Strategic Plan* include making transit and passenger rail more viable options for the traveling public and ensuring that transportation planning and investments for the movement of people and goods support economic development, strengthen neighborhoods, and are friendly to America's communities.

The physically disabled, the elderly, and urban and rural poor that have neither use of an automobile nor ready access to public transportation may all be considered transportation-disadvantaged. U.S. Census data indicate that the majority of the elderly live in areas not readily serviced by public transit, e.g., the suburbs and rural regions of the Nation. Likewise, those in rural areas, particularly the rural poor and Native American populations are at a disadvantage when traveling to work or to health care. Data indicate that one-fifth of rural trips that receive transportation assistance are to work, another 17 percent are to access human services, and a further 14 percent are in connection with access to health care.

The Department continues to investigate, develop, and foster new technologies and service delivery concepts that will improve the mobility of the transportation disadvantaged. Programs are on-going in the development of new road, simulation and ITS-related technologies to extend the capacity of older Americans to use their cars while ensuring a high level of safety. Likewise, DOT, in concert with the Departments of Health and Human

Services, Agriculture and other state, regional, and tribal governments are investigating improved transportation service delivery concepts to enhance rural transportation options.

In addition to improving access for those Americans that may be considered transportation-disadvantaged, innovation in this area may, in the long term, make transit systems a more viable and convenient alternative for those that are otherwise able to own and operate an automobile (e.g., middle- and upper-income suburban residents). This could help to relieve congestion, reduce air pollution, and possibly improve the Nation's economic competitiveness by reducing total transportation expenses.

Basic Goal: Assess and demonstrate technologies and concepts that enhance the availability of public transportation systems to everyone.

Principal Participants: The Department will coordinate and work with the technology community, auto industry, organizations representing elder and rural Americans, and other state, regional, and tribal governments that are involved in developing improved transportation service delivery concepts.

Benefits: Improved mobility, access, and connectivity for the transportation-disadvantaged and other Americans throughout the United States, thereby enhancing economic productivity and reduced transportation costs. Better accommodation of changing demographics, increased demand, and changing and emerging demand patterns.

Summary

Almost every thrust supports a multiplicity of DOT missions and contributes significant benefits in several areas. Application of information technologies, for example, can contribute in all five benefit areas. Indeed, the activity of accumulating knowledge of the surface transportation system and an a ability to assess its condition from a range of perspectives has benefits in all of these areas, and serves all of the Department's fundamental missions. Several of the other thrusts are more focused on one or two general missions of the Department and benefits to the Nation. Cumulatively, the long-term R&D thrusts described above address the entire set of basic DOT missions (with the exception of operation of transportation-related facilities, as this mission does not arise for surface transportation) described in Chapter 3 of this section, and provide benefits in each of the five broad benefit areas also presented in Chapter 3. In an era of serious resource constraints, they constitute a set of strategic R&D priorities that will be critical to the Nation's ability to continue providing efficient, safe, clean, convenient, and affordable surface transportation in the future.

SECTION III

NEAR-TERM PLAN FOR SURFACE TRANSPORTATION RESEARCH AND DEVELOPMENT

CHAPTER 1

RELATIONSHIP BETWEEN FUTURE PLANS AND CURRENT ACTIVITIES

In Section II of the plan, the Department has established sixteen major long-term thrusts for surface transportation R&D, based on a review of the key trends and issues for the future, and directed toward the goals established in DOT's *Strategic Plan*. In Section III, planned near-term R&D activities, shaped by the same considerations, are described in detail. As is discussed in the first chapter of Section II, these activities are also responsive to NSTC strategic guidance. As a result, the structure of the Department's near-term plan reflects the structure established by the NSTC. Planning funding and staffing levels, as summarized in Appendix A, are also categorized according this structure. The NSTC Transportation Committee has identified R&D priorities in the following broad elements of the transportation enterprise:

- Physical Infrastructure for Transportation
- Information Infrastructure for Transportation
- Next-Generation Transportation Vehicles
- Human Performance in the Transportation System
- Transportation System Assessment Tools and Knowledge

These general categories are used in Section III as a structure for near-term R&D planning. To this structure, the Department has added the following two elements which cut across the above five categories, and enhance the Nation's ability to achieve gains in these areas:

- DOT Investment in University Research, Education, and Cooperative Activities; and
- DOT R&D Facilities and Administrative Support for R&D.

The chapters devoted to these areas provide notation indicating which of the five NSTC categories cover specific programs included in these two areas.

There are prominent relationships between the Department's near-term R&D activities and the long-term thrusts its has presented in Section II. In most cases, near-term activities form the technical foundation upon which a major long-term thrust will stand. On the other hand, the Department has identified security in public transportation as a major future priority which, although it may draw significantly on the Department's related work in Aviation security, will otherwise be a new R&D area for surface transportation. For each of the long-

term R&D thrusts identified in Section II, the following table shows examples of related near-term activities that help to form an underlying foundation.

Table 2. Relationship between Long-Term Thrusts and Near-Term Activities

Long-Term R&D Thrust	Key Related Near-Term R&D Programs
System Assessment and Knowledge Base	*See Chapter 6: System Assessment, Design, Planning, Management, and Operations*
Intermodal Freight Transportation	Assess Barriers (FHWA) Intermodal Development (MARAD) National Security (MARAD)
Revitalization of U.S. International Freight Transport Industry	Industry Competitiveness (MARAD) Shipyard Revitalization (MARAD)
Improved Materials, Designs and Methods for Renewal Engineering	Pavement Research Program (FHWA) Structures Research Program (FHWA) Technical Assessment and Deployment (FHWA) Strategic Highway Research Program (FHWA) Applied Research and Technology Pgm. (FHWA) Seismic Research Program (FHWA) Fundamental Properties of Asphalts (FHWA) Timber Bridge Research (FHWA) Ship Structures Cmte. (MARAD/USCG/Navy/MSC/ABS)[1]
Advanced Technologies for Inspection, Monitoring, and Maintenance	Structures Research Program (FHWA) Equip., Oper., and Hazardous Mat'l. Res. (FRA) New Rail Vehicles and Infrastructure (FTA) Pipeline Safety Research (RSPA) Ship Structures Committee (MARAD/USCG/Navy/MSC/ABS)
Application of Information Technologies to Transportation System Operations	*See Chapter 3: Information Infrastructure*
Advancement of Intermodal Public Transit Vehicle Technology	New Rail Vehicles and Infrastructure (FTA) New Bus Vehicles and Infrastructure (FTA) Advanced Bus Propulsion Systems (FTA)
Technical Foundation for High-Speed Ground Transport Systems	Safety of High-Speed Ground Transportation (FRA) Next-Generation High-Speed Rail (FRA)

[1]An interagency organization consisting of the five U.S. agencies plus the Canadian Defence Research Establishment Atlantic, Transportation Canada, and the Canadian Coast Guard.

Accident Avoidance	*See. Ch. 5: Human-Centered Transportation Systems, also:* Crash Avoidance--Driver/Vehicle Performance (NHTSA) Motor Carrier Research (FHWA) Equip., Oper., and Hazardous Mat'l. Res. (FRA) Track Safety Research (FRA) Maritime Safety (MARAD) Ship Structures Committee (MARAD/USCG/Navy/MSC/ABS)
Accident Survivability	Safety Systems (NHTSA) Biomechanics (NHTSA) Heavy Vehicles (NHTSA) PNGV (NHTSA) Equip., Oper., and Hazardous Mat. Res. (FRA) Hazardous Materials R&D (RSPA) Ship Structures Committee (MARAD/USCG/Navy/MSC/ABS)
Safety Data and Analysis	Highway Safety (FHWA) Fatal Accident Reporting System (NHTSA) National Accident Sampling System (NHTSA) State Data Program (NHTSA) Data Analysis Program (NHTSA) Restraint Usage Data Program (NHTSA) Special Crash Investigations (NHTSA) Hazardous Materials Information Systems (RSPA) Ship Structures Committee (MARAD/USCG/Navy/MSC/ABS)
Security in Surface Transportation	Safety and Security (FTA) National Security (MARAD)
Environmental Impact Models and Data	Environmental Research (FHWA) Highway Planning Research (FHWA)
Environmental Technologies	Pavement Research Program (FHWA) PNGV (NHTSA) Environmental Protection (MARAD) Ship Structures Committee (MARAD/USCG/Navy/MSC/ABS)
Accessibility for Persons with Personal Mobility Limitations	Transit Services and Management Innovation (FTA)
Intermodal Transit System Innovation	Rural and Specialized Transportation (FTA) Metropolitan/Rural Policy Development (FTA)

CHAPTER 2

PHYSICAL INFRASTRUCTURE

Most of us take America's superb transportation physical infrastructure for granted--our roads, railroad tracks, transit systems, airports, railroad terminals, bridges, tunnels, and navigable waterways are unmatched in all the world. However, as stated in the Clinton Administration's technology policy, "Technology for America's Economic Growth, A New Direction to Build Economic Strength,"...one of the greatest challenges we face is to rehabilitate and maintain the huge stock of infrastructure facilities already in place."

Infrastructure renewal is also a core element of Secretary Federico Peña's *Strategic Plan* for the US DOT. US DOT is committed to achieving the goal of a coherent and interconnected multimodal National Transportation System. As stated in the plan: "transportation infrastructure strengthens America by bringing people and communities closer together, spurring trade and commerce to meet the new demands of a global economy...Our challenge now is to shift our attention from what we've built to how we can make it work better for our country - through the adaptation and modernization of our existing infrastructure." In response to the Administration's identification of transportation infrastructure renewal as a National priority area, the NSTC Subcommittee on Transportation Physical Infrastructure endorsed the President's four major transportation physical infrastructure strategic R&D goals:

1. *Develop technologies, advanced materials and methods to efficiently maintain and renew the aging transportation infrastructure.*

2. *Improve existing infrastructure performance (Lifecycle cost, environmental impact, service life, traffic capacity, safety).*

3. *Develop and expand technology base for innovative vehicles and systems and for intermodal integration.*

4. *Enable efficient infrastructure emergency response and quick recovery after disasters.*

In addition, the NSTC Transportation Physical Infrastructure Subcommittee has identified a number of crossmodal and generic R&D priority thrusts. These include:

1. *Nondestructive Test, Inspection and Evaluation, diagnostic sensors, technologies and modeling tools*

2. *High performance materials*

3. *Automation and robotics for renewal engineering*

4. *Emergency response technologies (e.g., seismic damage repair)*

5. *Intermodal hazards reduction (e.g., highway/rail and transit crossings)*

6. *Tools for infrastructure maintenance and prioritization management*

The current US transportation infrastructure includes 4 million miles of roads; 575,000 bridges, 180,000 miles of railroad track, 11,000 miles of urban rail, 1,264,000 miles of natural gas pipelines, 26,000 miles of navigable waterways, and airports and seaports. The United States' 4 million miles of surfaced roads carry one-third of the ton-miles of domestic freight and nearly 90% of passenger-miles travelled. High-performance airports are central to long-distance public transportation. Public expenditures for construction and maintenance of the highway system alone, derived largely from direct user fees as well as non-user-based tax revenues, are approximately $80 billion per year, requiring a workforce of about 800,000 people.

Obtaining the best life-cycle performance from America's surface transportation infrastructure is thus of great importance not only to users, but also to government at all levels. USDOT's 1995 *Status of the Nation's Surface Transportation System: Conditions and Performance Report to Congress* is the latest in a series of biennial reports that track changes in transportation physical and operating characteristics, finance, and usage patterns. The report finds that personal and freight demands on our systems are at an all time high and are expected to increase with population and economic growth, but at a slower rate than in past decades.

Near Term Efforts

Emphasis in the area of surface transportation physical infrastructure research is on technologies and procedures associated with: operational efficiency, durability, performance, safety, environmental impacts, renewal and maintenance, real-time nondestructive inspection and monitoring of infrastructure condition and performance; improved design and construction concepts and practices, processes, structures, materials, resource use, and disposal of construction process wastes, recycling and reuse of byproduct and waste materials, as well as design and construction principles and technologies specifically relevant to intermodal connection points. The surface transportation programs that have physical infrastructure as their major focus are listed below and described in the paragraphs that follow:

Highway Safety (FHWA)

FY[1]	1996	1997	1998
Funding	8,509	8,768	NA[2]
FTE	22.8	23.8	NA

FHWA continues to focus on improving the safety of the highways in the United States. Great advances have been made in the last 20 years but more needs to be accomplished to reduce the more than 40,000 fatalities, 3 million injuries, and $100 billion in economic loss incurred annually due to highway crashes. The FHWA safety research program is directed at improving both the design features of the roadway, and traffic control systems so drivers of all ages can use the highway system in the safest and most productive manner. The research program focuses on driver and pedestrian decision behavior and the highway features such as traffic management, traffic control devices, highway design geometry, signage, markings, and environmental conditions. Current research efforts include:

- Advanced Traffic Control Methods and Devices - In the condition responsive traffic control devices program, the evaluation of the automatic ramp truck warning system for high speed trucks; automatic work zone traffic control for speed control; and automatic adverse visibility (fog) warning systems will be completed. A relatively inexpensive ($300) visibility sensor will be developed and tested to enable more roadway environmental systems to be installed at problem locations. Guidelines for the use of these systems will be developed and distributed to State and local governments. The need to accommodate new headlighting systems will be researched for overhead signing. Assessments will be conducted on the use of UV headlights with fluorescent materials to improve delineation of roadways and pedestrian detection during night and adverse weather conditions.

- Highway Safety Information Management - The highway safety information management program will develop high quality, easily accessible highway safety information systems and provide the technology and analytical tools for the analysis of highway safety problems. The FY 1997 program will provide for the continued improvement and operation of the Highway Safety Information System. This effort will include development of supplemental roadway and traffic volume files; full incorporation of advanced technologies such as GIS; and significant improvement of the user friendliness of the system. The program will also include an evaluation of administrative, technological, and analytical improvements to the design and operation of state accident and roadway data systems.

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[1]Throughout Section III, funding levels for each fiscal year are expressed in thousands of dollars, and staffing levels are shown as Full-Time-Equivalents (FTE).

[2]Not available at the time of publication.

- Pedestrian and Bicyclists Safety - This effort is in support of the Department's National Bicycling and Walking initiative, which aims to double the number of pedestrian and bicycle trips. The goal of the program is to safely accomodate increased numbers of pedestrians and cyclists in the highway environment. This program will develop improved planning techniques, new methods for identifying problem locations, innovative engineering countermeasures, and training tools to guide users in the implementation of improved pedestrian and bicycle facilities.

- Interactive Highway Safety Design Model - The objective of this program is to develop an integrated design process that systematically considers safety in developing and evaluating highway design alternatives. Vehicle Dynamics, Driver, Accident Analysis, Traffic, and Policy modules are being developed to allow examination of the entire roadway design including the roadway alignment, the roadway cross-section, and the roadside. Full implementation will occur as these modules are integrated into commercially-available computer aided design (CAD) packages.

- Roadside Safety Hardware - The objective of this research effort is to reduce the severity of run-off-the-road crashes by developing cost-effective roadside safety hardware and other roadside features that can effectively accomodate a diverse vehicle fleet. The research is focused on the development of advanced computer simulation techniques that will reduce the need to rely on crash tests alone and will allow evaluation of safety hardware for a wide range of vehicle types and impact conditions. To insure that the roadside hardware and the vehicles are treated as a "design system", this research program is being closely coordinated with NHTSA.

- Human Factors Research for Highway Safety and Intelligent Transportation Systems - The goal of this program is to increase highway safety by improving the compatibility between drivers (including commercial vehicle operations), basic highway design functions, traffic control devices, and smart technologies to enhance highway safety, traffic control centers and traffic flow. The results of this research will be the completion and publication of the numerous study findings and human factors handbooks for highway designers and traffic systems engineers who make design and operational decisions about highway geometric design, traffic control devices, traffic operations, and driver information systems.

A major milestone for fiscal year 1997 will be the completion of an evaluation of automatic enforcement equipment used to reduce the accident risk at signalized intersections.

Pavement Research Program (FHWA)

FY	1996	1997	1998
Funding	17,099[3]	23,200	NA
FTE	24	24	NA

The goal of the FHWA Pavements Research Program is to conduct activities that will contribute to the development of cost-effective and better-performing pavements. This program has consolidated and absorbed the Long Term Pavement Performance (LTPP) program, previously funded separately. To improve the clarity of purpose and to demonstrate that the LTPP program is an integral part of the total pavement research program (especially the life-cycle cost perspective), FHWA has combined this work.

Although there are significant differences in the typical loading profiles (e.g., longitudinal motion of multi-axle line-haul trucks compared to rapid vertical motion of much heavier aircraft), FHWA works closely with FAA on the improvement of pavements. FAA is currently seeking partners to share the cost of building a pavement test facility that would enable testing of new pavements, and the identification of the best possible replacements at airports where heavier new transport and cargo aircraft pose a particular problem for runway deterioration.

Major FHWA pavement research efforts planned for fiscal year 1997 include:

- Complete accelerated rutting tests for Strategic Highway Research Program (SHRP) asphalt research.
- Complete second year of loading and data collection at the test track for accelerated testing of Performance Related Specifications (PRS) for hot-mix asphalt pavements.
- Begin validation of performance models for use in PRS for Portland Cement Concrete (PCC) Paving.
- Complete development of protocols for State pavement management systems to gather, store, analyze, and use pavement condition data.
- Finalize guidelines for the use of recycled concrete as aggregate in concrete mixes, and the design of concrete pavements using these mixes.
- Develop prototype concrete mix designs and specifications which consider higher strength and associated properties for improved rigid pavement performance.

[3]Includes funding for the *Long-Term Pavement Performance* Program ($8,308k in FY96).

- Award contracts for construction of high performance concrete pavements.
- Distribute the results of the staff effort to validate the SUPERPAVE (Superior Performing Asphalt Pavements) materials design procedures.
- Design and deploy an embeddable, fiber-optic system for continuous measurement of temperature and deflection of asphaltic pavement and portland cement concrete pavement.
- Complete investigation of chemical morphological, and rheological properties of crumb rubber and Crumb Rubber Modified (CRM) asphalt.
- Develop advanced materials characterization and classification using neutron scattering methods.
- Evaluate the cost effectiveness of quality assurance programs.
- Continue the data collection activities for the 2200 LTPP inservice pavement test sections.
- Continue the analysis of the LTPP data base and the development of LTPP products.

Structures Research Program (FHWA)

FY	1996	1997	1998
Funding	12,558	22,000	NA
FTE	15	15	NA

FHWA's Structures Research Program strives to obtain (1) measurable improvement in the life cycle costs of US highway structures built after 2005 and (2) observable inspection and maintenance cost savings or extensions of services life in all common types of existing structures without degradation of highway safety or the environment. FY 1997 milestones include:

- Develop, in cooperation with the National Laboratories and Industry, a revolutionary bridge deck inspection system based upon ground-penetrating radar and infra-red thermography techniques to "find" or quantify deck deterioration.
- Develop and implement repair procedures and criteria for deteriorated concrete substructures, using advanced composite materials to "fix" the problem.
- Publish final report on cathodic protection developments for PS/C bridge members.
- Complete fully operational National system of geotechnical experimentation test sites.

- Develop test procedures for durability of geosynthetic reinforcement elements.
- Commence deployment, installation and demonstration of bridge monitoring systems.
- Award a contract for test, evaluation and start-up of nondestructive inspection test facility.
- Develop new timber bridge deck/rail designs.
- Complete durability testing and design criteria guides for structural adhesives.
- Award contracts for construction of high performance concrete bridges.
- Develop advanced computer simulation of concrete bridge beam.
- Develop design data and design criteria for an advanced composite-reinforced concrete bridge deck field installation.
- Develop design criteria for incorporating polymer composite, structural elements into existing reinforced concrete structures.
- Develop seismic design concepts for micro pile foundation systems and evaluate foundation lateral load design for earthquake and ship collision.
- Conduct pilot course for early implementation of technologies for simulating sediment transport and scour hazards to bridges.
- Develop scour equations for supporting foundation materials exposed to effects of scour and erosion.
- Award contracts for construction of high-performance steel bridges.
- Develop a new prototype fatigue crack detection system for steel bridges.
- Evaluate nondestructive methods for determining chemical composition of steel.

Environmental Research (FHWA)

FY	1996	1997	1998
Funding	5,317	5,593	NA
FTE	5.0	5.0	NA

FHWA's Environmental Research Program addresses issues of Air Quality, Wetland Resources, Water Quality, Noise Impacts, Environmental Processes, Historic Preservation, and Hazardous Materials. The goals of the environmental research program include: better

capability to understand and predict the impacts of highway transportation systems on the natural environment, cultural resources, and the local community; development of methods to avoid and mitigate those impacts and enhance the environment; the integration of environmental considerations into the system planning and project development processes in a cost effective manner; and share innovations with FHWA partners in State and local governments. Some specific initiatives include:

- Developing methods to rehabilitate wetlands, historic bridges, and historic and scenic roads.

- Determining impacts to receiving waters from highway runoff and developing guidance for assisting and managing highway storm water runoff.

- Assisting State and Metropolitan Planning Organizations (MPOs) with meeting Clean Air Act requirements by providing improved analysis methodologies, and information on the relationship of transportation programs and emissions on air quality levels.[4]

- Assisting EPA in their efforts to develop a new and more accurate mobile source emissions model.[5]

- Examining the impacts on the transportation program, and the additional control strategies that are necessary, resulting from new and tighter National ambient air quality standards for ozone and fine particulate matter.

- Developing a new highway traffic noise model and software.

A major fiscal year 1997 milestone will include the publication of best management practices for controlling storm water runoff from highways.

Right-of-Way Research Program (FHWA)

FY	1996	1997	1998
Funding	408	322	NA
FTE	0.25	0.25	NA

FHWA's Right-of-Way Research Program enhances State and local government highway agency capabilities in right-of-way program management, technical development and information sharing. This research effort includes studies that identify and advance right-of-way management methodology; right-of-way technical innovation; and harmonious land use applications.

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[4]Discussed further in Chapter 6, under the description of FHWA's Transportation Planning Research.

[5]Discussed further in Chapter 6, under the description of FHWA's Transportation Planning Research.

FY 1997 milestones include:

- Disseminate published methods for improved right-of-way program management.
- Disseminate report on results of key legal and appraisal/acquisition issue analysis.

Technology Assessment and Deployment (FHWA)

FY	1996	1997	1998
Funding	12,499	14,846	NA
FTE	27	27	NA

The purpose of FHWA's Technical Assessment and Deployment program is to identify and assess innovative research results, technology, and products and to promote the application of those that are determined to be of potential benefit to the highway community. Key areas of interest are pavements and structures, safety and traffic, technology assessment, and program support. Ongoing activities and FY 1997 milestones include the following:

- Implement state-level programs on construction quality.
- Train bridge engineers in all States to apply the Load & Resistance Factor Design bridge code.
- Implement a comprehensive procedure for designing highway bridges for extreme events such as ship impacts, seismic events, and scour.
- Evaluate automated enforcement equipment to reduce accident risk at signalized intersections.
- Demonstrate and promote leading-edge corridor management technology for freeway and urban arterial traffic control.
- Showcase state-of-the-art equipment designed to improve accuracy, timeliness, and quality of highway safety related data collected by enforcement personnel.

Local Technical Assistance Program (FHWA)[6]

FY	1996	1997	1998
Funding	8,866	10,100	NA
FTE	2	2	NA

The FHWA's Local Technical Assistance Program improves access to highway technology for local communities. The LTAP, with its 56 LTAP technology transfer centers—one in

[6]A portion of the funding for the LTAP is through Section 6004 of ISTEA.

each state, one in Puerto Rico, and five to serve American Indian tribal governments (a sixth is to be added in FY 1996)—serves as the primary channel through which innovative transportation technology and training are delivered to both urban and rural communities. Key FY 1997 products and milestones include:

- Identify new technology transfer techniques suitable for local governments.
- Determine and provide new products and specific services needed by the five centers for American Indian tribal governments.
- Determine and provide special products needed by Alaska natives and by U.S. territories.
- Operate LTAP technology transfer centers.

Technical Training (FHWA)
National Highway Institute

FY	1996	1997	1998
Funding	4,153	6,000	NA
FTE	15	15	NA

The goals of the National Highway Institute are to increase the knowledge, skill, productivity, and effectiveness of the transportation work force at all levels from top professionals to entry level technicians; to foster the use of new technology developed through research; to promote innovation which facilitates the economic vitality of the nation, and to provide technical assistance and training to foreign countries while improving the US competitive position in the global market place. The National Highway Institute offers technical training programs addressed to Federal, State, and local government agencies; industry; universities; and international transportation groups. Major activities for fiscal year 1997 include:

- Traffic management and intelligent transportation systems, at least 15 courses and 60 presentations to 1,800 participants.
- Highway safety, at least 10 courses and 100 presentations to 3,000 participants.
- Structures and hydraulics, at least 20 courses and 150 presentations to 4,500 participants.
- Pavements and materials, at least 10 courses and 50 presentations to 1,500 participants.
- Geotechnical and foundation engineering, at least 10 courses and 40 presentations to 1,200 participants.

- Fellowships to students and faculty for purposes of attracting, enhancing, and retaining the Nation's brightest minds and top talent as part of the transportation enterprise.

- Presentations of NHI courses to U.S. industry and international groups at no cost to the Government.

- Using distance learning, satellites, teleconferencing, interactive computer programs, and other modern instructional technology to deliver high quality training in the most cost-effective manner.

Implementation of the Strategic Highway Research Program (FHWA)

FY	1996	1997	1998
Funding	20,000	20,000	NA
FTE	16	16	NA

The Strategic Highway Research Program (SHRP), authorized for six years under ISTEA, includes implementation of the products from the Long-Term Pavement Performance program. The benefits of the SHRP are being realized through its systematic implementation. Products of the research program are being developed under the guidance of technical working groups, which includes FHWA field organizations, industry associations, the Transportation Research Board, and users. Their work includes the following:

- Publish a Strategic Highway Research Program implementation plan for fielding more than 130 program products and for technical training and technology transfer support.

- Prepare and conduct showcase packages of technology modules for demonstration and delivery to the states via FHWA regional offices and through workshops for state planners and industry.

- Form a Technology Delivery Team to address SUPERPAVE with representation from the research and development, technology applications, and program offices within FHWA.

Key products and milestones for FY 1997 include:

- Continue implementation of SHRP products for local governments.

- Complete development and field trial of improved prototype Performance Related Specifications for concrete pavement.

- Initiate studies to evaluate the SUPERPAVE mixture tests and performance models for rutting, fatigue cracking, and low temperature cracking.

- LTPP verification sections designed and constructed and field assistance provided for SUPERPAVE technology.

- Continue demonstrations of the latest test procedures and equipment using the concrete mobile laboratory.

- Design, construct, and evaluate projects using criteria established for high performance concrete pavements.

- Develop interim specifications for Performance Related Specifications for portland cement concrete and hot-mix asphalt pavements and begin validation of performance models established for use in PRS for concrete paving.

- Complete interim development and assessment of the SHRP binder direction tension test.

- Ensure that all applicable SHRP products are now provisional AASHTO standards for use by the States and industry.

- Provide information on the products and the schedule for implementation activities through FHWA's SHRP Information Clearinghouse.

- Continue to work internationally to promote cooperation in the use of SHRP technology, including cooperative efforts with Canada, Latin and South America, the European Community, and Japan.

Applied Research and Technology Program (FHWA)

FY	1996	1997	1998
Funding	41,000	41,000[7]	
FTE[8]	-	-	-

ISTEA Section 6005(e) laid out the Applied Research and Technology (ART) Program with the goal to accelerate the testing, evaluation, and implementation of technologies to improve the durability, efficiency, environmental impact, productivity, and safety of highway, transit, and intermodal transportation systems. The legislation had several requirements and special provisions:

- It required the development of Guidelines for the selection of technologies to be tested.

[7]FHWA will propose continuing a modified version of this program under the ISTEA reauthorization.

[8]The FTE to administer this program are located in various research and technology offices throughout FHWA.

- It broadly described the types of technologies to be tested.

- It designated specific technologies that were to be tested.

- It required the projects to be carried out on the "Federal-aid systems" with the Federal share not exceeding 80 percent.

- It provided for technical assistance to the States and for an annual report to Congress.

- It provided funding of $35.0 million for fiscal year 1992 and $41.0 million for each of the fiscal years 1993-1997 for the overall program and provided funding of not less than $4.0 million per fiscal year for heated bridge technologies, not less than $2.5 million per fiscal year for thin bonded overlays, and not less than $2.0 million per fiscal year for all weather markings.

To implement the provisions of the legislation, FHWA, through the Research and Technology Executive Board, developed a program composed of three elements: Priority Technologies, Test and Evaluation Through the Highway Innovative Technology Evaluation Center (HITEC), and Applied Research. The programs are jointly administered by the Associate Administrators for Safety and System Applications and Research and Development with funds assigned to a variety of headquarters offices carrying out the program.

Priority Technologies involve the implementation and evaluation of technologies specified in the legislation and other priority technologies that have been identified by FHWA and proposed for partnerships through general solicitation. Test and Evaluation Through HITEC involves full-scale testing of new technologies of projects originating in both the public and private sector coming through HITEC. The use of HITEC was incorporated into the Guidelines that FHWA developed. Applied Research projects support the development of R&D products, the implementation of new technologies and support for International activities and the Advanced Research Program. Key products and milestones for FY 1997 include:

- Field initiate Priority Technology Projects employing a variety of partnership and cost sharing techniques which will accelerate the test, evaluation, and implementation of new and underutilized technologies that will benefit the intermodal transportation system by improving the durability, efficiency, environmental impact, productivity, and safety.

Seismic Research Program (FHWA)

FY	1996	1997	1998
Funding	2,000	2,000	NA
FTE	2	2	NA

This FHWA research program for the seismic protection of bridges studies the seismic vulnerability of highways, and bridges on the Federal-aid system and works to develop and implement cost-effective methods of retrofitting such systems to improve their seismic performance. Major efforts in FY 1997 include:

- Complete evaluation of approaches for portraying the National hazard exposure to the highway system.
- Complete development of design time history ground motion.
- Complete seismic retrofit of shear-critical bridge columns with final report.
- Complete development of training course for seismic retrofitting for bridges.
- Complete study of "Effect of Spatial Variation of Ground Motion on Highway Structures."
- Complete Liquefaction Remediation Techniques for Bridge Foundations.

Fundamental Properties of Asphalt (FHWA)

FY	1996	1997	1998
Funding	3,000	0	NA
FTE	2.4	2.4[9]	NA

Pursuant to Section 6016 of ISTEA, FHWA is managing a 5-year, $15 million research contract with the Western Research Institute in Laramie, WY. The primary objective of this contract, "Fundamental Properties of Asphalts and Modified Asphalts," is to support the implementation of the asphalt portion of the Strategic Highway Research Program (SHRP, 1987-1993) through both fundamental and applied research by building upon, extending, and validating SHRP results. Ultimately, the goal is to improve the asphalt concrete highway system of the United States.

[9]FTE to conduct FY 1997 activities are located within various FHWA offices.

Major anticipated milestones for FY 1997 include:

- Improvement of the SHRP performance-based binder specifications. This includes improving the speed and precision of the asphalt oxidation step (environmental conditioning) necessary for conducting the specification tests, developing concepts and procedures for including moisture susceptibility (stripping) into the specifications, and enabling the specifications to handle modified asphalts.

- A clear understanding into the physical bases of asphalt pavement distress mode, i.e., primarily cracking and rutting. Some of the models and theories of pavement failure developed under SHRP are incomplete. For instance, it has been demonstrated under this program that fatigue-cracked pavements can "heal," i.e., regain their strength in the absence of traffic ("rest" periods). Such improvements to our fundamental understanding can lead to more accurate pavement specifications and tests.

- Development of a "model" for asphalt. Such a model consists of a picture of asphalt from the molecular level on up to include how its physical (rheological) properties depend on its chemical structure. The practical utility of such a model is that it provides the basis upon which to develop improved asphalts, either through the manufacturing process or by the use of additives, to improve the performance of our asphalt-based highways.

- Development of new, improved, faster, and/or more precise research tools for asphalts. Various types of chromatography, spectroscopy, nonaqueous potentiometric, titration, rheometry, etc., have been and are being developed under this contract including interpretations of their data heretofore unavailable to asphalt scientists. Of particular interest is the development of magnetic resonance imaging (MRI), now a modern tool of hospitals, for visually studying the intrusion and interaction of water with asphalt and asphalt pavements, the interaction of crumb rubber with asphalts, etc.

- Description of the science and systematics of the interaction of waste crumb rubber (from ground-up discarded tires) with asphalt. Such information is vital for the successful use of crumb rubber in asphalt. The manufacturer needs a rational basis (not by trial and error) for choosing the most chemically compatible asphalt and interacting it at the optimum time and temperature to maximize the performance of asphalt-rubber pavements.

Timber Bridge Research Program (FHWA)

FY	1996	1997	1998
Funding	875	0	NA
FTE	1	1[10]	NA

FHWA's Timber Bridge Research Program focuses on developing new timber bridge systems, and/or improving present systems which permit the efficient use of primary commercial wood species and previously under utilized species for transportation use. Key FY 1997 products and milestones include:

- Standard plans for several timber bridge types.
- Computer design aids, and interactive designs.
- New NCHRP 350, Test Level 3 bridge rails.
- Refined design criteria to update AASHTO codes.
- Find alternative stressing systems for post-tensioning stressed deck bridges.

Track, Structures, and Train Control (FRA)

FY	1996	1997	1998
Funding	7,082	8,967	NA
FTE	5	3	NA

FRA's Track, Structures and Train Control program addresses those elements of railroad fixed facilities which account for over a third of the annual number of train accidents. The goal of the program is to reduce train accidents due to track and signal defects, which are almost always the leading cause of train accidents. The damage associated with those accidents totals on the order of $50 million annually. The program will work to develop technology to discover such track defects before failure; develop methodologies for predicting service life of track and signal components and how they behave under dynamic conditions; develop protocols to improve efficiency in inspection, preventive maintenance, repair, and renewal actions; and develop technology to enable safe train operation in a heavy tonnage environment. Research will increase emphasis on the testing, analysis, and

[10]FTE to conduct FY 1997 activities are located within various FHWA offices.

evaluation of safety-critical track, grade crossing, signal system components, inspection devices, and vehicle response to track irregularities. Research efforts include:

- Develop comprehensive mathematical model of vehicle/track interactions.
- Perform wheel/rail force evaluations using instrumented wheelsets.
- Utilize FRA's track testing equipment to perform sophisticated tests of track strength by measuring loaded gauge and harmonic cross-level change.
- Develop computer models and conduct full-scale tests to determine dynamic force levels of locomotives and heavy-load cars and to assess the ability of track structures to support them.
- Provide operation and test support for heavy axle load tests.
- Improve reliability of train detection methods for rail traffic control and activating grade-crossing devices.
- Quantify and test resistance of concrete-tie track to lateral buckling from heat and load stress.
- Develop technology and protocols to ensure safety during advent of new advances such as 125-ton cars, multiplatform intermodal vehicles, computerized control of train routing and separation, and improved rail flaw detection equipment.
- Develop improved technology for assessing rail and track condition.

A key milestone for fiscal year 1997 will be the quantification and testing of resistance of concrete-tie track to lateral buckling from heat and load stress.

Intermodal Development (MARAD)

FY	1996	1997	1998
Funding	NA	300	NA
FTE	NA	NA	NA

The goals of the Maritime Administration's Intermodal Development program are to assess and deploy innovative technology and management practices for all components of the transportation system infrastructure to improve system capability, efficiency, productivity,

safety, environmental sensitivity, and military utility. There are five research programs under Intermodal Development:

1. Intermodal Transportation Research Program -- This program works to improve the efficiency of all aspects of the flow of cargo and data from origin to destination in U.S. domestic and international trade through the introduction of advanced technologies and operating systems designed to enhance productivity, reduce costs, and increase service quality. MARAD assists U.S. ocean carriers, inland waterway operators, stevedores, terminal operators, ports, and others involved in intermodal transportation through National multi-modal studies and joint MARAD/industry cost-shared research and development. MARAD provides for coordination of intermodal studies with the Department's Office of Intermodalism and other modal administrations, as well as other Federal, state, and local agencies.

2. Cargo Handling Cooperative Research Program -- This cost-shared program is carried out under a cooperative agreement between MARAD and industry members to improve the cargo handling productivity of American carriers. The research activities are jointly selected by the participants.

3. Commercial-Military Transportation Research Program -- This program focuses on the identification and development of marine intermodal transportation technology which can be used to meet military and commercial requirements.

4. Port Development Planning Research Program -- The Maritime Administration's Port Development Research Program goal is to determine port requirements for U.S. ports in order to improve transportation system capability, efficiency, productivity, and safety. The program also ensures that ports are able to operate with efficiency and minimal disruption during times of National emergency.

- Complete the study and workshop on the impact of future fleet and trading pattern changes on port infrastructure requirements.
- Completion of the National Freight Transportation and Logistics Model, which will provide planners with the ability to identify potential infrastructure constraints and allow for the testing of options to address the constraints.
- Initiate development of a port productivity program designed to assist U.S. ports in enhancing their marine terminal productivity and facility utilization.
- Develop analytical methodology for assessing the security vulnerabilities of marine terminals.
- Examine the special problems and future role of small and modern-sized U.S. ports.

- Examine the issues associated with competition between U.S. ports and regional economic efficiency and cooperation in planning.

5. Small Business Innovation Research Program -- The SBIR program is carried out under agreements between MARAD and small business firms to integrate intermodal technology deployment. The research activities are selected through a coordinated process within the Department, and are discussed in more detail in Chapter 7.

Key FY 1997 products and milestones include:

- Start next phase of the Marine-Rail Intermodal System project, which will focus on testing the commercial and military applicability of an inland rail dual-use sorting facility.

- Initiate the identification and review of Electronic Data Interchange configurations for establishment of international standards for intermodal container carriers.

- Initiate development of ISO standards for 45-foot containers through the Cargo Handling Cooperative Program.

- Work through the IMO Facilitation of International Maritime Traffic Committee to assist in the review and establishment of protocols and standards for information channeling, communications, and equipment for intermodal carriers.

- Work with the Marine Board to evaluate the implementation of advanced maritime information systems in U.S. ports to investigate individual port needs as well as possible barriers to development of these systems.-- This program works to improve the efficiency of all aspects of the flow of cargo and data from origin to destination in U.S. domestic and international trade through the introduction of advanced technologies and operating systems designed to enhance productivity, reduce costs, and increase service quality. MARAD assists U.S. ocean carriers, inland waterway operators, stevedores, terminal operators, ports, and others involved in intermodal transportation through National multi-modal studies and joint MARAD/industry cost-shared research and development. MARAD provides coordination of intermodal studies with the Department's Office of Intermodalism and other modal administrations, as well as other Federal, State and local agencies.

Environmental Protection (MARAD)

FY	1996	1997	1998
Funding	NA	75	NA
FTE	NA	NA	NA

MARAD provides a National level leadership role in coordination with the maritime industry in meeting the obligations of National and international environmental laws and regulations in

a manner that protects the environment and the public health and welfare, while fostering the economic well-being of the U.S. shipping, shipbuilding, and port interests. R&D activities enable MARAD to work together with federal agencies and the private sector to define effective solutions for controlling environmental hazards from marine vessels, and for managing dredged materials. Near-term environmental protection priorities include:

- Initiation of a cooperative research project with the USCG, EPA and NOAA to implement the Marine Board's recommendations in its assessment of ship ballasting strategies and technologies for controlling introductions of nonindiginous marine organisms into U.S. waters.

- Initiation of a cooperative research project with the ACE, EPA, NOAA, and FWS to implement the recommendations of the Marine Board's assessment of the state of practice of remediating and managing contaminated marine sediments and the related recommendations of the Interagency Task Force on the Dredging Process.

A key milestone in fiscal year 1997 will be the assessment and evaluation, in cooperation with the USCG, of various marine engine air pollution reduction strategies, criteria, and technologies based on emission, safety, engineering, and economic perspectives.

New Rail Vehicles & Infrastructure (FTA)

FY	1996	1997	1998
Funding	3,000	500	NA
FTE	NA	NA	NA

The FTA's New Rail Vehicles & Infrastructure program has multiple goals, including: increase and improve rail transit efficiency, safety, and effectiveness through research and adoption of new technology. It also provides assistance to domestic rail transit manufacturers and technical service industries to enhance US competitive position in global markets; to encourage the use of advanced communications and information infrastructure; and to encourage advanced monitoring and inspection systems for improved state of the physical infrastructure.

The key FY 1997 milestones in this program are:

- Completion of the Advanced Automatic Train Control Project at San Francisco's Bay Area Rapid Transit (BART) system. The advanced train control system will provide the precise location of rapid transit trains, allowing them to operate with reduced separation distance. It is anticipated that this system will offer unprecedented safety, reliability, and ease of retrofit to existing transit systems at half the cost of conventional technologies.

- Development of Standards for Rail Transit Subsystems, continuing efforts initiated under the Transit Cooperative Research Program in FY 1995.

- Demonstration of Non-Destructive Testing (NDT) techniques for inspection of aging rail transit infrastructure.

- Demonstration of directional warning systems at grade crossings to warn of second train in crossing.

- Continued development of circuit breaker for high voltage AC rail systems.

Pipeline Safety Research (RSPA)

FY	1996	1997	1998
Funding	2,142	2,144	NA
FTE	NA	NA	NA

RSPA's Pipeline Safety Research program provides technical competence to assess pipeline integrity, determine ways to rehabilitate or rebuild pipelines, and set long-term performance goals for improvements. Major FY 1997 products and milestones include:

- Evaluating mapping and expert systems, helping regulation and compliance.

- Developing project plan for rehabilitation project.

- Issuing interim report on improving internal inspection devices' sensitivity for stress corrosion cracking and mechanical damage and on constraints on applying the devices.

- Developing third generation of risk assessment model.

- Issuing final report on nondestructive evaluation technology to detect dents and flaws earlier.

- Issuing final report on how design criteria are related to leak before rupture principles.

CHAPTER 3

INFORMATION INFRASTRUCTURE

Introduction

The importance of timely, accurate and complete information to effective transportation planning and operations has become undeniable in recent years. New communications and information systems technologies are developing rapidly, and there are unprecedented opportunities for making substantial improvements to transportation through their effective implementation.

In order to capitalize on the potential advantages of these new technologies, the Department of Transportation has established as a strategic goal to *"Create a new alliance between the Nation's transportation and technology industries to make them both more efficient and internationally competitive."* [Strategic Goal #3 in the Department's *Strategic Plan*]. This goal envisions a future intermodal transportation network in which each mode uses information systems and technologies to operate more effectively, both by themselves and as an integral part of the larger, seamless transportation system for moving people and goods safely and efficiently throughout the United States and to and from foreign destinations.

This vision for the future of transportation has striking similarities with depictions of the evolution of the National information infrastructure, or the NII. In fact, the direct parallel between effective transportation and effective communications services has been pointed out by noting the NII can "have the same effect on U.S. economic and social development as public investment in the railroads had in the 19th century." [Federal Interagency Information Infrastructure Task Force, The National Information Infrastructure Agenda for Action", September 1993]. There has already been discussion of the advantages of defining a 'Transportation Information Infrastructure' or 'TII', to encompass those components of the NII whose primary purpose is to expedite the flow of passengers and freight on the National transportation system. If this concept were adopted, then the Federal government and the Department of Transportation would have significant and important new responsibilities.

However, a coordinated and comprehensive Federal approach to managing this intersection of transportation and communications has yet to be formulated. This would be a complex endeavor that would need to address a number of topics, such as:

- the need to support large numbers of both mobile and fixed users and platforms;
- the need to transmit significant amounts of data in real-time or near real-time;

- the need for seamless inter-connectivity among communications modes (wired, wireless, hybrid) and regions, both nationally and internationally, including managing the allocation and use of communications spectrum;

- the need for high reliability and survivability for safety-critical and National security-related applications; and

- the need to ensure compatibility among the regulations, legislation and administrative procedures of numerous public authorities at the local, regional, state, National and international levels.

Even given these daunting parameters, it is in fact possible to integrate state-of-the-art communications and information systems technologies into transportation. In many ways, the Intelligent Transportation System (ITS) program, previously known as Intelligent Vehicle Highway Systems (IVHS), is a model for the advantages that can accrue when the latest information and communications technologies are applied to transportation.

Intelligent Transportation Systems (ITS)

The ITS program arose in the late 1980s out of an awareness that parallel advances in such fields as electronics, communications, control, and information processing technologies offered a unique opportunity to make profound improvements in the Nation's surface transportation system. The ITS program seeks to apply these technologies in a manner that will enable the public to use the Nation's surface transportation infrastructure and energy resources to help achieve multiple goals simultaneously, including: improved safety, increased efficiency of transportation operations, reduced environmental and energy impacts of transportation activities, enhanced economic productivity, and enhanced mobility for transportation users.

The Federal Government is only one, although a major, participant in the National ITS program. Other players include private electronics, communications, and transportation technology companies; professional societies and organizations; consumer and industry groups; academia; and State and local governments. In addition, the Intelligent Transportation Society of America, or ITS America, is utilized as a Federal Advisory Committee to advise the DOT on the ITS program.

The primary role of the Federal Government, and of DOT in particular, in this program is to assure the development and deployment of a truly compatible, nationwide ITS system. This is accomplished through a number of coordinated activities. DOT encourages and coordinates the development of uniform technologies, standards, and associated knowledge bases. Because of its statutory mandate, the Department also provides a National emphasis and perspective on the safety aspects of ITS. It funds high-risk research that has the potential for a significant public benefit, but is not sufficiently attractive for the private sector

to pursue. It also plays a major role in ITS operational tests, technology assessment, and program planning.

Within DOT, the Joint ITS Program Office, or JPO, reports to five modal administrators (with a reporting link to the DOT Deputy Secretary), and is housed in the FHWA. The JPO coordinates the Department's overall ITS activities within FHWA itself, NHTSA, FTA, RSPA, and OST. Other Federal organizations with significant roles in the ITS program include the Departments of Commerce, Justice and Energy; the Federal Communications Commission, the Environmental Protection Agency, and the National Laboratories.

In coordination with ITS America and other interested parties, the Department has organized its ITS activities into 29 *User Services* which, in turn, are aggregated into seven *User Service bundles*. Each of these bundles represents a coherent aspect of the overall ITS program. This programmatic organization can be seen in **Table 3**.

The Department's ITS program has already achieved a number of significant accomplishments. In cooperation with ITS America, it has defined a comprehensive vision for ITS and developed a strategic plan for achieving it. It has established a long-term research program that focuses on key technologies in the areas of advanced vehicle control and safety systems, advanced traffic control, and automated highway systems. It has validated a number of technological ITS concepts in a series of operational tests and evaluations. It has initiated the development of a consensus system architecture and a series of technical standards for ITS components. It has supported the development of plans for the deployment of key ITS travel management and commercial vehicle elements by state and local agencies. Finally, it has identified a set of core ITS elements that can provide the basis for a successful National implementation of ITS.

Intelligent Transportation Infrastructure (ITI) and Operation TimeSaver

The early results of field testing, initial systems deployments and system architecture analysis all reinforce the advantages of having a set of 'core infrastructure' elements in place within a region. Once installed, these elements would generate for public awareness the real safety, security and congestion benefits of ITS technologies. They would also serve as the foundation for the deployment of more advanced ITS features as they became available. However, the continued uncoordinated deployment of these key infrastructure features was making it difficult both to implement well-integrated ITS systems at the local level, and to validate these benefits in a consistent and effective manner.

Table 3. ITS User Service Bundles and User Services

Bundle	User Services
Travel and Transportation Management	●En-Route Driver Information ●Route Guidance ●Traveler Services Information ●Traffic Control ●Emissions Testing/ Mitigation ●Incident Management
Travel Demand Management	●Pre Trip Travel Information ●Ride Matching/Reservation ●Demand Management and Operations
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 Inspection ●On-board Safety Monitoring ●Commercial Vehicle Administrative Processes ●Hazardous Material Incident Response ●Commercial Fleet Management
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 ●Precrash Restraint Deployment ●Automated Highway Systems

As a result of this observation, the Department defined a core set of nine first-level ITS components that should ideally be deployed by a region as an integrated system. Together, these nine components comprise the *Intelligent Transportation Infrastructure, or* ITI, as listed in **Table 4**. Together, these nine elements provide key traffic detection and monitoring, communications and control systems needed for the effective implementation of ITS.

Many of the components of this infrastructure are already being deployed across the Nation, but not as an integrated unit. However, there are numerous advantages to a region in implementing this core infrastructure in a coordinated manner. Installation of these systems can be accomplished more rapidly and cheaply if it is done as an integrated project. Once these systems are installed, operations and management of a region's roadways and transit resources can be readily optimized. This in turn will enable the safety, congestion relief, and security benefits of ITS technologies to appear sooner and in greater measures. The core infrastructure also serves as a solid foundation for the later deployment of additional ITS user services, which can be added as they evolve.

On January 10, 1996, at the 75th annual meeting of the Transportation Research Board (TRB) in Washington, D.C., Secretary Peña announced the establishment of the National goal of building the ITI across the Nation. As part of this initiative, also known as *Operation TimeSaver*, the Department will encourage local officials -- such as mayors, county executives and governors -- to invest in these intelligent transportation features. The Secretary established the goal of installing a complete ITI in seventy-five of the Nation's largest metropolitan areas within the next 10 years. Parallel commitments were made to pursue the installation of ITI components in 450 smaller communities, rural areas, and along the Interstate highways.

It is estimated that effective implementation of these 75 ITI locations could reduce the travel time of Americans by at least 15 per cent. As a result of these time savings, the Nation could avoid up to $150 billion of spending on additional road capacity over the next decade for an investment cost of only about $10 billion in ITI over the same period. Additional elements of *Operation TimeSaver* include: contracts with professional and industrial Standards Development Organizations to facilitate the dissemination of ITS standards; selection of up to three model sites for full deployment of ITI elements to act as examples for other localities; and training in the electronics and communications aspects of ITI systems for public sector transportation engineers.

Table 4. Intelligent Transportation Infrastructure Elements

Core Infrastructure Features	Purpose and Function
Traffic Signal Control Systems	Optimizes traffic flow by adjusting signal timing and patterns in response to real time traffic data.
Freeway Management Systems	Provides the ability to focus attention on improving traffic flow on high-volume roadway segments.
Transit Management Systems	Enable managers to make more productive use of their vehicle investments by maximizing performance of both individual vehicles and the fleet as a whole.
Incident Management Programs	Identify choke points caused by vehicle accidents or disablements and respond quickly with the appropriate towing and emergency services.
Electronic Toll Collection Systems	Provide non-stop payment for vehicles thereby decreasing delays and slow downs at toll booths and improving overall traffic flow.
Electronic Fare Payment Systems	Make public transit more convenient for passengers and provide centralized financial information to transit agency managers.
Railroad-Grade Crossings	Prevent accidents at railroad grade crossings through improved monitoring and notification.
Emergency Response Providers	Provide emergency vehicles with the ability to directly influence signalization to clear routes during emergencies.
Regional Multi-modal Traveler Information Centers	Collects the surveillance and detection data gathered by the other system elements, analyzes it, and disseminates results back to drivers and travelers as useful information.

Future Directions for ITS

As was mentioned previously, the Department's ITS program can already claim a number of successes. As the focus of the program moves from planning and R&D increasingly to the more complex stage of implementation, however, new themes will come to dominate the Department's activities. Over the next several years, the following themes are expected to become prominent, and are reflected in the Department's ITS plans:

- encouraging the installation of ITS core elements and services at the state and local level through model deployment, the Champions program and similar efforts;
- field testing new technologies such as crash avoidance systems, advanced traffic control capabilities and AHS;
- refining ITS system architecture and technical standards;
- evaluating more rigorously ITS component performance; and
- establishing a comprehensive National training program for transportation professionals on the technical aspects of ITS.

In addition to these major themes, a number of issues will need to be discussed and resolved in order to maintain the momentum of the ITS program. For example, there are important questions over the wireless spectrum needs of a fully installed ITS network and guaranteeing that the requisite bandwidth will be available when it is needed. There is also concern from the private sector over the impact of publicly-owned wireline communications systems, especially those based on fiber optic cables, that may support ITS but have considerable excess capacity that could be offered or sold to other users. Finally, responsibility for the effective long-term maintenance of the vast array of software, system architecture and technical standards generated by ITS, and resident in a number of separate public and private sector organizations, must be confirmed. The Department is taking action in each of these areas to begin the process of addressing and resolving these concerns.

NHTSA Crash Avoidance Research

The NHTSA Crash Avoidance Research program seeks to facilitate the identification and development of effective safety-related ITS products and systems that will contribute to attaining the goal of a collision-free driving experience for all highway users. In pursuit of this goal, it is envisioned that a wide variety of innovations can be implemented both inside and outside the motor vehicle to supplement the driver's ability to maintain vigilance and effective vehicular control. These innovations -- many of which will rely on state-of-the-art communications, information systems and sensor technologies -- would monitor the drivers'

own physiological condition, enhance perceptions of the driving environment, provide additional information about potential safety hazards, warn of impending collisions, assist in making appropriate vehicular maneuvers, and, eventually, even intervene with automatic controls to help avoid such collisions. Thus, the crash avoidance program supports a number of the Department of Transportation's major goals, including: contributing to the National economy, advancing U.S. technology, and supporting the safety of the transportation system.

The crash avoidance program is pursuing a multifaceted research and development effort incorporating five major thrusts:

Thrust #1 — Develop research tools such as portable data acquisition systems that can be installed in vehicles, and utilize these tools to develop a better understanding of driver-vehicle interactions and in estimating safety benefits of potential countermeasures concepts.

Thrust #2 — Conduct detailed analysis of crash databases, develop descriptions of specific crash problems to be addressed (head-on, rear-end, lane change/merge, backing, etc.) and identify potentially promising countermeasures for further research.

Thrust #3 — Develop performance guidelines for countermeasures associated with these crash categories, as the basis for developing crash avoidance systems.

Thrust #4 — Work cooperatively with private industry and research institutions to facilitate the commercial development of promising crash avoidance systems.

Thrust #5 — Assess the safety of ITS mobility- and productivity-enhancing systems to make sure they do not degrade safety.

The significant near-term products and current and planned activities of the NHTSA crash avoidance program can be found in the program summaries in this chapter ('Research and Development', 'Operational Tests', and 'Crash Avoidance - Driver/Vehicle Performance'); as well as in other chapters of this plan ('Crash Avoidance Research - Heavy Vehicles' in Chapter 4, and 'Crash Avoidance Research - National Advanced Driving Simulator' in Chapter 6).

Other Information Infrastructure Programs

In addition to ITS and crash avoidance, other surface and non-surface DOT programs also reflect applications of information technologies to transportation. FRA's Next Generation High-Speed Rail program is funding three positive train control projects which utilize

datalink communications and GPS positioning. The Maritime Administration (MARAD) manages an Industry Competitiveness program which places a high priority on the identification of information, communications and navigation systems and technologies that can improve the U.S. maritime industry's competitiveness. The Research and Special Programs Administration's (RSPA) Hazardous Materials Research program relies heavily on the application of information and navigation technologies to support its regulatory enforcement responsibilities. The Response Management Support program, also in RSPA, manages crisis management systems that enable the Secretary of Transportation and senior DOT officials to respond effectively to natural disasters or other National emergencies. Other non-surface transportation activities that have an important impact on surface transportation can be found in the Federal Aviation Administration's Aviation Satellite Navigation program, and the U.S. Coast Guard's work in differential GPS.

Finally, there are several related surface transportation R&D programs with a major information technologies content which are described in other sections of this document. The data collection and analysis and system assessment activities undertaken by the National Highway Traffic Safety Administration (NHTSA), the Federal Transit Administration (FTA) and the Bureau of Transportation Statistics (BTS), for example, are described in Chapter 6 of this section.

Near Term Efforts

Research and Development (FHWA/NHTSA)

FY	1996	1997	1998
Funding	36,166[1]	42,935[2]	NA
FTE	NA	NA	NA

The ITS Research and Development (R&D) program explores issues critical to advancing the development and deployment of ITS systems and components. The program covers a wide range of technical areas essential to the success of ITS. They include: traffic management, commercial vehicle operations (CVO), crash avoidance, vehicle detection and surveillance, human factors, communications, navigation, and rural applications.

One of the major topics of this program is advanced traffic control. For a number of years, the Federal Highway Administration has developed and deployed new concepts, technologies and technical assistance in improved traffic management to state and local agencies. The ITS program has significantly enhanced these capabilities. Previously, the emphasis had been on simple interconnection and computerized signal control; however, ITS allows for a fully-

[1]FY1996 funding includes $13,250k for NHTSA (Crash Avoidance Research), and is supplemented by $7,120k in ISTEA Section 6058 funds (discussed below).

[2]FY1997 funding includes $15,400k for NHTSA (Crash Avoidance Research) and $350k for FTA (Advanced Fleet Management Research), and is supplemented by $4,300k in ISTEA Section 6058 funds.

integrated, network-wide approach to proactive management of freeway and arterial roadways at the regional level. Ultimately, once the benefits of the ITS R&D activities are fully realized, "real-time" control capabilities which anticipate and adapt to changes in traffic flow and patterns and optimize traffic control functions will be available.

A number of activities have been supported by the ITS R&D program. For FHWA, these have included:

- developing and enhancing software and algorithms for traffic management systems such as RT-TRACS (Real-Time Traffic Adaptive Signal Control System), ramp metering control, and incident detection. Successful application of these technologies is anticipated to provide the foundation for improved roadway network control efficiency in the future; and

- pilot testing of electronic roadside verification by CVO motor carrier safety inspectors equipped with portable pen-based computers, license plate readers and advanced brake testing technologies.

NHTSA has also funded a range of R&D efforts in this area:

- augmenting the positioning capability of the Global Positioning System (GPS) for surface transportation users;

- constructing a Variable Dynamics Testbed Vehicle with adjustable ride and handling characteristics for testing various crash avoidance and automated highway system concepts;

- evaluating a prototype human factors data acquisition system (DASCAR), which can be installed in vehicles to monitor driver behavior and vehicle response unobtrusively, and developing functional and performance specifications for it;

- evaluating safety of the ADVANCE route guidance/navigation system; and

- development of preliminary performance specifications for intelligent collision avoidance systems which can assist drivers in avoiding various types of collisions, including rearend, lane change, backing, road-departure, and intersection, as well as assisting in situations where the driver is drowsy or in conditions of reduced visibility.

The R&D program also supports innovative projects through the ITS IDEA program, administered by the Transportation Research Board (TRB), which issues grants to explore innovative ITS concepts; as well as the three ITS Research Centers of Excellence established

in 1993 at the University of Michigan, Texas A&M University, and Virginia Polytechnic University.

A number of accomplishments are anticipated for the R&D program through FY 1997. In CVO, for example, 200 motor carrier safety inspection sites will be equipped with pen-based portable computers, and the one-stop purchase of electronic commercial vehicle credentials will be extended nationwide. The DASCAR system will be used to collect driver/vehicle performance data when driving both with and without collision warning and avoidance systems in operation. Performance specifications for a wide range of collision warning and avoidance systems will be finalized. Guidelines to ensure electromagnetic compatibility of ITS devices in the roadway environment will also be developed, and field evaluations of the performance of ITS rural traveler applications will be conducted.

Automated Highway System (FHWA)

FY	1996	1997	1998
Funding	14,000[3]	30,700	NA
FTE	2.0	2.0	NA

Section 6054(a) of the ISTEA legislation established as a goal that the Department of Transportation develop "the first fully automated roadway or an automated test track" by FY 1997. This Automated Highway System (AHS) will, when refined, serve the Nation's needs for a next generation of highway transportation system for light, heavy commercial and transit vehicles well into the 21st century. It will provide automatic transit, commercial and private vehicle operation in special lanes; and it also will facilitate the more productive intermodal movement of people and goods.

In pursuit of this ambitious goal, the Department of Transportation entered into a cost-shared cooperative agreement with the National AHS Consortium (NAHSC) in October 1994. Core consortium members include Bechtel, the California Department of Transportation, Carnegie Mellon University Robotics Institute, Delco Electronics, General Motors, Hughes Aircraft, Martin Marietta, Parsons Brinkerhoff, and the University of California Partners for Advanced Transit and Highways (PATH) Program. The NAHSC is responsible for specifying, developing and demonstrating a prototype AHS.

Three phases of the AHS program are envisioned. The first, or *Analysis* phase, is nearly completed. It established the analytical framework for the program and defined the schedule of actions. The program is currently at the second, or *System Definition* phase, which will establish performance and design objectives, prove the technical feasibility of the AHS concept, and lead to the selection of a preferred AHS system configuration and documentation. The third and final, or *Operational Test and Evaluation* phase, is anticipated to begin in 2002. It will include integrating AHS into the overall surface transportation

[3]This funding is supplemented by $2,500 in ISTEA Section 6058 funds.

technological and regulatory environment, evaluating its effectiveness in operational conditions, and determining the specific means by which DoT will support AHS deployment.

Currently, the AHS program is conducting numerous research, development, and testing activities. Enabling technologies such as vehicle and roadway sensors, vehicle-to-vehicle communications systems, and advanced algorithms for vehicle control are being identified and assessed. A human factors handbook for AHS designers has been completed. Development of an AHS computer simulation tool is underway. In addition, the potential institutional and societal impacts of AHS deployment in such areas as user needs, automated transit and freight operations, impacts on emissions, and appropriate public and private sector roles are being carefully evaluated.

The program's primary objective for FY 1997 is the successful demonstration of AHS proof-of-technical-feasibility. This will take place on high-occupancy vehicle (HOV) lanes in the median of I-15 in San Diego CA. The demonstration will include operating a fleet of both light and heavy AHS vehicles. Among the results of this demonstration will be information that can be incorporated into the development of heavy vehicle safety components such as sensors, communications systems and vehicle control algorithms.

Architecture and Standards (FHWA)

FY	1996	1997	1998
Funding	0[4]	7,050[5]	NA
FTE	NA	NA	NA

In order to ensure the rapid and widespread deployment of ITS systems and components on a nationwide basis, it is essential that an effective ITS National System Architecture be developed, which will describe how the various ITS systems and components will smoothly interact with each other. This architecture, which is to be developed as a fully consensual process, will guide -- and not mandate -- consistent decisions among investors, producers and purchasers of ITS products and services so that the risk of incompatibility is minimized. The expertise of existing professional and industrial Standards Development Organizations (SDOs) -- such as AASHTO, IEEE, ITE, ASTM and SAE -- will be sought for the development and dissemination of ITS standards.

After initial System Architecture concepts were generated by four different teams led by Hughes Aircraft, Westinghouse Electric, Rockwell International and Loral Federal Systems, the latter two companies were awarded contracts in February 1995 to work cooperatively to develop a consensus National architecture incorporating the best features of the available concepts and suggestions. Meanwhile, the Johns Hopkins University Applied Physics

[4]This funding is supplemented by $10,089 in ISTEA Section 6058 funds.

[5]This funding is supplemented by $6,200 in ISTEA Section 6058 funds.

Laboratory is developing a comparable and coordinated system architecture for commercial vehicle operations. Additional public comment and reaction will be solicited throughout this phase of the process. Agreement on the National architecture will in turn stimulate the development of uniform ITS technical standards.

To date, a proposed ITS System Architecture Implementation Plan has been drafted, covering deployment, R&D, operational tests, standards development, and policy recommendations. Analysis of the traffic flow, communications and costs/benefits aspects of a representative urban ITS system design has been completed. Interface standards needed to ensure compatibility with the System Architecture have been identified, and development of a number of specific standards is well underway. These include, for example:

- Spatial Data Reference Standards so that different GIS (Geographic Information System) databases can share information;
- the National Traffic Control/ITS Communications Protocol (NTCIP) to ensure the inter-connectivity of control devices such as variable message signs; and
- Commercial Vehicle Operations (CVO) Standards so that data on these vehicles can be shared and transmitted via Electronic Date Interchange (EDI) systems.

Major FY 1997 activities will continue the evolution of the architecture and standards effort. An ITS Deployment User's Guide including design guidance to ensure National interoperability will be developed. To facilitate inclusion of National design principles and standards into local ITS systems, a System Architecture Deployment Assistance Team will be formed to manage a National outreach program. The program will also support the development and adoption of traffic management system standards and guidelines for Advanced Traffic Management Systems (ATMS) and Traffic Management Centers (TMC).

Operational Tests (FHWA/NHTSA)

FY	1996	1997	1998
Funding	31,052[6]	28,125[7]	NA
FTE	NA	NA	NA

An essential step in the ITS deployment process is to evaluate the performance, costs and benefits of candidate systems and components, as well as the broader technologies and systems concepts embodied in them, in real-world conditions. The results of these tests are

[6]This funding includes $1,429k for NHTSA (AVCSS) and $333k for FTA (APTS), and is supplemented by $21,226k in ISTEA Section 6058 funds.

[7]FY 1997 funding includes $7,000k for NHTSA (AVCSS) and $2,575k for FTA (APTS).

essential to facilitate the transition of systems and components from the R&D phase to wide-scale commercial deployment. The Operational Tests program provides the ability for public and private sector partners to work cooperatively to perform this function. In particular, the DOT role in these tests is to assist in evaluating the systems and to facilitate the commercial deployment of those judged to be successful.

More than seventy-five field tests of multiple ITS systems and components have already been completed or are currently underway in all parts of the Nation, including several tests involving multiple states. Among them are the following:

TRANSMIT -- (TRANSCOM's System for Managing Incidents and Traffic) operational test evaluating the use of automatic vehicle identification (AVI) technology in incident detection in Rockland and Bergen Counties NJ, 1993-1996.

"CAPITAL" -- a completed operational test in the Washington DC area (completed December 1995) which used cellular phone broadcasts to locate vehicles in traffic.

Genesis -- an Advanced Traveler Information System (ATIS) operational test using personal communication devices (PCDs) to distribute travel advisory information in the Minneapolis/St. Paul MN area, running from 1992 to 1997.

TRAVLINK -- an ATIS/APTS (Advanced Public Transportation System) operational test along the I-394 corridor in Minneapolis MN, part of the Minnesota Guidestar ITS program, provides real-time transit schedules and travel information to kiosks and computer terminals, 1992-1996.

TransGuide -- an Advanced Traffic Management System (ATMS) operational test in San Antonio TX area including the construction of a control center and a 190-mile ATMS network, 1993-1996.

Smart Commuter -- an operational test in the Houston TX area to develop and evaluate a real-time traffic and transit information system, 1993-1997.

DIRECT -- (Driver Information Radio Experimenting with Communications Technology), an operational field test of various low-cost means of transmitting travel advisory information to motorists along sections of I-75 and I-94 in the Detroit MI area, running from 1991 to 1997.

Smart Corridor -- an operational test along the Santa Monica freeway corridor in Los Angeles CA using highway advisory radio (HAR), variable message signs, kiosks and teletext to make travel advisory information available, 1991-1996.

TravInfo -- a comprehensive, region-wide travel information system in the San Francisco CA area based on a multi-modal transportation information center making

integrated travel information available to the public, commercial vendors and government agencies, 1993-1997.

ITS systems which recently underwent operational testing phases include 'smart cards', automated roadside safety inspections for commercial vehicles, database integration, and elements of system architecture.

In CVO, operational tests are completed or underway at U.S.-Canada and U.S.-Mexico international border crossings, as well as individual tests nationwide covering hazardous material incidence response, electronic clearance of tagged vehicles, one-stop purchase of credentials, and electronic collection and reporting of vehicle mileage.

The following are among the operational tests planned by FHWA for FY 1997:

- Algorithms for the Real-Time Traffic Adaptive Control (RT-TRACS) traffic management system in two large urban networks;
- location referencing and spatial database transfer standards in two locations with different highway configurations and existing map database systems, to demonstrate sharing geographic information between different databases; and
- roadside testing of commercial vehicle emissions at highway speeds.

NHTSA has planned the following operational tests for FY 1997:

- Ongoing testing of Intelligent Cruise Control (ICC) and Automatic Collision Notification (ACN) systems; and
- on-board safety diagnostics for installation in commercial vehicles to monitor critical vehicle, cargo and operator systems.

Evaluation (FHWA)

FY	1996	1997	1998
Funding	0[8]	4,000	NA
FTE	1.2	1.2	NA

In addition to operational tests, another means for DOT to facilitate the deployment of ITS user services is through an active Evaluations program. In this effort, information regarding the status of ITS user services deployed at the local level, the costs and benefits associated with them, and the decision-making process is collected and assessed. The resulting database will provide information, insight and understanding of the benefits and consequences of ITS

[8]This is supplemented by a $3,500k transfer from the FY 1996 funding for ITS Research and Development.

operations so that adjustments can be made and new research areas can be identified. Operational testing teams are helped to develop comprehensive evaluation plans incorporating all significant elements of the test. The results of these efforts can be used to assist local officials in planning their own ITS deployments, as well as to assess the success of the ITS program itself in meeting its stated milestones. The primary goal of the Evaluation program in FY 1997 is to expand the collection of ITS deployment information to the largest 75 urban areas.

Mainstreaming (FHWA)

FY	1996	1997	1998
Funding	0[9]	950[10]	NA
FTE	NA	NA	NA

DOT has been assisting state and local officials and private sector participants in the development of plans for "early deployment" of ITS products and services for commercial vehicle safety regulations and travel management. In the CVO area, this has included supporting states in the development of CVO deployment business plans, holding regional forums and supporting institutional and technical studies which help the CV community -- both public and private -- to understand ITS programs and benefits and be prepared to incorporate them into their ongoing activities.

For ATMS and ATIS, about $33 million has been made available to 90 metropolitan areas and selected intercity corridors to prepare detailed Early Deployment Planning studies, which provide the region with guidance on implementing their overall ATMS/ATIS projects, including key ITI features. About 75 of these studies will be completed by the end of FY 1997. Technical training courses and workshops are held across the Nation in topics such as operating and maintaining new ITI equipment and systems, use of computer simulation models, and conducting environmental evaluations. Technical experts are made available to consult with state and local officials on how to plan for and deploy ITS systems. Case studies describing the planning and implementation of actual ITS projects are also prepared and distributed. Much of this training is provided in close cooperation with National professional associations and state and local transportation agencies.

These activities will continue and be expanded in FY 1997. In addition, there are other important initiatives in that year which will further assist in the deployment of ITS services. A handbook on integrating ITS systems into the local transportation planning processes will be issued. Under the 'ATMS/ATIS Champion' program, local and state transportation agencies will be asked to nominate qualified individuals to lead local deployment activities. Ten of these individuals will be selected to receive DOT funding support for those efforts, to

[9]This funding is supplemented by $15,285k in ISTEA Section 6058 funds.

[10]This funding is supplemented by $20,800k in ISTEA Section 6058 funds.

be matched by equal funding from the nominating region. A 'National ITS Training Initiative' will seek to enhance significantly the understanding of ITS systems among transportation professionals.

Model Deployment (FHWA)

FY	1996	1997	1998
Funding	0	100,000	NA
FTE	NA	NA	NA

The Model Deployment program seeks to encourage the widespread deployment of ITS user services by supporting the implementation of state-of-the-art intermodal transportation management and travel information systems for ATIS and CVO in selected major metropolitan areas. It is hoped that the experiences of these locations will introduce the public and state and local officials to ITS products and services while demonstrating their benefits in real-life scenarios. Qualifying metropolitan areas for these implementations will be selected through an open competitive process.

The ATIS element of this program will integrate the data collection functions of existing core infrastructure elements -- such as freeway management, traffic adaptive controls, incident management, transit management, and emergency management systems -- into a regional transportation information system with a common database of traveler information. Public relations and outreach activities will highlight the availability and advantages of these information and management systems within the local communities, and user acceptance of these services will be carefully evaluated. The model CVO deployments will include roadside electronic verification, electronic purchase of credentials, facilitation of international border crossings, and out-of-service verification capabilities.

The major FY 1997 milestones for this program are to implement model traveler information deployment at up to three additional metropolitan areas identified in the open competition; and to implement model CVO deployment at an additional three to four multi-state regions, as well as two to four additional international border crossing locations. Additionally, a National strategy for deploying hazardous material incident response capabilities will be developed.

Commercial Vehicle Operations (FHWA)

FY	1996	1997	1998
Funding	13,750	0[11]	NA
FTE	NA	NA	NA

FY 1996 funding for DOT's Commercial Vehicle Operations (CVO) model deployment supports the deployment of model CVO systems (information, physical infrastructure,

[11]This is supplemented by a $7,750k transfer from the FY 1996 funding for ITS Research and Development.

reengineered procedures and partnerships) in a few states for multiple CVO applications including: roadside electronic verification, border crossings, and electronic purchasing of motor carrier credentials.

Major activities and anticipated FY 1996 accomplishments include:

- Test Phase I prototype of a nationwide computer system network for roadside electronic verification, purchase of credentials, and out-of-service verification in three sites in two states.

- Showcase an integrated set of technologies for roadside electronic verification at fixed and mobile sites (e.g., transponders, readers for transponders and license plates, roadside-to-State/CVISN communications, pen-based computers, brake testing technology, high-speed WIM, inspection selection algorithm, and out-of-service and credential hot lists).

- Provide support for up to 15 States and all regions to complete a multi-year business plan for CVO deployment.

Program Support (FHWA)

FY	1996	1997	1998
Funding	10,034	10,000	NA
FTE	NA	NA	NA

The Program Support function provides for the central coordinating role of the U.S. DOT in the ITS program. This role includes facilitating the development of a National consensus among public and private sector participants on the goals, plans and progress of the ITS program, as well as ensuring that the various ITS activities receive proper technical review and integration.

This function also supports the Cooperative Agreement with ITS AMERICA, a chartered Federal Advisory Committee, for program planning and assessment; and support for MITRE Corporation to provide the Department with program management and system engineering services in support of the ITS program. Additionally, it provides for information management support, local area network services, and technical and program advice in specific areas such as advanced traffic management system applications and system architecture.

ITS-ISTEA Section 6058 (FHWA)

FY	1996	1997	1998
Funding	98,827	113,000	NA
FTE	NA	NA	NA

The ITS program (formerly, IVHS) was established in Title VI of ISTEA and is authorized at up to $113 million per fiscal year. ISTEA established requirements for the promotion of compatible standards and protocols to promote widespread use of ITS technologies, the establishment of guidelines for ITS operational tests, and the establishment of an information clearinghouse. Demonstration by 1997 of a "prototype" automated highway and vehicle system is required. An ITS Corridors program, discussed below, was established to provide for operational test and implementation under "real world" conditions. Corridors which meet certain transportation and environmental criteria will be designated to participate in developing and implementing ITS technologies. Also supported are innovative, high-risk projects in other activities necessary to implement the National ITS Strategic Plan.

Corridors Program (FHWA)[12]

The ISTEA legislation included provisions for an ITS Corridors program. Under this concept, between three and ten sites in the United States were to be designated as Priority Corridors to become 'showcase' sites for demonstrating and implementing promising ITS systems under "real world" conditions. The program placed particular emphasis on such potential ITS benefits as improved air quality, intermodal linkages, and consolidated traffic management functions. Four such Priority Corridors have been identified. They are: (1) the Interstate 95 Northeast Corridor between Maine and Virginia; (2) the Gary-Chicago-Milwaukee Corridor along Interstates 80, 90 and 94 through Indiana, Illinois and Wisconsin; (3) the Houston Corridor along Interstates 10 and 45 in Texas; and (4) the southern California Corridor along Interstates 5 and 10.

A detailed Program Plan was developed for each Corridor, and implementation of these plans is now underway. There are a number of innovative initiatives already underway in these Corridors. These include: an electronic 'Information Exchange Network' linking the state DOTs and toll authorities along the Corridor; designing an integrated, multi-modal information system, including a backbone communications system for transmitting real-time transit schedules, traffic information and weather advisories; a monitoring and advisory system that can detect flooding conditions and respond by revising traffic control strategies; and an adaptive traffic control system that automatically optimizes traffic signal timing based on real-time traffic information.

[12]All funding for the Corridors Program, $42,607k in FY 1996 and $81,700k in FY 1997, is derived from ISTEA Section 6058 funds.

In FY 1997, emphasis will be placed on supporting the deployment in these Corridors of the ITS systems identified as part of the 'Intelligent Transportation Infrastructure'. Other projects will assist in testing and evaluating key communications standards and protocols needed to integrate these ITI systems into a coordinated regional program. Additionally, model deployment projects of ATMS, ATIS and CVO core infrastructure features in locations other than these four Corridors will be supported by this program.

Crash Avoidance--Driver/Vehicle Performance (NHTSA)

FY	1996	1997	1998
Funding	0	4,000	NA
FTE	NA	NA	NA

This program's goals are to help drivers of all types of vehicles avoid crashes or to lessen the severity of crashes that do occur by: improving driver direct and indirect visibility; improving tire traction performance; improving vehicle braking, directional, and rollover stability; improving vehicle lighting, signaling, and marking; ensuring compatible driver/vehicle interfaces; developing objective test procedures for collision avoidance systems; and acquiring, archiving, and making available to customers driver/vehicle performance characterization data. Research activities include the following:

- Initiate research into the performance of antilock braking systems of light vehicles; assessment of driver reaction and driver feedback to activation of the antilock feature; assessment of brake performance on various surfaces;

- develop protocols for combining simulator and test track experimental data into objective test procedures that could serve as the basis for performance-based standards or regulations;

- conduct research into issues associated with vehicle rollover such as developing a methodology for determining critical characteristics of vehicles and developing test procedures for demonstrating the impact on vehicle stability and rollover propensity; and

- provide support for collision avoidance rule making activities on an as-needed basis.

A key milestone for FY 1997 will be to evaluate the effects of head-up displays on driver visibility, distraction, and work load.

Industry Competitiveness (MARAD)

FY	1996	1997	1998
Funding	NA	280	NA
FTE	NA	NA	NA

One of the responsibilities of the Maritime Administration is to foster the development of a competitive U.S. maritime industry that contributes to both the Nation's economic growth as well as important National security goals. A top priority of MARAD's Industry Competitiveness program is to assess and deploy effective and innovative information, communications and navigation systems and technologies that will improve the efficiency, productivity and safety of the National maritime transportation system.

In pursuit of this goal, MARAD has expanded participation by the maritime industry in the Ship Operations and Cargo Handling Cooperative Programs, which facilitate the development and sharing of new technologies in these fields. Both of these government/industry cooperative efforts are industry-led and cost-shared. One current project is the development of an integrated Reliability Availability Maintainability Database (RAM) designed to collect ship's equipment failure/corrective maintenance data. The U.S. maritime industry, and foreign fleets as well, have a worldwide need for such a database which can be achieved only with Government participation and leadership.

This program also assesses advanced information systems designed to improve vessel operating safety and efficiency, and conducts research on innovative cargo handling equipment, techniques and systems. The program has also supported the development of these technologies, such as a shipboard Personal Computer-based training system for ship crews. Finally, designated National Maritime Enhancement Institutes will participate in these activities as appropriate.

Hazardous Materials Research (RSPA)

FY	1996	1997	1998
Funding	1,542	1,161	NA
FTE	2.2	2.2	NA

RSPA's hazardous materials safety (HMS) program is a comprehensive nationwide safety program to protect the Nation from the risks to life, health, property, and the environment inherent in the transportation of hazardous materials by water, air, highway, and railroad; to protect the environment from damage by oil and other pollutants; and to ensure the safe transportation of food. The research and development program provides the technical and analytical foundation necessary to support DOT's regulatory, international standards development, compliance, and emergency response activities in the area of hazardous materials transportation safety. Current research and development efforts are organized into three program areas.

The first area is Information Systems. The Hazardous Materials Information System (HMIS) is a computerized information management system containing data related to the Federal hazardous materials safety (HMS) program to ensure the safe transportation of hazardous materials by air, highway, rail, and water. The HMIS is the primary source of National data for the Federal, state and local governmental agencies responsible for the safety of hazardous materials transportation. Data from the system are also used by the HMS program, industry, news media, and general public. See further description of the HMIS in this section.

The second program area, Research and Analysis provides the technical and analytical foundation necessary to support risk management, program assessment, assessment and implementation of new technologies, and the development of domestic and international hazardous materials transportation safety regulations and programs.

The third program area is Regulation Compliance. Packaging is critical to the safe transportation of hazardous materials. This program performs the testing necessary to determine the extent of manufacturer compliance with the regulations to protect the public and the environment from unintentional release of hazardous materials.

The HMIS contains six sub-systems serving the varied needs of the Department's hazardous materials safety program. These sub-systems contain data related to:

- incidents involving the release of hazardous materials in transportation by all modes. The data include consequences, such as deaths, injuries, and evacuations;
- exemptions issued to the hazardous materials regulations;
- interpretations of the regulations issued by the RSPA, as requested by interested parties;
- approvals of specialized container manufacturers, reconditioners, and testers;
- compliance activities, including inspections performed and completed enforcement proceedings; and
- registrations filed by certain carriers, shippers and offerors of hazardous materials.

HMS uses data in the HMIS to support its mission activities, including: developing regulations; issuing exemptions, approvals, and interpretations; and enforcing safety regulations. This function is even more critical as the Department of Transportation (DOT) monitors the transition to performance-based packaging standards and internationally harmonized hazardous materials regulations.

Emergency Transportation (RSPA)

FY	1996	1997	1998
Funding	67	68	NA
FTE	NA	NA	NA

The Office of Emergency Transportation, located in RSPA, provides the Secretary of Transportation and senior DOT officials with an effective ongoing emergency response capability within the overall interagency context of the Federal Response Plan (the Federal Government's plan for performing disaster assistance missions). The Response Management Support program is responsible for maintaining and enhancing the Department's ability to provide these decision-makers timely information in the event of a crisis. In particular, this effort focuses on the ability to assess the effects of a natural disaster on the National transportation system, as well as effective tracking of the flow of critical relief supplies during the response phase. This activity researches available crisis management software systems, including mapping and communications capabilities, and implements improvements to them.

Related Departmental Activities

Aviation Satellite Navigation (FAA)

The Federal Aviation Administration's Navigation program, includes two major program elements. The first element, Satellite Navigation, supports the operational use of satellite navigation technologies such as the Global Positioning System (GPS) and the International Marine Satellite (INMARSAT) in civil aviation. A number of ITS concepts and systems also utilize GPS for surface navigation and vehicle location purposes. The second element, Navigation Systems Development, identifies and evaluates new navigation technologies and concepts that may be applicable to civil aviation. This includes assessing the feasibility of transitioning from primarily ground-based to satellite-based navigation systems, and contributing to the updating of the Federal Radionavigation Plan (FRP).

Waterways Safety and Management (USCG)

One of the primary responsibilities of the U.S. Coast Guard is to facilitate the safety and ease of use of the nation's waterways. Towards this end, the USCG's Waterways Safety and Management program investigates and applies new and emerging navigation, communications, display and information systems technologies to marine navigation. These activities include continuing the development and enhancement of the Advanced Vessel Traffic System (VTS), as well as assessing new concepts for buoys and other short-range aids to navigation. The program also supports the implementation of International Maritime Organization (IMO) standards for Electronic Chart Display Information Systems (ECDIS) and Electronic Nautical Charts within the U.S.

CHAPTER 4

NEXT-GENERATION VEHICLES AND FUELS

Transportation vehicles are a major element of our transportation system. In fact, transportation's performance, safety, security, cost, environmental impact, economic consequences, and contributions to quality of life are all determined largely by the vehicles that carry people and goods. Today, our transportation system faces a dual challenge: increased global competition for our transportation industries, and increased demands for mobility from our citizens. Meeting this challenge will require a next generation of vehicles that meets rigorous standards for reliability, cost, safety, energy use, and environmental impacts. Thus, a strategic goal for transportation R&D is enhancing the overall performance of vehicles of all types, while expanding the range of available alternatives.

Unlike physical infrastructure improvements, a large number of which the Government is responsible for, vehicle technology improvements are achieved through long-term R&D that optimizes and leverages the use of both public and private resources. Federal investment is needed to reduce the risk to the private sector and to assure a continuous flow of innovation.

In its Strategic Planning Document for 1995, the NSTC Committee on Transportation R&D identified a number of major program objectives for motor vehicle R&D. Among these are the following:

- *Develop a personal motor vehicle that will deliver up to three times the fuel efficiency of today's comparable vehicles while reducing emissions, without compromising performance, safety, room, and utility.*

- *Develop and introduce manufacturing technologies and practices that will reduce the time and cost associated with designing and mass-producing this new personal motor vehicle.*

- *Improve and regain the U.S. position in the world truck and bus market.*

- *Assure that advanced truck and bus technologies consider accessibility, energy efficiency, and environmental impacts.*

- *Facilitate innovation in rail vehicle design and construction by introducing advanced materials, communications, and control technologies.*

- *Improve the propulsion and emission performance of intercity and commuter locomotives, and expand the range of alternatives available to meet future transportation needs.*

- *Develop strong and competitive international ocean shipping and domestic water transportation industries.*

- *Develop a strong and competitive commercial ship design and production capability.*

Near-Term Efforts

The majority of DOT's near-term vehicle research is aimed at meeting the transportation committee's objectives. Specific programs are discussed in the following paragraphs:

Motor Carrier Research (FHWA)

FY	1996	1997	1998
Funding	7,390	7,774	NA
FTE	9	9	NA

The Office of Motor Carriers' (OMC) research program includes the following: (1) human factors research on commercial driver alertness, medical fitness, drug and alcohol use, and driver licensing and training (discussed in Chapter 5, below); (2) evaluation and promotion of safety-enhancing vehicle and data- reporting technologies; (3) establishing and undertaking program analysis activities; (4) undertaking a comprehensive, multiyear regulatory review to make regulations more enforceable, understandable, and performance-based; and (5) creating more opportunities for innovation, partnerships, and shared financing in the pursuit of OMC research objectives. Non-driver-related OMC research includes:

- Technology — Review ITS technologies to determine near-term applications for improving motor carrier safety and productivity. Determine the effectiveness of various technologies and their impact on the operations of multiple-trailer commercial vehicles. In coordination with NHTSA, assess recommendations for the marking and identification of commercial motor vehicle replacement parts and accessories. Assess the feasibility of standards for "after market" brake linings and other brake system components.

- Information Analysis — Implement a system to improve the validity and reliability of information in the motor carrier Census File update. Analyze the effectiveness of fines and penalties, as well as technical assistance and education programs, in achieving motor carrier and driver compliance with safety regulations. Evaluate the characteristics of reported crashes by different motor carrier operations, vehicle types, crash locations, and other pertinent factors.

- Services and Partnerships — Continue efforts to develop and implement new, cost-effective reporting, recordkeeping, and registration procedures.

- Creating more opportunities for innovation, partnerships, and shared financing in the pursuit of its research objectives.

Major milestones for FY 1997 will include the identification of potential technologies for rapid and reliable roadside inspection activities, and the development of an effective interface between SAFETYNET and ITS data systems.

Safety Systems (NHTSA)

FY	1996	1997	1998
Funding	5,910	6,500	NA
FTE	20.36	19.94	NA

Frontal, side, and rollover crashes account for most of the deaths and injuries to occupants of passenger cars and light trucks and vans. Ejections, pedestrian impacts, and fires also cause death and injury. The goal of this research is to provide improvements in vehicle structure and occupant compartment design, in combination with improvements in restraint systems. These improvements require research in test procedures, injury likelihood measurement, and countermeasure development and evaluation, including the following:

- Evaluating the reliability of rollover test procedures.
- Analyzing the feasibility of modeling the early phase of air bag deployment.
- Continuing to update and maintain the vehicle attributes crashworthiness database.
- Continuing to test various impact configurations.
- Evaluating designs of modified vehicles to establish the effectiveness of side-impact countermeasures.
- Using the developed seat model, investigate countermeasures that would mitigate whiplash and other injuries.
- Continuing work on a near-term, economical crash sensor to reduce occupant injuries.
- Continuing R&D on advanced air bag systems.

A milestone for FY 1997 will be to evaluate production vehicles and develop countermeasures for improved frontal crash protection.

Biomechanics (NHTSA)

FY	1996	1997	1998
Funding	5,890	7,450	NA
FTE	15.27	14.96	NA

NHTSA's Biomechanics research program pursues efforts that (1) study physical conditions and human consequences of real-world crashes with multidisciplinary teams of medical, engineering, and accident investigation professionals; (2) provide a detailed understanding of the forces, motions, and distortions the human body experiences in a crash and their relationship to the extent and severity of resulting injuries; (3) create detailed computer models of the human body that can simulate human impact response and trauma; and (4) develop and improve dummy components and other mechanical trauma assessment devices that evaluate human impact risk. Ongoing efforts include:

- Conducting hospital-based, in-depth crash injury studies at four trauma centers.
- Continuing experiments to increase public safety with better seat belt and air bag systems.
- Conducting experiments to increase public protection in side impacts.
- Continuing experiments to determine neck trauma and validate neck computer model.
- Continuing to develop human thorax computer model.
- Continuing upgrading and updating of existing crash dummies.
- Studying brain trauma resulting from crashes.

A major milestone for FY 1997 will be completion of a final prototype of a crash dummy with innovative lower extremities. Applicability of research in biomechanics to multiple modes will be actively pursued by NHTSA.

Heavy Vehicles (NHTSA)

FY	1996	1997	1998
Funding	517	597	NA
FTE	5.09	4.99	NA

The goals of this research effort are to reduce the nation's health care costs by improving heavy vehicle crash avoidance and crashworthiness capabilities. Heavy vehicles compose 3 percent of the vehicle population and accumulate 7 percent of the vehicle miles traveled, but are involved in 12 percent of all fatal crashes. Most of these fatalities are occupants of

smaller vehicles involved in collisions with heavy trucks. Near-term research includes the following:

- Complete a cooperative program with industry to develop braking stability performance test procedures for trailers.
- Continue joint efforts with industry to characterize the range of truck tire traction performance properties that influence truck dynamic stability and braking capabilities.
- Continue feasibility assessment of methods for reducing the severity of truck/car frontal collisions.
- Continue to foster the application of advanced technology to improve the collision avoidance performance of heavy vehicles.

An FY 1997 milestone will be to complete development of braking stability performance test procedures for trailers.

Partnership for a New Generation of Vehicles (NHTSA)

FY	1996	1997	1998
Funding	0	5,000	NA
FTE	3.39	3.32	NA

This NHTSA program provides technical support for the Administration's Partnership for a New Generation of Vehicles (PNGV) initiative. As the focal point within DOT for the PNGV program, this research ensures that the PNGV-developed vehicles will meet existing and anticipated safety standards and that the overall crash and other safety attributes are not compromised by their light weight or use of new advanced materials. Ongoing work will:

- Continue to develop advanced computer models to evaluate the crashworthiness of conceptual designs.
- Continue research in the area of advanced composites.
- Provide the required PNGV infrastructure analyses.
- Provide peer review of conceptual designs.

A key FY 1997 milestone will be to develop analytical capability to support the PNGV program.

Equipment, Operations, and Hazardous Materials Research (FRA)

FY	1996	1997	1998
Funding	5,560	5,820	NA
FTE	7	7	NA

This FRA program is designed to improve safety and enhance productivity within the railroad industry by reducing injuries, accidents, and their related costs. Near-term work includes the following:

- Evaluating, testing, and validating locomotive crashworthiness features.
- Developing and evaluating improved inspection/detection methods for wheels, roller bearings, and suspension components.
- Evaluating potential strategies for mitigating the effects of fatigue for locomotive engineers.
- Evaluating safety of operating practices in yards and terminal areas.
- Studying damage tolerance of tank cars as part of acceptance guidelines for new tank car designs.
- Analyzing/identifying tank car critical parts and acceptable flaw size in head welds.

A key FY 1997 milestone will be to publish findings on improved roller bearing inspection development.

Safety of High-Speed Ground Transportation (FRA)

FY	1996	1997	1998
Funding	9,378[1]	7,169	NA
FTE	1	1	NA

This FRA program will identify and investigate safety issues of planning, design, construction, and operation of new high-speed ground transportation to support FRA rulemaking. Research efforts include the following:

- Evaluate actual safety performance of prototype high-speed positive train control demonstrations in Michigan and Illinois.
- Provide a firm technical basis for FRA rulemaking and policies affecting high-speed rail and maglev deployments.

[1]$1,728k is devoted to physical infrastructure R&D.

- Identify where candidate high-speed technologies must be improved to sustain necessary safety levels.

- Monitor potential impacts of electromagnetic fields for high-speed rail, maglev, and conventional rail.

A major milestone for FY 1997 will be to evaluate the safety of car tilt and brake systems for 150-mph travel.

Next-Generation High-Speed Rail (FRA)

FY	1996	1997	1998
Funding	24,151[2]	26,526[3]	NA
FTE	2.5	4	NA

This FRA program's goal is to develop, demonstrate, and validate cost-effective high-speed passenger rail technology that operates on existing infrastructure. Research activities include:

- Initiating demonstration of communications-based train control in high-density freight and passenger corridors; and

- Sustaining progress toward development, demonstration, and validation of key technology for making cost-effective high-speed rail available by 2000.

For FY 1997, a key milestone will be to demonstrate the feasibility of flywheel energy storage systems.

Shipyard Revitalization (MARAD)

FY	1996	1997	1998
Funding	NA	734	NA
FTE	NA	NA	NA

This program addresses the implementation and execution of President Clinton's Plan entitled "Strengthening America's Shipyards: A Plan for Competing in the International Market." In support of this initiative, the Congress enacted legislation on November 30, 1993, containing the National Shipbuilding Initiative (NSI). This legislation serves as a catalyst for promoting construction of ships in U.S. shipyards as part of the transformation from a primarily military focus to one serving the international commercial marketplace. Goal 3.7 of the

[2]$7,750k is devoted to physical infrastructure R&D.

[3]$3,000k is devoted to physical infrastructure R&D. This funding is supplemented by a $1,420k trust fund carryover, for a total FY 1997 project funding level of $27,946k.

DOT's Strategic Plan commits the Department to "Implement the President's new shipbuilding initiative to enable American shipbuilding to be more competitive globally." As the U.S. Government's commercial shipbuilding advocate, the Maritime Administration is undertaking the initiatives identified in the President's program. These are:

- Ensuring Fair International Competition
- Improving Competitiveness
- Eliminating Unnecessary Government Regulation
- Financing Ship Sales through Title XI Loan Guarantees
- Assisting International Marketing

An important milestone for FY 1997 will be to continue the implementation of these National goals. The full implementation of the mission of the Maritime Administration's National Maritime Resource and Education Center will provide the industry with: a coordinated administration of MARAD MARITECH funded projects designed to improve shipbuilding processes and the development of new and improved ship designs; support for U.S. efforts at reaching consensus on domestic and international standards and regulations affecting the competitiveness of the U.S. maritime industry; access to comprehensive Marine Standards and International Standards Organization (ISO) 9000 and 14000 information; and MARAD sponsored topical seminars, training and other resource support as requested by the industry.

Given sufficient funding, another element for consideration is the Ship Structure Cooperative Research Program. The goals of this cooperative research program are to investigate ship structural problems, pursue new technology, and develop structural design, analysis and fabrication techniques in areas of common interest. The research is defined and directed by the Ship Structure Committee with assistance from the Committee on Marine Structures, Marine Board of the National Research Council. The Ship Structure Committee is jointly funded by participating agencies, which include the Maritime Administration, the U.S. Coast Guard, the Military Sealift Command, the U.S. Navy, the American Bureau of Shipping, Transport Canada, and the Canadian Defense Research Establishment. MARAD is unable to contribute funds in 1996, but has been allowed to continue to participate in the Cooperative's program decision making process.

Key milestones for the Ship Structure Cooperative Research Program include: the completion of research on hull monitoring systems, visual detection of structural defects, weld repair adequacy, corrosion control during fabrication and improved fatigue life of weld details; and the awarding of contracts for new research in the Ship Structures Cooperative Research Program as chosen by U.S./Canadian government participants.

New Bus Vehicles and Infrastructure (FTA)

FY	1996	1997	1998
Funding	5,295	6,800	NA
FTE	NA	NA	NA

This FTA program aims to improve the safety, service, and cost-efficiency of public transportation through research and adoption of new technology, management practices, and service innovation. The program will develop and demonstrate new vehicles and vehicle technologies that will significantly lower operating and maintenance costs for transit operators and will foster the commercialization of these new technologies. Research activities include the following:

- Advanced Technology Transit Bus (ATTB) — Continue development of a lightweight, low-floor, low-emissions 40-foot transit bus that will significantly reduce operating expenses. The ATTB makes use of defense conversion technologies and light-weight aerospace-type materials and construction techniques to reduce the curb weight of the ATTB to 18,000 pounds, allowing it to meet the FHWA 20,000 pound single-axle weight requirement. This weight reduction will also reduce fuel consumption, reduce brake and tire wear, reduce pavement damage, and extend vehicle service life.

- Advanced Subsystems for Buses — Continue development and demonstration of advanced lightweight, power-efficient auxiliary systems for hybrid-electric, fuel cell, and battery-powered transit buses.

A major FY 1997 milestone will be to complete the DUETS project.

Advanced Bus Propulsion Systems (FTA)

FY	1996	1997	1998
Funding	5,500	6,900	NA
FTE	NA	NA	NA

This program's goals are fourfold: develop and demonstrate a low- and zero-emission propulsion system for transit vehicles with lower operating and maintenance costs; foster introduction and commercialization of low- and zero-emission transit vehicles; complement efforts under the PNGV program for automobiles; and enhance the vitality, competitiveness, and responsiveness of U.S. industry in the fuel cell, electric, and hybrid-electric propulsion market. Work includes:

- Fuel Cell Transit Bus Program — Develop full-sized, domestically produced, phosphoric acid and proton exchange membrane fuel cell transit buses. Build upon ongoing efforts in the fuel cell bus program to develop advanced fuel cell technologies for transit bus propulsion.

- Electric Vehicle Program — Develop advanced battery-powered 40-foot transit buses. Build upon the ongoing efforts in the electric vehicle program to develop improved electric and hybrid-electric propulsion systems for transit vehicles.

A key FY 1997 milestone will be to complete development of a fuel cell-powered 40-foot transit bus.

Related Departmental Activities

Modular Fuel Cell System for Ship and Heavy Rail Use (USCG)

Develop a nominal 200 kilowatt molten carbonate fuel cell module and demonstrate in a nominal 2 megawatt multimodal propulsion system in a government-owned vessel and/or locomotive. Research in this area could lead to significant environmental and economic benefits for ship operations in Coast Guard, Naval, and commercial maritime services, and may stimulate similar gains for land vehicles (e.g., buses, locomotives).

CHAPTER 5

HUMAN-CENTERED TRANSPORTATION SYSTEMS

Acting as operators, crew members, or passengers, people are essential components of all transportation systems. Their capabilities, decisions, and performance significantly affect the transportation system's overall safety and efficiency. Likewise, there is no doubt that reducing or mitigating human errors could improve safety: Approximately 60 to 80 percent of all transportation accidents involve some form of human error.

Today, transportation is undergoing a revolution. We are developing, introducing, and adopting many new technologies, largely based on advanced information and computer systems, to assist transportation operators in making critical decisions. If properly employed, these technologies can dramatically improve transportation safety, reliability, and productivity. However, these gains will in large part depend on properly incorporating the human as a central element in the new systems.

As they are applied to transportation, advanced technologies often do not achieve their full potential because of a failure to consider fully the human factors involved in technology use. If we are to realize significant improvements in safety and efficiency, it is imperative that we design, employ, and operate new technologies from a "human-centered" perspective. Human-centered approaches recognize that technology can be only as good as the humans that operate it. The success of human-centered technology comes from putting people first and recognizing that the human contribution is a critical part of technology development and implementation.

The NSTC Subcommittee on Behavioral Sciences and Human Performance in Transportation Systems breaks out the elements of a human-centered technology into three components:

- *Human-centered interfaces — Focusing design, product, and systems development to fully anticipate, take advantage of, and effectively use human capabilities.*

- *Human-centered operations — Focusing on ways to make operation of systems more effective and safe through improvements in procedures, training, and selection.*

- *Human-centered systems integration — Focusing systems design, construction, and implementation to include fully the human user in the assessment of safety, security, environmental risk, comfort, efficiency, economics, and choice.*

By contributing to safety and productivity, R&D in the area of human-centered technology supports National goals for economic growth, competitiveness, and job creation.

Because human performance R&D often lacks private support, and because human performance is crucial to the safety of the transportation system, Federal investment and leadership is required. The objective of Federal efforts supporting the development of human-centered transportation systems is to ensure that needed data and methods are available to U.S. industries that design and produce advanced transportation technologies. The following surface transportation programs have human-centered concerns as their primary focus. Related near-term programs are discussed in the next section.

Near-Term Efforts

Commercial Vehicle Operator Human Factors (FHWA)[1]

FY	1996	1997	1998
Funding	-	-	-
FTE	-	-	-

The objective of this program area of the FHWA Office of Motor Carriers is to ensure that commercial motor vehicle (CMV) drivers are physically qualified, have the knowledge and skills necessary to operate safely, are appropriately licensed, and are alert and unimpaired behind the wheel. The program embraces a broad range of topics, including CMV driver medical qualifications, loss-of-alertness/fatigue, substance abuse, and driver training.

Research results may form the technical foundations for changes to DOT's Federal Motor Carrier Safety Regulations, which primarily govern trucks and buses in interstate commerce. Accordingly, the topics for research are highly applied. The experimental designs provide representative models of real-world motor carrier operations. Near-term research activities include the following:

- Driver Fatigue and Alertness — Provide a scientifically-sound basis for evaluating hours-of-service requirements. Assess the costs, practicality, and safety benefits of alternative hours-of-service scenarios through economic analysis and real-world testing. Develop countermeasures for reducing driver fatigue and increasing alertness, and disseminate information on these countermeasures.

- Driver Fatigue and Stress — Determine if operating a single trailer and two types of triple-trailer combination vehicles leads to differences in drivers' performance, stress, and alertness levels.

- Fitness-for-Duty Testing — Evaluate the use of in-terminal and in-vehicle fitness-for-duty testing technologies and devices for commercial drivers.

[1]Funding for this program is included in the Motor Carrier Research program, discussed in Chapter 4.

- Sleep Apnea — Estimate the prevalence of sleep apnea (transient cessation of respiration while sleeping) in a population of high-risk truck drivers and the level of sleep apnea at which driving performance becomes impaired.

- Rest and Recovery — In a laboratory setting, determine the number of hours, or range of hours, a driver needs to recover from fatigue after operating a commercial motor vehicle. Modify an existing software model based on activity monitoring to predict the alertness of drivers placed on various work/rest schedules.

- Rest Areas — Determine the availability of public rest areas and private truck stops and how well the current level of public and private facilities meets commercial truck drivers' needs and demands.

- Shipper Study -- Determine the scope, nature, and extent of shipper involvement in noncompliance with Hours-of-Service violations, such as shipper demands for delivery schedules which make Hours-of-Service violations likely.

- Scheduling Practices -- Survey drivers, motor carriers, and shippers to determine the prevalence of various shipping scheduling practices, associated driving schedules, and possible fatigue effects.

- Sleeper Berth -- Determine why commercial drivers who rely on sleeper berths for rest tend to demonstrate signs of sleep deprivation and degradation, such as driving performance deficits, and determine what interventions (regulatory or non-regulatory) would alleviate this apparent commercial driver fatigue problem..

- Local/Short Haul -- Determine the fatigue effects of commercial motor carrier activities which may be characterized as local/short-haul pick-up and delivery and whether such activities should quality for full or partial exemption from commercial driver Hours-of-Service regulations.

- Loading and Unloading -- Determine relationships between driver loading/unloading activities and subsequent driver alertness, fatigue, and driving performance.

- Fatigue Education and Training -- Develop, disseminate, and evaluate educational and training programs targeted at commercial drivers, dispatchers, risk managers, and shippers to explain current knowledge on fatigue and effective countermeasures.

- Entry-Level Driver Training — Assess the adequacy of entry-level training of commercial motor vehicle drivers in the private sector. The study includes four phases:

  Phase 1 — Research CMV simulation technology to improve driver training: involves identifying and evaluating CMV driver training simulator technology

and developing criteria for the use of simulators in CMV driver training and testing.

Phase 2 — Assess the adequacy and effectiveness of entry-level CMV driver training in the private sector.

Phase 3 — Identify a profile of safe CMV driver characteristics to establish those training aspects that are associated with a safe driver.

Phase 4 — Develop a motorcoach driver training program: involves the development of a 1-week, instructor-led training program based in part on bus information collected in Phase II, and on additional training needs determined by other information collected.

- Management Practices for Driver Training and Evaluation -- Identify, evaluate, and select recommended management practices (e.g., education, monitoring, performance evaluation) for identifying high-risk commercial vehicle drivers and modifying their behavior before traffic violations and crashes occur.

- Survey of Industry Opinion Pertaining to Graduated Licenses -- Query industry and the licensing community about the need for, benefits of, and potential acceptance of provisional, restricted licenses for new commercial motor vehicle operators.

FY 1997 milestones include completing an initial assessment of fatigue and loss of alertness associated with specific types of CMV operations.

Highway Safety Research (NHTSA)

FY	1996	1997	1998
Funding	5,069	4,833	NA
FTE	NA	NA	NA

NHTSA's Highway Safety Research Program is designed to change the knowledge, attitudes, and behavior of drivers, passengers, pedestrians, bicyclists, and others who share the road. Results of the program are directed at both roadway users and at organizations, such as law enforcement agencies, the judiciary, and the senior citizen and health care communities, which are in a position to influence roadway users. The program has eight major components, with the largest effort aimed at reducing the effect of driver alcohol and drug use — clearly the principal cause of driver performance failure and a high priority for NHTSA. Key initiatives and ongoing research in each of the components include:

- Alcohol and Drugs — Determine the feasibility of expanded breath testing programs, assess use of advanced communications technologies to detect suspended drivers, develop prototype countermeasure programs for high-risk target groups, and improve

police DWI patrol procedures and methods for detecting alcohol- and drug-impaired drivers.

- Occupant Protection Use — Develop better data on the causes for low usage rates in youth, rural residents, and minority groups. Develop strategies to improve levels of seat belt law enforcement. Conduct a biennial National survey on occupant protection issues. Determine crash consequences of common forms of child safety seat misuse.

- Older Driver Research — Identify ranges of common impairments and determine methods for measuring and modeling performance of drivers with various levels of impairment. Develop guidelines for police, licensing agencies, physicians and allied health professionals, and friends and family members to assist older drivers in making appropriate decisions about driving.

- Pedestrian and Bicycle Safety — Develop cost-effective countermeasures for states and localities. Assess public attitudes and awareness of pedestrian and bicyclist safety problems. Evaluate pedestrian safety zone approaches in reducing accidents involving older pedestrians. Develop safety countermeasures for specific types of bicyclist/motor vehicle crashes. Examine the involvement of various populations in alcohol-related pedestrian crashes.

- Speed and Unsafe Driving — Complete 1) a crash investigation study to determine when, where, and under what conditions speeding leads to crashes; and 2) a nationwide driver survey on why drivers speed and engage in other unsafe driving behaviors, including the conditions under which such behaviors occur. Develop enforcement strategies.

- Driver Education — Adapt curriculum materials to fit two-phased instruction coordinated with states' provisional or graduated license systems. Develop support training modules, including the use of parents and other adults in improving driving practice and decision-making skills and the use of electronic simulators to improve the teaching of safe driving.

- Driver Fatigue and Inattention — Collect and analyze information regarding the role of fatigue and inattention in crashes. Develop and test technological, informational, and educational countermeasures to reduce the incidence of these factors.

- Evaluation — Document and assess implementation processes and evaluate existing and new countermeasure programs to determine their impact and suitability for widespread adoption. Evaluate occupant protection demonstration grants, alcohol-impaired driving countermeasures, the Safe Communities Program, and various other innovative state and local programs.

A major milestone for FY 1997 is to determine the crash risk for various blood-alcohol levels.

Maritime Safety (MARAD)

FY	1996	1997	1998
Funding	NA	175	NA
FTE	NA	NA	NA

MARAD's program focuses on a human-centered approach to the practical application of behavioral science principles to implementation of people improvements in transportation maritime systems. Improvements are necessary because of the high probability of human error, the extreme competitiveness in international trade, the rapid introduction of automation advances combined with great pressures for low manning levels, and the significant safety and environmental impacts of maritime accidents. Research initiatives are accomplished largely through industry-government cooperatives involving industry leadership. Near term cooperative research initiatives include:

- Human Factors Cooperative Research Program with the Federal and the six State Maritime Academies. The program consists of shared research efforts to apply human factors knowledge and advanced technologies to improve safety and performance of maritime transportation. Projects benefiting the entire industry are identified and their execution shared by the cooperative members. Projects range from developing a bibliographic data base of maritime human factors resources for the World Wide Web to reforming the education of cadets to include human factors elements such as bridge resource management concepts to developing a consensus view of the maritime transportation system in the twenty first century.

- Vessel Piloting Cooperative Program with the American Pilots Association (APA) with its more than 50 member associations. The program works through the APA Navigation and Technology Committee and develops efforts that seek to apply advanced technologies to provide practical improvements to the safety of piloting operations in U.S. waterways. Focus is on human factors aspects and ship-pilot interactions and the use of advanced electronics and technology.

One FY 1997 milestone for the Vessel Piloting Cooperative is to complete test and evaluation of portable navigation technologies by pilot associations through the Piloting Cooperative and report results to the industry through workshops or symposia.

Safety and Security (FTA)

FY	1996	1997	1998
Funding	1,100	1,100	NA
FTE	NA	NA	NA

The performance of transit operators is a key determinant of the personal safety of transit passengers, and of the ability to deter security threats to transit passengers, vehicles, and facilities. The goals of FTA's Safety and Security work are to improve personal security and operational safety, to develop and demonstrate new and innovative security and safety technologies, and to improve emergency management planning. These goals are accomplished primarily through a program of workshops, training, and regulatory support. Ongoing research projects include the following:

- Regulatory Support — Provide assistance to grantees and states in implementing Federal requirements for drug and alcohol testing of safety-sensitive employees and for state safety oversight through the dissemination of training materials and technical guidance.

- Industry Support — Provide training for approximately 6,000 students annually through the Transportation Safety Institute on subjects that include system safety, accident prevention and investigation, system security, emergency management, and alternative fuels handling. Collect, analyze, and publish safety and security data. Provide outreach to transit authorities through a National clearinghouse and bulletin board on safety and security matters.

- Security — Provide technical assistance to transit systems seeking to replace traditional security strategies with more proactive, creative approaches. Conduct security audits to support enhancement of transit security operations.

An important milestone for FY 1997 is to update drug and alcohol implementation guidelines based on changes to the rules.

Related Departmental Activities

Aviation Human Factors (FAA)

FAA human factors programs are responsive to the *National Plan for Civil Aviation Human Factors*. This plan, jointly developed by the aviation industry, academia, NASA, DOD, and the FAA, establishes a behavioral research agenda and strategies to enhance the safety and efficiency of the aviation system. The FAA core research program includes:

- Human-Centered Automation — Establishment of human interface design principles and criteria for automated and advanced systems.

- Selection and Training — Establishment of criteria and techniques for efficiently acquiring and training aviation personnel.

- Human Performance Assessment — Establishment and utilization of measures to assess individual, crew, and organizational human performance in aviation systems.

- Information Management and Display — Establishment of critical human performance parameters required to effectively transfer information in the aviation system.

- Bioaeronautics — The bioengineering, biomedicine, and biochemistry associated with performance and safety.

Marine Safety: Human Factors Analysis (USCG)

This Coast Guard program addresses a variety of issues concerning professional and nonprofessional operators with a wide range of skills, from highly trained ship masters to barge operators, fishing boat crew, and recreational boaters. Human factors data on operation of oceangoing vessels is shared with the Maritime Administration. Near-term research includes:

- Develop human factors criteria for vessel inspections and Coast Guard Operations.

- Develop human factors design guidelines for advanced ships, including bridge ergonomics and obtaining maximum safety and productivity benefits from automation.

CHAPTER 6

INTERMODAL SYSTEMS ASSESSMENT, DESIGN, PLANNING, MANAGEMENT, AND OPERATIONS

System assessment capabilities need to be applied across the wide range of activities and externalities associated with the entire transportation enterprise; covering both the system as a whole as well as its individual elements. This need is evident in the research, investment, operational and policy decisions made by both public agencies and the private sector. In many cases, the results of a single system assessment activity -- whether it be data and information or analytical judgments -- can support a wide range of transportation decisions. In general, however, it is possible to sort the application of transportation system assessment capabilities in the Federal government into two broad categories: support for infrastructure planning, design, management and operations; and support for public policy decision making.

Infrastructure Planning, Design, Management and Operations

Perhaps the most clear-cut role for system assessment lies in the planning and design of transportation infrastructure construction and rehabilitation activities, and in managing existing facilities. Without credible quantitative measures of current performance, the degree of need for improvements in one area cannot be judged or compared to other uses of the same resources. The multi-dimensional costs and benefits -- covering economic, safety, environmental, energy, and mobility and access issues -- of alternative courses of actions, including the decision to "do nothing", can only be known if the data, analytical tools, performance measures, and other elements of system assessment are available.

Similar issues arise in evaluating choices among operational strategies and practices. For example, better understanding of flows on networks, and the underlying transportation needs that shape them, can facilitate improved system management and operations and better maintenance, fleet assignment, and vehicle replacement decisions. This is equally true for a public sector transit agency or for a private sector airline or trucking company. Broad system assessment knowledge is even more important in responding to complex topics such as tradeoffs between demand management and increased capacity.

At present, widespread gaps exist in our capabilities in this area. Many of the models and data available to address these issues often provide an inadequate foundation for satisfactory resolution. And the current movement toward shifting many transportation infrastructure responsibilities to Metropolitan Planning Organizations (MPOs) and other state and local authorities creates the challenge of assuring that these organizations, which often possess limited resources, have the tools and information necessary to make cost-effective long-term decisions. Thus, there is a need for better infrastructure investment-related models that can be applied by authorities without high level skills and that can cover such topics as life-cycle

costs; the incremental costs associated with attaining accessibility, environmental and other social goals; and intermodal system optimization.

Public Policy Decision Making

Policy and other decision making, including decisions about transportation research and development, require effective data collection and analysis. The absolute and relative values of research in infrastructure materials, vehicle technologies, intelligent transportation systems, and other topics can be judged only on the basis of substantive estimates and comparisons of their impacts on the cost, quality and availability of transportation services and equipment. What would the impacts be of potential innovative transportation technologies, such as a passenger car with 3 times current fuel efficiency? In the transport of hazardous materials, where are the most serious risks for harm and what improvements will have the greatest payoffs? How can new technologies be deployed to benefit transportation? Making the best and most cost-effective transportation investment decisions requires a solid and robust capability for assessment of existing and innovative transportation technologies and their potential impacts. Many DOT programs have associated assessment efforts and BTS serves DOT needs as a policy-neutral focal point for National transportation data.

While outside input is essential, the Federal government can and must take the lead. It is in the best position to coordinate efforts by the transportation community to assess the opportunities and challenges of the future. It can play a key role in developing the necessary knowledge and tools, given the long time-frame associated with transportation investments, the potentially broad impacts of regulatory and policy decisions, and the need for a broad perspective in monitoring social, economic, demographic, and technological trends.

As is discussed in Chapter 4 of Section II, among the most important elements of system assessment are performance measures, data, analytical tools, technology assessments, and awareness of anticipated trends. These are discussed in greater detail in that portion of the report. The Department's plans for R&D in these areas over the next 3 years is presented below.

Near Term Efforts

Policy Research (FHWA)

FY	1996	1997	1998
Funding	5,401	5,681	NA
FTE	6.0	8.0	NA

The objectives of FHWA's policy research program are to develop a coordinated program of research to evaluate the appropriate level of future Federal involvement in the highway program, to maximize the return on funds invested in the Federal-aid highway program, and to provide the information needed to evaluate policy alternatives. Policy research is essential

for the development of Federal highway policies that are responsive to Federal interests in promoting interstate commerce and improving the competitiveness of domestic products in international markets.

Policy research addresses many of the short- and long-term Federal highway policy issues raised in the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA), and will provide analytical tools and data needed to analyze highway program alternatives for the 21st century. Data management and dissemination activity under the Policy Research program is closely coordinated with related activities by other jurisdictions in the following areas: development of highway data standards; collection and analysis of information regarding the quality and performance of the highway and bridge system; and evaluation of the highway system and projected changes in travel demand and travel patterns. Research efforts include:

- Analysis of innovative highway financing strategies and implications of emerging public/private partnerships for highway construction and operation.

- Analyses of implications of alternative fuels, congestion pricing, travel demand management, and other energy and environmental initiatives.

- Analysis and quantification of the contribution of the highway program to economic productivity and international competitiveness, employment impacts of highway construction, and the impacts of highway network alternatives.

- Develop improved methods for collecting traffic, vehicle classification, and weight data; improved survey methods and tools to collect and evaluate travel behavior data; and improved data and tools to forecast passenger and freight travel.

- Analysis of highway investment requirements, analysis of targeted border crossing, infrastructure investment requirements, alternative multimodal investment strategies, highway system condition and performance, highway cost allocation, and truck size and weight policy.

- Analysis to quantify external costs and benefits of the highway program, interrelationships between transportation programs and metropolitan development patterns, and opportunities for the highway program to support community development and environmental justice objectives.

Major milestones for fiscal year 1997 will be the evaluation of the State Infrastructure Bank pilot program established in the National Highway System Designation Act of 1995 to support preparation of a report to Congress on that program; deployment of the newly developed HPMS software to all States and FHWA field offices for use in generating annual data submissions to the FHWA; and analysis of financing, energy, and environmental issues likely to arise in reauthorization legislation.

Transportation Planning Research (FHWA)

FY	1996	1997	1998
Funding	5,769	8,300[1]	NA
FTE	4.0	5.25	NA

FHWA's RD&T program is designed to develop cost effective methods for State, regional and local governments to evaluate transportation investments and alternatives. Its further goals are to:

Develop and disseminate improved metropolitan and statewide transportation planning methods to enhance the understanding and analysis of land use, intermodal transportation, congestion and environmental interrelationships and to implement planning processes that meet legislative requirements.

- Identification of various barriers to intermodal activity and provision of information about intermodal freight planning and programming techniques, best practices, resources, and funding opportunities.

- Work with the Office of the Secretary to evaluate the characteristics of the National Highway System (NHS) and develop an analytical framework for National transportation.

- Develop improved Geographic Information System (GIS) analytical tools to support National program evaluation and legislation and for information and data sharing with State and local governments.

- Develop and disseminate improved methods to assist States and MPOs in implementing effective, multimodal congestion relief and mobility enhancement programs.

- Support the use of new technology and integrated information systems in metropolitan and statewide planning activities.

- Develop and disseminate improved methods for major investment studies and methods to assess alternative multimodal investment proposals, including social and environmental costs. The *Travel Model Improvement Program* (TMIP), which is conducted jointly with FTA and discussed below, is a major emphasis in this area.

[1]In FY97 and FY98, FHWA intends to replace prior years' use of Section 6005 funds to support the TRANSIMS initiative, and ensure continued funding of the overall program, including TRANSIMS, with a more secure source.

Travel Model Improvement Program

ISTEA and the CAAA requirements have placed increased emphasis on sophisticated applications of travel demand models. This, coupled with the lack of significant advances in travel demand procedures in the last 15 years, has resulted in a DOT (FHWA, FTA, OST) and EPA sponsored program to improve the use of existing travel demand forecasting procedures, and to develop a new generation of demand models. The program, called the Travel Model Improvement Program (TMIP), consists of five tracks. The first addresses outreach activities such as the conduct of conferences, courses, and technical assistance, publication of newsletters, and distribution of documents. The second is oriented to the enhancement of existing methods, which includes the development of new techniques, documentation of best practices, and development of manuals oriented to various components of the forecasting process. The third is a major effort, called TRANSIMS (Transportation Analysis and Simulation System), to develop a new generation of models using a microsimulation approach. This is a multiyear project performed by the Los Alamos National Laboratory, taking full advantage of its experience with supercomputers. The fourth is oriented toward improving data collection methods to support travel forecasting. Finally, the fifth track is oriented toward improving land use forecasting.

TMIP is jointly funded by FHWA, FTA, and EPA. Of the $7 million planned for TMIP in FY 1997, approximately $4.5 million will come from FHWA's FY 1997 budget for Transportation Planning Research, supplemented by approximately $1.5 million from FTA and $1 million from EPA. A key FY 1997 milestone will be the completion of the second interim operating capability of TRANSIMS.

National Advanced Driving Simulator (NHTSA/FHWA)

FY	1996	1997	1998
Funding	2,000	14,500[2]	NA
FTE	5.09	4.99	NA

In February 1996, the National Highway Traffic Safety Administration (NHTSA) announced the award of a $34.1 million contract to TRW's Transportation System Division in Sunnyvale, Calif., for the development, testing and installation of the National Advanced Driving Simulator (NADS). This simulator will offer a major advance in helping researchers to understand the human factors involved in traffic crashes, in order that their frequency can be reduced.

The NADS will be the world's most technically sophisticated research driving simulator, capable of providing test drivers with an experience that nearly duplicates real world driving. The facility will be located at the University of Iowa in Iowa City at the Oakdale Research Park. The University of Iowa was selected for the NADS site based on the recommendations

[2]Includes $4,000k from FHWA.

of the National Science Foundation, which helped NHTSA to conduct a National competition among major transportation research universities for the potential site for the NADS.

Because of its superior design, TRW was selected as the winner of the construction project in a preliminary engineering design competition conducted by NHTSA between TRW and Contraves, SSI., two of the Nation's leading simulator developers. The construction of the simulator will be completed in 39 months and it will become operational in spring 1999.

The University of Iowa has agreed to provide cost sharing to the NADS project in the amount of $11.58 million. This will include the design and construction of a $5.7 million building, which will be a facility dedicated to housing the simulator operation.

The NADS will be able to put drivers in realistic problem situations such as the sudden appearance of a child in the road, a skid on glare ice or an oncoming vehicle driving over the centerline. Imminent crashes can be simulated without the unwanted and unsafe consequences of crashes on the highway. The study of driver reactions can lead to potential improvements in vehicles, highway and vehicle design, and advanced safety systems.

Current NADS priorities are to:

- Complete the detailed design and design review of all subsystems.
- Initiate fabrication, installation, and test of the facility.

An important milestone for FY 1997 will be to begin the simulator building construction.

Fatal Accident Reporting System (NHTSA)

FY	1996	1997	1998
Funding	4,585	5,251	NA
FTE	6.79	6.65	NA

The FARS annually compiles detailed information regarding the drivers, occupants, vehicles and environmental conditions associated with all fatal motor vehicle accidents occurring in all 50 states, the District of Columbia, and Puerto Rico. Maintenance of this data base is based on 52 cooperative agreements between DOT and the governments of these jurisdictions, which cover the collection and coding of data on fatal motor vehicle incidents. Among the data categories included in FARS are: demographic data and alcohol levels of fatalities, use of safety belts and child restraint devices, types of vehicles and their accident-related movement ("first harmful event"), types of road and roadway surface conditions, time of day, light and atmospheric conditions, and emergency medical services response times.

The system is a key database for the study of fatal accidents and their causes, as well as the development and implementation of possible measures to ameliorate the number of such incidents and their severity. Users include researchers, analysts and policymakers from

Federal, state and local government, universities and other research organizations, private interest groups and the transportation industry. A key fiscal year 1997 milestone will be the completion of the fifth year of a five-year cooperative agreement with the 50 states, Washington D.C., and Puerto Rico.

National Accident Sampling System (NHTSA)

FY	1996	1997	1998
Funding	9,200	9,675	NA
FTE	8.48	8.31	NA

The NASS is an extensive, nationwide data collection system managed by NHTSA's National Center for Statistics and Analysis, which compiles information on both fatal and nonfatal motor vehicle accidents. The NASS has two components: the General Estimating System (GES) and the Crashworthiness Data System (CDS). In the GES, data collectors regularly visit several hundred law enforcement agencies and select a random sample of approximately 48,000 Police Accident Reports (PARs) from among the more than 6 million such reports filed annually in the United States. The CDS contains crashworthiness-related data from detailed investigations of approximately 5,000 passenger vehicle crashes annually.

Information from these samples is then entered into the NASS databases and is made available to Government agencies, researchers, transportation businesses, insurance companies, and the general public. These NASS resources are used extensively to identify and analyze trends in motor vehicle accidents, to discern highway safety problem areas, to support highway safety rulemaking and research (such as ITS), and to form the basis for cost and benefit analyses of potential highway safety initiatives. A major milestone for fiscal year 1997 will be the collection and coding of NASS data in 26 states.

Data Analysis Program (NHTSA)

FY	1996	1997	1998
Funding	1,415	2,100	NA
FTE	22.05	21.60	NA

The NHTSA Data Analysis Program supports the agency's achievement of its Government Performance and Results Act of 1993 (GPRA) performance goals by providing sampling, statistical design, and quality control support to NHTSA's major data collection systems, including the FARS, CDS, and GES. These services are provided to both internal (NHTSA) and external (other Federal agencies, nongovernmental) customers of these important highway safety data systems. This program also produces regular statistical reports on highway safety and motor vehicle crashes.

Among the uses of the data made available through this program is evaluating the effectiveness of NHTSA's crashworthiness, crash avoidance, and traffic safety efforts, as well as relating human, vehicle, roadway, and environmental factors to the frequency of

crashes and injuries. A key milestone for fiscal year 1997 will be the identification of injury mechanisms and associated outcomes in motor vehicle crashes.

State Data Program (NHTSA)

FY	1996	1997	1998
Funding	1,550	3,850	NA
FTE	15.27	14.96	NA

In addition to NHTSA, individual states also manage highway safety databases, compile statistics, and prepare reports on highway safety and crashes. NHTSA's State Data Program is the major interface between the agency and these state level data systems. The Program obtains highway safety data files for NHTSA from 17 different states, assists states in making improvements to state data collection efforts and data systems, and promotes the development of linked databases which combine information from motor vehicle crashes and the medical outcome of treatment for crash victims. This latter function is particularly important to meeting NHTSA's health care initiatives.

Among the program's near-term goals are promoting the increased use of linked crash and medical outcome databases by states. The results of this effort can be then used by the states to develop and evaluate initiatives to prevent injuries from traffic crashes and enhance health care for accident victims. A major milestone for the 1997 fiscal year will be obtaining, documenting, and making available for use the data files from 17 states.

Occupant Protection Survey (NHTSA)

FY	1996	1997	1998
Funding	0	300	NA
FTE	0.42	0.42	NA

The goal of the Occupant Protection Survey program is to support NHTSA's efforts to promote the increased use of safety belts, child safety restraints, and motorcycle helmets by the general public. This will be accomplished by a second National Occupant Restraint Use Survey, which will be conducted in FY 1997. Periodic surveys of safety belt and child safety seat use and misuse are critical needs of our safety belt use program. A major milestone for fiscal year 1997 will be the analysis and publication of results from the FY 1997 National Occupant Protection Use Survey.

Special Crash Investigations (NHTSA)

FY	1996	1997	1998
Funding	315	331	NA
FTE	1	1	NA

NHTSA's major data activities -- such as FARS, NASS, and the Data Analysis Program -- cover the vast majority of highway safety and vehicle crash circumstances. However, there

are specific safety-related topics which require a more focused and detailed approach. The Special Crash Investigations program tackles these problems. It is the agency's primary resource for studying the safety issues associated with new technologies, such as air bags and alternative fuels, as well as potential motor vehicle safety defects. In pursuit of this goal, the program conducts approximately 50 detailed crash investigations annually covering such diverse issues as school bus crashworthiness and fatalities, potential vehicle safety defects, the performance of automatic restraint systems, and electric vehicles. A major milestone in fiscal year 1997 will be the creation of an electronic file of all special crash investigations.

Technology Transfer Programs (NHTSA)

FY	1996	1997	1998
Funding	40	40	NA
FTE	NA	NA	NA

The goal for this program is to provide more timely information about ITA's safety research and development results, contracts, and reports to the interested motor vehicle and traffic safety community by periodically publishing and distributing a technical journal, *Auto & Traffic Safety*. It contributes to the larger goal of a healthy, educated citizenry. The major fiscal year 1997 milestone will be the production of two additional issues of this journal.

National Security (MARAD)

FY	1996	1997	1998
Funding	NA	200	NA
FTE	NA	NA	NA

The fifth goal of the MARAD Strategic Plan is to "provide sealift for National security and the National defense." The American maritime industry is a vital component of our Nation's defense, both in providing strategic sealift and in supporting the shipbuilding and repair industrial base. MARAD is a partner with the industry and the Department of Defense (especially the U.S. Transportation Command) in ensuring that this goal is met. New R&D initiatives in this area for fiscal year 1997 include:

- Initiation of projects to assist in the administration of the Maritime Security Program (MSP) and related functions to ensure the availability of a modern, efficient merchant marine to support National security objectives.

- Initiation of analysis of various sealift planning strategies under different mobilization scenarios taking into account factors such as manning requirements and availability, increased use of containerization and other commercially adaptable cargo handling practices by the military, geographic effects on trade, multiple theatre conflicts, and varying lift requirement levels.

Transit Services Management Innovation (FTA)

FY	1996	1997	1998
Funding	1,430	1,000	NA
FTE	NA	NA	NA

The goals of the Transit Services and Management Innovation Program are to enhance transit services to improve the quality of life for all Americans by utilizing science and technology to increase job opportunities and improve the U.S. position in world markets.

- Research and evaluations will investigate concepts to improve service delivery and market definition.

- Transportation service demonstrations will focus on testing innovative community-oriented services aimed at inner-city needs, and demand-responsive neighborhood services designed around GIS techniques.

- Transit management and operations demonstrations will test a variative of innovative techniques designed to improve management and operations efficiency. Congestion management activities will include telecommuting demonstrations and congestion pricing case studies.

- Information activities will include support for ongoing TRB efforts and development of a transit information internet homepage.

A key fiscal year 1997 milestone will be the conduct of "Bridges-to-Work" demonstrations where programs of placement, transportation, and support services will aid disadvantaged inner-city unemployed in joining and remaining in the workforce.

Rural and Specialized Transportation (FTA)

FY	1996	1997	1998
Funding	2,270	2,300	NA
FTE	NA	NA	NA

Through the Rural and Specialized Transportation Program, FTA will bring together the Administration's various rural and specialized research and technical assistance efforts in order to provide adequate assistance to develop innovative and creative solutions to many problems that impact the rural and specialized transportation industry. Major activities include the following:

- Development of managerial, operational, safety, training and employment issues that affect rural, small urban, and specialized transportation.

- The ADA Technical Assistance and Support component continues Project Action effort through the National Easter Seal Society to develop materials and conduct demonstration programs that address accessibility issues for mobility impaired citizens and transit agencies serving them.

- The Program for Coordinating Social Service Transportation will continue social service coordination demonstration where social service agencies funded by other Departments like Health and Human Services, Education, and Agriculture partner with public transit organizations funded by DOT to reduce service duplication and achieve more efficient and effective utilization of resources.

- The Rural and Specialized Services Program will provide a linkage for rural and specialized transportation clients to mobility, employment and life enhancement opportunities and continue to design research activities for managers and state and local decisionmakers to enhance the efficient use of limited transportation funding in rural and small communities.

A key fiscal year 1997 milestone will be the development of technical assistance capabilities to enhance mobility for disabled and low income transportation passengers in rural areas.

Metropolitan/Rural Policy Development (FTA)

FY	1996	1997	1998
Funding	650	1,000	NA
FTE	NA	NA	NA

The goals of FTA's Metropolitan/Rural Policy Development research are to address transportation needs through intermodalism, improve ongoing program evaluation to increase the effectiveness of FTA programs, promote participation processes that stress community involvement, and emphasize improved transit services for minorities and transit dependent persons in low income populations. Major near-term initiatives include the following:

- Studies assessing the transportation, economic, and social benefits of transit investments.

- Outreach on transit's contribution to the future of cities and neighborhoods.

- Workshops on the use of innovative funding techniques.

A key fiscal year 1997 milestone will be a report under 49 USC 308 estimating transit's condition, performance, and short and long term transit investment needs.

Transportation Planning and Project Development Research (FTA)

FY	1996	1997	1998
Funding	1,900	1,200	NA
FTE	NA	NA	NA

FTA funds research in support of the metropolitan and statewide transportation planning and project development process. Through this research, FTA identifies and disseminates information on best professional practices and develops methods which advance the state of the art in planning and preliminary engineering. The research is often conducted in cooperation with FHWA.

Five topic areas are covered:

- General Planning -- This topic area includes research related to the overall transportation planning process, planning institutions, citizen participation, and decisionmaking on plans and programs.

- Planning Methods -- This research includes the Travel Model Improvement Program (TMIP), which is developing a new generation of demand forecasting methods. Improved methods for estimating costs and evaluating a multimodal set of alternatives are also being developed.

- Major Investment Planning and Development -- Planning-related research supports major investment studies and decisionmaking as part of the metropolitan planning process. The Turnkey Demonstration Project called for in ISTEA is evaluating the impact of turnkey procurements on the time and cost of transit project development, construction, and operation.

- Land Use and Environmental Planning -- Research is performed to improve the environmental impact assessment process. Studies help advance the state of the art in noise, air pollution, and other impact areas. Before/after studies examine the effect of completed projects. Transit-friendly land use patterns are examined as a way to increase transit ridership and make transit an integral part of communities and neighborhoods.

- Financial Planning -- Better methods for financial planning and analysis are developed within this topic area. Information is gathered and disseminated on innovative financing techniques.

A key milestone for FY 1997 will be the demonstration of best practice in innovative transit finance and in turnkey construction.

Human Resources (FTA)

FY	1996	1997	1998
Funding	155	500	NA
FTE	NA	NA	NA

FTA's activities related to Human Resources are intended to provide training and assistance for disadvantaged business enterprises to promote long-term economic growth, employment training programs, and outreach programs to increase transit employment opportunities for socially and economically disadvantaged individuals. Training and development focuses on methods and techniques to train unemployed persons for entry-level employment. Transit courses are provided in minority high schools, colleges and universities so that students can prepare for careers in transit. Training is also provided to enable grantees to successfully implement diversity programs. Conferences of transit vehicle manufacturer/suppliers are proposed to review obligations under the Department's disadvantaged business enterprise (DBE) program. A major milestone in fiscal year 1997 will be the resolution of ADA concerns.

National Transit Institute (FTA)

FY	1996	1997	1998
Funding	3,000	3,000	NA
FTE	NA	NA	NA

The National Transit Institute assists the transit industry in the education, training, and development of its work force. It serves as a major resource to FTA in support of regulations, standards, and policy initiatives as well as in the implementation of new technology resulting from research initiatives. The NTI coordinates with the NHI (see Chapter 2) to support the implementation of intermodal transportation system.

Major efforts planned for fiscal year 1997 include:

- Expansion of the transit-related curriculum on a variety of subjects related to the finance, planning, management, technology and other topics required to assist the transit industry in keeping pace with the mobility needs of the nation.

- Acknowledging excellence and sharing innovative practices to support and present annual awards at transit trainers conferences for outstanding training accomplishments.

- Continued coordination with the NHI to promote intermodalism.

Rural Transit Assistance Program (FTA)

FY	1996	1997	1998
Funding	5,200	5,200	NA
FTE	NA	NA	NA

The Rural Transit Assistance Program (RTAP) provides training and technical assistance for rural public transportation operators, improves professionalism and safety of rural transit services, and supports coordination with human service transportation providers. Major activities include training for drivers, mechanics, and rural public transportation managers; support for implementation of drug and alcohol testing requirements; and technical assistance needed by rural transit and human service transportation providers. A major fiscal year 1997 milestone will be the provision of training and technical assistance to rural transit operators in each state.

Research and Technology (RSPA)

FY	1996	1997	1998
Funding	3,257	7,488[3]	NA
FTE	NA	NA	NA

The RSPA Research and Technology (R&T) program is the primary Federal mechanism to address cross-cutting technical and other issues in transportation. It is designed to strategically assist in the definition of Federal transportation R&T policy; maintain oversight over R&T programs conducted by the Department, and coordinmate the broad range of mission-specific R&T activities conducted by the DOT operating administrations. Major activities include the following:

- Ensuring technical support to the key interagency and Departmental research coordination bodies, including the NSTC Coordinating Committee on Transportation R&D, the DOT R&T Steering Committee, and the DOT R&T Coordinating Council.

- Conducting strategic planning for transportation research, culminating in the annual development of the Department's Surface Transportation R&D Plan.

- Examination of technical issues and alternatives that cut across DOT's modal structure. In FY-1997 RSPA plans to examine four areas of this type:

    1. Advanced Materials and their Application

    2. The Interoperability of the National Information Infrastructure (NII) and the National Transportation System (NTS)

[3]$200k is devoted to information infrastructure activities.

3. Sustainability, Energy Efficiency, and Environmental compatibility of Transportation Systems

4. Human Factors and Human Performance Issues in Transportation.

- Investigation of the applicability of INTERNET/World Wide Web technologies to improve Department-wide information sharing.

Related Departmental Activities

Regulatory and Economic Policy Research (OST)

The OST Policy office conducts policy research to develop and implement departmental environmental and safety policies across all modes, and to assure that specific public and private sector transportation programs implement that vision; to balance the energy requirements and environmental requirements of our transportation systems, through new technology and better public policies; and to conduct analyses and coordinate policy in support of the implementation of the ADA. Research efforts include:

- Compare resources dedicated to safety in each mode versus fatalities.

- Test effectiveness and multimodal applicability of on-board operator fatigue detection devices.

- Quantify and analyze the relationship between transportation and land use.

The OST Policy office also supports the development and implementation of the National Transportation System; identifies current and emerging transportation policy issues requiring attention of agency management; analyzes the economic and institutional factors relevant to those issues; and develops legislative and program management recommendations. This office is concerned with 1) development of policies, program guidance, and data analysis which foster the integration of transportation system components into an efficient, integrated intermodal system serving National goals and objectives; 2) the economic and other impacts of Federal financial assistance and regulation of public transportation facilities and services; 3) the feasibility and effectiveness of existing and alternative financing arrangements, including trust funds and user charges; and 4) the relationships between the National transportation system and economic, energy, environmental, community development, and other National goals. Related research efforts include:

- Analyze the latest demographic and economic data for policy implications.

- Address political and other barriers to congestion pricing.

- Develop multimodal system performance measures.

International and Aviation Policy Research (OST)

As a result of ratification of the North American Free Trade Agreement (NAFTA), over a ten-year period existing reciprocal restrictions on the transport of cargo and goods between signatory countries will be removed. One of the elements of the agreement's land transportation provision is a review after five years to determine the impact of access and investment liberalization. This review is intended to determine the effect of gradually increasing access on, for example, market share, rates, service, and technological advancement, and any problems or unanticipated consequences. The findings of this review could result in modifications to the schedule for the removal of legal barriers. Research efforts include updating the baseline data for analysis of impacts on Mexico and the United States of the removal of legal barriers to truck and bus operations in each other's country. This effort will ensure that we have independent statistics to compare with those to be generated by the Mexican Government.

Bureau of Transportation Statistics (BTS)

BTS was created by the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA), partly in response to the perception that the data available to support transportation policy making and decisions were not sufficient for that purpose. BTS fulfills several important functions:

- Compiling, analyzing, and publishing a comprehensive series of transportation-related statistics.

- Coordinating data collection across the Federal government and identifying both short-term and long-term data collection needs.

- Issuing guidelines for the accurate and reliable collection of the data.

- Making the data readily accessible.

BTS, a young organization in operation for just 3 years, is committed to providing quality customer service and actively reaching out to and supporting the Department, the transportation community, and the public. BTS is responding to this challenge with the following efforts:

First, the Bureau produces and distributes several data compilations, including the National Transportation Statistics and the 1990 Census Transportation Planning Package (CTPP) data tabulations in statewide and urban packages.

Second, BTS provides significant support to Secretary Peña's National Transportation System (NTS) initiative, particularly in the areas of data collection, data analysis, and map generation.

Third, the Bureau is actively engaged in three major multimodal surveys on domestic freight movements, passenger movements, and transborder freight flows.

Fourth, the Bureau prepares a number of analytical studies to address and help facilitate the National dialog about important issues such as the contribution of transportation infrastructure to economic growth, international competitiveness, and environmental quality. The centerpiece is BTS's Transportation Statistics Annual Report, which summarizes the state of the U.S. transportation system, the quality of the available statistics, and planned efforts to improve these statistics.

Fifth, the Bureau has established a Geographic Information System (GIS) Center to provide data integration, display service, and analysis.

Sixth, the Bureau provides public access to data and reports through a spectrum of channels and is developing new technologies to provide electronic library and archival services. Services include Internet, an electronic bulletin board, and fax-on-demand.

BTS participates in many Departmental and Federal activities. As discussed above, BTS provides information, analytical tools, and other services central to the National Transportation System initiative. BTS is a major partner with other DOT Operating Administrations in the development of new monitoring and forecasting methods for several key aspects of the Travel Model Improvement Program (TMIP). The Director of BTS has chaired the Transportation System Assessment Subcommittee of the NSTC Interagency Coordinating Committee on Transportation Research and Development for the past two years. BTS plans to continue its leadership role in coordinating transportation system assessment activity within DOT and the Federal government.

An effective system assessment capability is essential to assuring that the goals of sustainability, economic vitality and personal mobility and access are fully incorporated into the transportation decision and policy making processes. Expanding research and development efforts in system assessment can help in attaining these goals. For example:

- Recent technological advances in fields such as electronics, communications and information systems have magnified the potential benefits of data and information to the transportation community. Electronic Data Interchange (EDI) offers the possibility of real time data collection; computing power and new applications such as spreadsheets and Geographic Information Systems (GIS) enhance the ability to convert that data into valuable information; and the rapidly expanding information infrastructure will completely redefine the nature of making that information accessible.

- Further support for the development of programs based on advanced computer and modeling and simulation techniques will enhance our ability to address National transportation-related technical and policy issues.

- Effective cost-benefit analyses require as complete and accurate a collection of actual costs and benefits as can be assembled. Currently, data on many of these are either missing or only partially available, especially in such areas as economic benefits and the environmental and human health costs of various transportation activities. Cost-benefit analyses are increasingly important as we face ever decreasing options for expanding capacity through infrastructure investment and transportation demand management strategies.

- Research is just beginning on the behavioral responses of transportation users and providers to various transportation policy initiatives. This research is vital because future gains in throughput will likely rely more on economic incentives and other management strategies and less on adding physically to the transportation network.

- Our current transportation system is the product of many elements -- including transportation-related institutions, organizations, incentives, policies, and others -- that are continually interacting with each other. There is a need to increase our understanding of this "non-material infrastructure" so stakeholders can interact with each other more effectively in planning and operations.

The breadth and continuity necessary for successful accomplishment of knowledge base objectives, and the limited direct benefits to any of the many public and private users, require that this be a basic Federal responsibility, consistent with the ISTEA charter of the BTS, but involving a significantly wider scope cutting across all activities of the Department.

Near-term BTS goals include the following:

- Expanding, updating, and disseminating information to support the NTS, including expanding the data collection effort to include Canada, Mexico, and transoceanic corridors.

- Integrating data on transportation from a variety of surveys (including Commodity Flow, American Travel, Rail Waybill, Waterborne Commerce, Air Passenger, and Domestic Transportation of Foreign Trade Surveys).

- Developing National performance measures and supporting interpretive material to answer the basic questions: is the system getting better or worse and what do we mean by better or worse. Particular emphasis will be placed on measures that capture the shipper and traveler perspectives.

- Develop improved tools for unburdensome collection of data, data analysis, and information dissemination.

CHAPTER 7

DOT INVESTMENT IN UNIVERSITY RESEARCH, EDUCATION, AND COOPERATIVE INITIATIVES

Transportation efficiency and National productivity are inextricably linked. The capacity of the transportation system to enable the nation to respond to international economic challenges is an increasingly critical factor in transportation research, development, and education. America's future prosperity depends on new ideas and the people who will develop and apply those ideas to ensure the safe and efficient movement of people and goods. In its role as steward of the transportation enterprise, the DOT invests in the ideas and the education of the people who will contribute to the transportation system of the future.

The transportation enterprise is undergoing great change. Technological advance, new trends and approaches to logistics, and institutional change are transforming how the public and private sectors operate.

Technological Advance

The development of new applications and the conversion of defense-related technologies to transportation uses will demand new knowledge, approaches, and education. The application of new information technologies, that are the basis of intelligent transportation systems, promise improved safety and mobility. The successful deployment of ITS requires that transportation research now include investigations of how modern communications, computer and sensor technologies may be integrated into surface transportation.

Innovations in other technologies promise to improve the transportation system. New materials could greatly increase the durability and longevity of infrastructure. Next generation propulsion systems and alternative fuels could revolutionize all modes of transportation. New analytical methods and modeling techniques may improve our understanding and operation of the transportation system. However, if successfully deployed, these technologies and methods will require an educated work force to understand how such technological advances can be successfully integrated into the transportation system and a trained work force to operate and maintain these new systems.

Trends in Transportation Operations and Logistics

Transportation companies and shippers' logistics departments have had to accommodate profound changes in their operating environment. These changes include increased international competition, the technology-driven move to integrated logistics processes, intermodalism, and the increasingly global outlook of major customers. The demand for the efficient, timely, and global movement of goods now dictates the application of technologies that optimize the use of information and the entire transportation system as one. This

approach to goods movement requires that transportation professionals be trained in the use of new information technologies and in the array of technologies available to respond to customer demands on a global scale.

Institutional Change

In addition to advances in technology and business logistics, the transportation enterprise is undergoing institutional change. Transportation policy makers, planners, and operating departments at all levels of government are now increasingly sensitive to the implications of transportation on the natural environment and communities. Resolving transportation issues is no longer only the application of technology or the construction of a new facility, today's transportation professionals must understand the broader context of where transportation fits in a societal, economic, political and institutional framework in order to develop, plan, deploy, and operate effective transportation systems.

Strategic Co-Investment in Universities and Research Institutions

Since World War II, universities and collaborative research partnerships have been the intellectual centerpiece of Federal policy for research, education, and innovation in all policy areas. Federal research and development grants and contracts have been integral to new discoveries, education of new researchers and the training of operators so to provide a steady stream of ideas to improve the Nation's security, health, and industry. The DOT invests strategically in and partners with state and local governments, transit properties, universities, and research and training institutions to ensure that the transportation system maintains an adequate knowledge base and a pool of transportation professionals to operate a safe, competitive, and sustainable transportation system.

DOT relies particularly on universities because of their unique resources, capacity and qualifications in the area of knowledge-building, education and technology transfer, and their ability to bridge all sectors of the transportation enterprise.

The vast majority of scientists and researchers are located in institutions of higher learning. The largest proportion of government, corporate, and other institutional investment in research, development, and education is in universities. Compared to other cabinet departments the DOT invests far less in university-based research. However, DOT's policy is to *leverage* its comparatively small investment by strategically co-investing with others, enabling it to take full advantage of all the talent, resources, and knowledge being developed in universities. The benefits to the transportation enterprise from this leveraged co-investment strategy far exceed the likely gains of investing in any one corporation or specialized laboratory.

Transportation is increasingly a multi-disciplinary field. Advances, such as ITS, and institutional changes resulting from ISTEA and the CAAA necessitate research and education efforts in engineering, planning, and the social and behavioral sciences. The university

community offers a unique environment where each of these specialties may be brought to bear on specific transportation issues and research problems. Moreover, the "business" of universities is the creation of new knowledge and *education*. The DOT views the capacity of universities to assist the Department in education as integral to its mission of promoting transportation and ensuring that there is a well trained work force available to the transportation enterprise.

In addition to providing a mechanism for co-investment and education, universities are able to provide a vital bridge to all transportation stakeholders. For example, universities conduct considerable research on projects funded by the freight community and local governments. The Department's work with universities thereby provides another means by which DOT learns of specific issues that may impact transportation, but that are not yet a major focus of the Federal Government.

Near Term Efforts

The near-term efforts in this area include the continued support and management of the University Transportation Centers Program, University Research Institutes; National Highway and Transit Institutes ; Dwight David Eisenhower Transportation Fellowship Program; State Planning and Research Program; and the Small Business Innovation Research Program.

University Transportation Centers Program[1]

FY	1996	1997	1998
Funding	11,247[2]	12,000[3]	NA
FTE	NA	NA	NA

DOT's University Transportation Centers Program (UTCP) represents a major investment in fostering transportation innovation and in developing human capital on a variety of transportation issues in its nationwide network of universities. The UTCP was established in 1987 and is managed centrally, with funding provided by both highway and transit titles of ISTEA. The Federal funds are matched by sources such as industry, the universities, and State and local governments. Funded by FTA and FHWA and managed by RSPA, the program's missions are to strengthen education, research, and technology transfer of transportation knowledge and skills by addressing regional and National transportation needs. A minimum of 5 percent of each UTC's total funding is dedicated to technology transfer.

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[1]The UTC Program funded through FHWA and FTA, and is classified as a System Assessment activity.

[2]$5,247k under FHWA budget, $6,000k under FTA budget.

[3]$6,000k under FHWA budget, $6,000k under FTA budget.

Ten university consortia were competitively selected in 1988, 1 in each of the 10 standard Federal regions. In the current program, each center has a lead university and additional participating universities. By the end of its fifth year, the program encompassed a total of 63 universities (including 7 minority institutions) and involved more than 1,400 students and faculty. The ten regional centers were recompeted for the last three years of the authorization (FY 95-97). Three additional National centers were established by DOT in 1992 as a result of ISTEA. The new UTC's are: 1) the National Center for Transportation Management, Research, and Development at Morgan State University in Baltimore, 2) the National Rural Transportation Study Center at the University of Arkansas in Fayetteville, and 3) the Center for Transportation and Industrial Productivity at New Jersey Institute of Technology in Newark.

Education, research, and technology goals received strong affirmation as Congress extended the program for six additional years. Evaluation of proposals and selection of programs for future years are currently in progress.

University Research Institutes[4]

FY	1996	1997	1998
Funding	5,466	6,250	NA
FTE	NA	NA	NA

ISTEA also established the *University Research Institutes (URI)* program, which is also managed centrally for the Department, by RSPA, but funded by FHWA. The intent of the program is to provide centers of excellence in transportation research. The Institutes include the following: 1) a National Surface Transportation Policy Studies Institute based at San Jose State University; 2) an Infrastructure Technology Institute, based at Northwestern University; 3) an Urban Transit Institute, based at both North Carolina A&T University and the University of South Florida as lead of a consortium of Florida universities; 4) an Institute for IVHS Concepts, based at the University of Minnesota's Center for Transportation Studies, which is managed by FHWA in conjunction with other ITS Regional Centers of Excellence; and 5) an Institute for Transportation Research and Education based at the University of North Carolina.

Together the UTC's and URI's will help attract quality students toward careers in transportation, and will facilitate communication between state DOT's and other transportation organizations. In addition, they will provide effective technology transfer of research resulting from efforts at the Centers and Institutes.

Major fiscal year 1997 objectives are to continue to fund promising research efforts that represent advances in surface transportation. Research projects are chosen after funds are granted to the member institutions.

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[4]The URI program is classified as a System Assessment activity.

National Maritime Enhancement Institutes

In 1990, the Maritime Administration designated four universities as National Maritime Enhancement Institutes in recognition of their ability to provide leadership in solving problems confronting the maritime industry. The designation of Institutes was authorized under Public Law 101-115 (authorizing appropriation for fiscal year 1990 for the Maritime Administration). The four Institutes are the University of California at Berkeley, the Louisiana State University, the Massachusetts Institute of Technology, and Memphis State University.

The University of California was designated for technology research relating to the maintenance and operation of shipping fleets including human factors issues. The Louisiana State University chooses to be known as the Institute for Maritime Transportation Systems Research. The Massachusetts Institute of Technology designation was made to the DOT Region I University Transportation Center at M.I.T. for the full range of activities authorized by the legislation. The Memphis State University together with the University of Tennessee and the University of Kentucky are known as the Inland Waterways Studies Institute. Each of the Institutes is either part of a regional DOT University Transportation Center or is part of a university consortium with multimodal, multidisciplinary research capabilities.

No funding is available for the administration of the National Maritime Enhancement Institutes. The fiscal year 1997 objective for the Institutes is to provide a resource for the implementation of the funded Maritime Administration research program.

National Cooperative Highway Research Program

The NCHRP is a unique applied research program designed to respond to the needs of the state highway and transportation departments by solving important operation problems in highway transportation. NCHRP resources are a combination of state voluntary contributions of 5.5 percent of their Federal apportionment of planning and research funds. The NCHRP is administered by TRB under a three-party agreement between FHWA, National Academy of Sciences (NAS) and AASHTO. Since its inception in 1962, the NCHRP has administered 789 research projects with total funding of more than $149 million. The NCHRP's close association with AASHTO and its position within the National Research Council have enabled the program to carry out many important research tasks resulting in practical products used by state highway agencies and others.

Major activities planned for fiscal year 1997 include:

- Through AASHTO, solicit and administer research on behalf of the various State departments of transportation to address commonly shared problems.

- Support ongoing projects for state-of-the-practice reports, legal histories on topical issues, IDEA (Innovations Deserving Exploratory Analysis) topics, international

information sharing, and concerns affecting the administration of State departments of transportation.

- Prepare various guidance documents on multimodal transportation planning, geographic information systems, traffic control devices for the aging driver, impacts of economic trends on transportation, implementation of transportation control measures, and HOV (high occupancy vehicle) systems.

- Develop models for determining carbon monoxide concentrations at intersections and vehicle emissions.

- Make significant research contributions to the Highway Capacity Manual for the year 2000.

- Support the implementation of SHRP products, primarily SUPERPAVE, through additional research.

- Develop a strategic plan for roadside safety research.

- Produce several training programs on construction activities.

- Support activities for implementing a new philosophy in bridge design.

- Produce a design catalog for pavement types.

Transit Cooperative Research Program (FTA)[5]

FY	1996	1997	1998
Funding	8,250	8,250	NA
FTE	NA	NA	NA

FTA's Transit Cooperative Research Program (TCRP), authorized by ISTEA, is modeled after the NHCRP and is designed to conduct research that will yield innovative and near-term solutions to transit problems. TCRP activities are coordinated with a three party agreement that includes FTA, NAS, and the Transit Development Corporation. A broad range of research projects and activities to address the immediate and practical needs of transit, as well as to facilitate technical information transfer is an ongoing focus of the TCRP.

[5]The TCRP is classified as a System Assessment activity.

Major activities planned for fiscal year 1997 include:

- Continue support for special long range projects and programs such as Innovations Deserving Exploratory Analysis Program (IDEA); Rapid Response to Transit Issues Program; and the International Studies Program.

- Solicit research statements in the priority areas of planning, service configuration, equipment, facilities, operations, human resources, maintenance, policy and administrative services, and those that correspond with the FTA Strategic Plan.

- Develop guidelines on effective use of transit police/security personnel; how to apply low floor technology in America; and para-transit vehicle specifications and related maintenance equipment.

- Assess the relationship between economic development and economic impact of transit investment.

- Pursue initiatives that demonstrate how market research may be integrated into transit management.

Dwight David Eisenhower Transportation Fellowship Program (FHWA)[6]

FY	1996	1997	1998
Funding	2,000	2,000	NA
FTE	1.0	1.0	NA

The Dwight David Eisenhower Transportation Fellowship Program was authorized by ISTEA in 1991 and is funded at $2 million per year. Its purposes are to attract the Nation's brightest minds to the field of transportation, to enhance the careers of transportation professionals by encouraging them to seek advanced degrees, and to retain top talent in the transportation community of the United States. The program encompasses all areas of transportation.

The Eisenhower Transportation Fellowship Program awards five fellowships: Graduate Fellowships, Grants for Research Fellowships, Historically Black College and Universities (HBCU) Fellowships, Hispanic Serving Institutions (HSI) Fellowships, and Faculty Fellowships. The Program is administered by the National Highway Institute in the Federal Highway Administration and provides a critical investment in advancing, improving, and maintaining technical expertise in the transportation community. In fiscal year 1997, the Program will award fellowships to over 100 students and faculty members from colleges and universities across the United States.

[6]The Eisenhower Transportation Fellowship Fund is classified as a Physical Infrastructure activity.

State Planning and Research (FHWA)[7]

FY	1996	1997	1998
Funding	62,983[8]	72,015	NA
FTE	NA	NA	NA

Individual states and FHWA cooperate in the support of highway R&D through the State Planning and Research (SP&R) Program. States receive 2.0 percent of their total Federal-aid highway apportionment as SP&R funding to be used for conducting highway planning and research activities. State highway agencies allocate the SP&R funds between planning and research. In FY 1996, states will spent nearly $63 million of SP&R funds for research, development, and technology transfer activities. States also have an option to pool their SP&R and other available funds in nominal amounts to sponsor National and regional cooperative studies of common interest and concern.

Major activities for fiscal year 1997 include the completion of state research on quality assurance in highway design, construction and maintenance, improving traffic control devices, countermeasures to address bridge pier scour, and improving pavement drainage.

Small Business Innovation Research Program

The Small Business Innovation Development Act of 1982 (P.L. 97-219), reauthorizing legislation (P.L. 99-443), and Small Business Research and Development Act (P.L. 102-564) seek to encourage the initiative of the private sector and to use small and minority-owned businesses as effectively as possible in meeting Federal R&D objectives. To comply with the statutory obligations of the Act, DOT has established a SBIR Program which conforms to guidelines and regulations provided by the Small Business Administration (SBA). Annually, small businesses are solicited to submit innovative research proposals that address high-priority requirements of the Department and have the potential for commercialization. The activity is funded by the DOT operating administrations, and by statute has to be a given percentage of the Department's extramural research budget.

The DOT SBIR program is managed by the John A. Volpe National Transportation Systems Center in Cambridge, Massachusetts. The Volpe Center develops integrated systems approaches to critical transportation issues, particularly those that cut across multiple modes of transportation. Its unique role as a multimodal center assures that it will direct the DOT SBIR program to stimulate technological innovation by inviting small businesses to submit research proposals that address high priority research issues confronting transportation. In

[7]The State Planning and Research Program is classified as a Physical Infrastructure activity.

[8]As discussed in the text, this funding (and that for FY 1997) represents a 2.0% set-aside of State Federal-aid highway apportionments.

FY 1995, SBIR awards were made in a number of surface transportation research areas, including:

Phase I Awards (6 Months)	Phase II Awards (24 Months)
Safety Seat and Restraint Systems	Pavement Distress Identification
Transportation Planning Using GIS	Automated Reduction of Video-Based Data
High Speed Rail Sensor Systems	Embedded Piezoelectric Stress Sensors
Remote Sensing of Fatigue Cracks	Personal Alertness Monitor Technology
Dynamic Intrusion Sensing	Highway Fog Warning System
Marine Diesel Exhaust Catalysis	Trip Generation Data Collection Software

The Department's solicitation for FY 1996, which closes on May 1, 1996, is available for the first time ever through the internet, and can be accessed through the World Wide Web (WWW) site maintained by the Volpe Center (http:\\www.volpe.dot.gov). Priority research topics for surface transportation include, but are not limited to the following:

- CORSIM Traffic Simulation Model Training Course
- Energy Absorbing Utility Poles
- Digital Waveform-Based System for Acoustic Emission Measurement for Nondestructive Testing of Structural Steel
- Transportation Planning Uses of Commercial Data
- An Intermodal Operations Planning and Coordination System
- Highway Capacity Software in Portable Graphical User Interface (GUI) Format
- Advanced Train Coupling Designs
- Methods and Equipment to Inspect High-Speed Rotating Components Manufactured from Composite Materials
- Headlight Glare Reduction for Improved Visibility
- A Device for Monitoring Driver Hand Position in Instrumented Vehicles
- Motor Vehicle Crash Costing Technology
- Advanced Lightweight High Performance Construction Materials for Intermodal Transportation Systems

Consistent with NSTC recommendations for transportation-related strategic focus areas for the SBIR, the Department is considering the following topics, among others, for its FY 1997 SBIR solicitation: composite-bonded aircraft structures inspection, systems assessment and modeling of interface environments, crack detection in bridges using remote sensing, and concrete-composite material manufactured from recycled plastics. The final solicitation will be built upon both these recommendations and the emergence of priorities in other areas.

CHAPTER 8

DOT R&D FACILITIES AND ADMINISTRATIVE SUPPORT FOR R&D

In order to carry out its responsibilities for the management of DOT-funded R&D, and the actual implementation of a number of key activities, the Department devotes a portion of its funding and personnel to administration of these resources. Near-term funding and FTE levels devoted to R&D administration are as follows:

Operating Administration	Funding			FTE		
	1996	1997	1998	1996	1997	1998
FHWA[1]	9,275	9,275	NA	NA	NA	NA
NHTSA[2]	18,022	10,983	NA	NA	NA	NA
FRA[3]	1,695	2,189	NA	2	2	NA
MARAD[2]	0	242	NA	0	3	NA
FTA[4]	2,164	2,130	NA	NA	NA	NA

In addition, DOT maintains several actual facilities in which it conducts research supporting Departmental missions. Near-term funding requirements associated with maintaining and refurbishing these facilities are as follows:

Fairbank Building Renovation (FHWA)[1]

FY	1996	1997	1998
Funding	0	500	NA
FTE	0.20	0.25	NA

The objective of this activity is to complete the renovation of the Fairbank Building. The project has been broken into four stages. Stages 1 and 2, now complete, have included

[1]Considered a Physical Infrastructure activity.

[2]Considered a System Assessment activity.

[3]Considered a Vehicle-related activity.

[4]Considered a Human Behavior-related activity.

adding new rest rooms, an elevator, heating, ventilation and air conditioning equipment. During this phase five laboratories were also renovated, including the bituminous mixtures lab, concrete lab, corrosion lab, pavement binders lab, and petrographic lab.

The renovations slated for Stage 3 include completing the renovation of the remaining laboratories (paint analysis, chemistry, and soils and aggregates), attic insulation, and replacement of windows and lighting fixtures. Stage 4 will entail improving the safety and access of the building and reducing energy consumption. Among the renovations needed to accomplish this are enclosing the second floor walkway between the Turner and Fairbank Buildings, repairing the building's roof, and replacing the high pressure steam boilers in the Annex building with a low pressure system.

Key Milestones: Stage 3 is scheduled for completion in FY 1997 and Stage 4 is scheduled for FY 1998.

Truck Dynamic Test Facility (FHWA)[1]

FY	1996	1997	1998
Funding	713	0	NA
FTE	0.5	0.5	NA

The FHWA's research on truck pavement interaction has determined that the dynamic forces exerted on the pavement by heavy vehicles could accelerate pavement damage significantly. The FHWA fabricated a 4-actuator prototype shaker table, the Dynamic Truck Actuator (DYNTRAC), and used it to conduct the research. The DYNTRAC has proven to be an effective device for simulating and measuring the dynamic forces induced to the pavement by the heavy vehicles. Due to space and laboratory limitations at the Turner-Fairbank Highway Research Center, the DYNTRAC was disassembled. The FHWA planned to construct a laboratory to house the DYNTRAC shaker table and conduct further studies; however, preliminary cost estimates for constructing the facility were beyond the scope of the budget.

Consequently, other options were explored and a U.S. truck manufacturer as well as a Canadian Government agency agreed to cooperate with FHWA in the conduct of shaker table testing using their own facilities containing up to 8 actuators. The FY 1996 funds will be used to modify existing laboratory space, convert the DYNTRAC from a 4-actuator to a 1-actuator shaker table, correlate Truck Dynamic Test results from U.S. with Dynamic Truck Research being done under OECD's co-operative multinational DIVINE research project, determine the dynamic impacts on pavement damage due to different tire configurations, and to conduct truck pavement damage models and analyses. The 1-actuator shaker table will be used for most of the testing for some of the more extensive analyses.

Major research milestones planned for FY 1997 include:

- Identify road-friendly vehicles

- Develop new truck TS&W damage factors
- Implement DIVINE
- Develop Pavement Life Cycle Cost Models for new vehicle systems
- Identify WIM configurations for super single vs dual tires
- Identify correction factors for vehicle dynamic effects on WIM

Vehicle Research and Test Center (NHTSA)[3]

FY	1996	1997	1998
Funding	777	800	NA
FTE	NA	NA	NA

The Vehicle Research and Test Center (VRTC) is the in-house research, development, test and evaluation laboratory for the National Highway Traffic Safety Administration (NHTSA). VRTC provides engineering analysis in support of NHTSA defect investigations and rulemaking initiatives. Long term research programs in the areas of biomechanics, crash avoidance and crash worthiness are also performed at VRTC.

VRTC is located on contractor owned property. The agency leases the building and work areas. All expenses associated with maintenance of the facility are covered by the government via VRTC administrative funds. These include: utilities (heat, sewage disposal, electricity, phone equipment), lease of GSA vehicles, janitorial services, supplies, copier expenses, etc.

VRTC houses over $2M worth of specialized test fixtures and equipment. A significant amount of this equipment is ADP and electronics equipment. Calibration, maintenance, replacement and upgrade of this equipment is required on a yearly basis.

Department approval has been granted for a space expansion at VRTC. In response to a request for more space, the contractor has proposed relocating VRTC to a new building at the same location. Should this occur, increased lease and maintenance costs would be expected. Relocation costs would also be incurred. No time schedule has been set for this proposed relocation.

R&D Facilities (FRA)[1]

FY	1996	1997	1998
Funding	400	420	NA
FTE	1	1	NA

The overall goal of the FRA's Research and Development Facilities Program is to provide the timely replacement of equipment and facilities at the Transportation Technology Center (TTC). A world-class proving ground for railroad equipment, the government-owned TTC represents a facility capital investment of over $200 million. While the facility is operated for FRA under a no-cost contract with the Association of American Railroads (AAR), the AAR is only required to provide routine maintenance for buildings and equipment. The R&D Facilities Program is therefore essential for sustaining the viability of TTC's research capabilities by continuing to replace or refurbish facilities or equipment that can no longer be economically maintained by AAR. Activities to be accomplished by the end of FY97 fall into two categories: environmental law compliance and R&D facilities restoration. Environmental Law Compliance includes completing construction of new wastewater treatment facility. R&D Facilities Restoration includes:

- completing refurbishment of Warehouse/Laboratory Facility solar heating system;
- completing Center Services Building locomotive fueling facility;
- completing upgrade of electrical equipment in DC substations; and
- completing replacement of servo-controllers on Simuloader in Rail Dynamics Laboratory.

New initiatives scheduled for FY97 include:

- rebuilding trueing machine that enables railroad car steel wheels to be reprofiled without dismounting from truck assembly;
- installing heavier running rail on approximately 2 miles of 3rd-rail test track to enable testing of dual-mode locomotives;
- upgrading on-site ambulance support; and
- re-roofing rectifier substation #2.

Ongoing projects include the complete restoration of all solid-waste management units.

SECTION IV. CONTRACTING PROCEDURES

Section 6009(b)(3)(C) of ISTEA calls for:

> *Recommendations on changes needed to assure that Federal, State, and local contracting procedures encourage the adoption of advanced technologies developed as a consequence of the research programs in this Act.*

Experience has shown that Government contracting procedures significantly impact the adoption of advanced technologies. While it is understood that many traditional procedures (e.g., low-bid contracting with performance specifications) are in place to reduce risk, protect investments, and ensure accountability, at times such traditional procedures have the dual effect of discouraging innovation and failing to support the overall purpose of reducing life cycle costs through improved performance and durability.

As an example, current highway regulations facilitate separation of design from construction, primarily to obtain as much competition as possible during the highest cost phase of construction programs. This process also opens more opportunities to small and mid-sized construction firms which may not have architectural and engineering capabilities. By adding another party and step to the acquisition process, however, the procedures raise questions of contract performance and product liability responsibilities whenever new or unusual designs or construction technologies are attempted. Local government buyers tend to avoid "unnecessary" risks until innovations are thoroughly tested and available on the open market.

In responding to ISTEA's call for contracting procedures that promote advanced technologies, the Department is committed to determining which practices impede innovation and the alternatives or incentives that are available to encourage the use of innovations. An agency-wide effort has been undertaken to study DOT's contracting and acquisition procedures and determine ways to streamline the present system.

A number of innovative recommendations have resulted from this process, many of which have been implemented in recent months. The Department's new Re-invention Laboratory is one example of the outgrowth of these efforts. Modeled after other recently established re-invention laboratories within the Federal government, including NASA's, the Lab was created to increase flexibility and innovation in DOT's acquisition processes by allowing freedom, i.e., a waiver, from compliance with various administratively-imposed requirements. This is done primarily through the Agency's implementation and interpretation of the statutes and regulations. As an example, the regulations do not require proposals to be in written form, so oral proposals are now often used. With the Re-invention Lab, DOT now also has a means for experimenting with pilot programs for re-engineered processes. Among the issues the Re-invention Lab addresses include: establishing performance measurements and standards to assess the success of pilot programs; assessing and managing the risks associated with implementing changes such as greater delegation of authority and

reduced file documentation; re-engineering other processes and conducting pilot programs to determine potential benefits; influencing the development of Federal regulation and new procurement legislation; and addressing the multitude of cultural issues in the DOT procurement community.

In addition to these efforts, DOT has increasingly been making use of the flexibility offered by the provisions of ISTEA. This has enabled the use of a number of innovative financing tools including leveraging tools (e.g., flexible match; bonds and debt; ISTEA Section 1021 Loans; ISTEA Section 1044 Toll Investment Credit) and cash flow tools (advance construction; partial conversion of advance construction; phased funding; and tapering) and has promoted the increasingly necessary trend of public/private partnerships.

This chapter discusses a number of these innovative new financing tools, programs, and task force efforts along with an overview of current contracting practices and recent Federal actions on procurement laws and regulations.

Overview of Current Contracting Practices

Since DOT does not own nor operate surface transportation systems, contracts for all but about 3 percent of federally assisted surface transportation programs will be placed and managed by DOT grantees or subgrantees, such as State, county, and city governments, regional and municipal authorities, special districts, and Amtrak. Of the contracts placed by DOT, the largest dollar amount is for building and rehabilitating roads in National Parks and Forests. The remainder (only about 1 percent) of the Department's annual surface transportation funds is used for DOT sponsorship of research, development, training, technical assistance, and technology transfer.

In the future, the number of grantees and subgrantees can be expected to increase. More decisionmaking responsibilities have been vested in State and local governments by flexible funding provisions of ISTEA. Nationally, funding emphasis has shifted from completing the Interstate System to maintaining and improving the National Highway System, including local highways and access to intermodal facilities. Congestion mitigation, air quality, and regional traffic management systems can be expected to lead to increased involvement of city and county governments and regional agencies.

Through the Intelligent Transportation Systems (ITS) program authorized by ISTEA, the Department has increased its emphasis on using advanced sensing, computing, and communications technologies to improve the productivity of existing infrastructure. ITS developments will undoubtedly lead to increases in the variety and quantity of local procurements of hardware and software. This growing diversity of agencies and products underscores the need for a continuing effort by DOT to understand the effects of Government contracting practices at all levels.

General Requirements for DOT Grantees

Procurement procedures for State and local governments under grants and cooperative agreements that use Federal funds are set forth in title 49, Code of Federal Regulations (49 CFR, Part 18), "Uniform Administrative Requirements for Grants and Cooperative Agreements to State and Local Government" (the common grant management rule). The rule applies to all grants and subgrants awarded by DOT. Issued in 1988, the rule called for a less intrusive Federal role in grantee procurement activities. It responded to an Executive Order directing Federal agencies not to substitute their judgment for that of the recipient unless the matter is primarily a Federal concern, and that agencies, to the maximum extent feasible, defer to the States to establish standards, rather than setting National standards.

The common grant management rule prohibits Federal agencies from imposing additional administrative requirements, unless required by statute, and encourages grantees to avoid detailed or burdensome application requirements for subgrants. A key provision is that States are to follow the same policies and procedures they use for procurements using non-Federal funds. However, the procurements must conform to applicable Federal law. Grantees and subgrantees are to follow the provisions of Part 18 and use their own procedures reflecting applicable State, local, and Federal laws. Procurement transactions are to be conducted in a manner providing full and open competition. While this rule covers the majority of grantees, the States are authorized to follow their own procedures used for procurements from non-Federal funds. Noncompetitive procurements are permitted only under exceptional circumstances.

49 CFR Part 18 invokes Federal laws that apply to contracts awarded under any federally financed program. Examples are: Equal Opportunity Employment, Anti-kickback, Clean Air, Clean Water, and Davis-Bacon. For the convenience of State and local government grantees, and to assure universal application, FHWA requirements specify use of a uniform contract attachment. FTA lists laws and regulations which apply specifically to transit programs in its master agreement.

The grant management rule for universities and other not-for-profit institutions is 49 CFR Part 19.

Federal Aid Highway Programs

The objectives of highway design and construction contracting procedures are to minimize costs and risks, obtain essential uniformity in nationwide highway systems, and accelerate the rate of new construction nationally. In addition to the common grant rule, 23 CFR Parts 172, 633, and 635 provide detailed contracting procedures and forms for engineering and design contracts and for construction contracts. For engineering and design contracts, the regulations permit any form of competitive negotiation that uses qualification-based procedures. For highway construction, the regulations require low-bid procedures.

The regulations have been undergoing evaluation and refinement since the Federal Aid Highway Program began in the 1950s. They have been modified to respond to changes in National policies and laws and have been continuously tested by litigation. As was mentioned earlier, highway regulations facilitate separation of design from construction, primarily to obtain as much competition as possible during the highest cost phase of construction programs; a process that also opens more opportunities to small and mid-sized construction firms which may not have architectural and engineering capabilities. This additional step to the acquisition process, however, raises questions of contract performance and product liability responsibilities whenever new or unusual designs or construction technologies are attempted. In turn, risk-averse local government buyers tend to avoid "unnecessary" risks until innovations are thoroughly tested and available on the open market, and at competitive cost.

FHWA is able to use the greater flexibility of its R&D and demonstration programs to develop and test new construction technologies, materials, and processes. FHWA grantees are encouraged to participate in advanced technology programs through the NCHRP and the agency's R&D and special experimental projects. The special experimental projects include evaluating innovative contracting practices such as cost-plus-time bidding, lane rental, design-build contracting, and warranty clauses.

Building Partnerships with Innovative Financing

With current constraints at the Federal level, Federal funding in many programs will undeniably be limited in the future. Coupled with this, State and local governments are under similar constraints and face competing demands for various vital needs. The best response to this may likely be the new trend toward partnerships with the private sector. Many of the United States' international competitors already employ this tactic.

In January of 1995, President Clinton announced the "Partnership for Transportation Investment." Also known as "Innovative Financing," the term covers a broad range of strategies including the use of leveraging and cash flow tools. DOT's involvement with Innovative Financing began with provisions in ISTEA that allowed experimentation with varied ways of financing advanced technology projects. Over the last three years, DOT has aggressively pursued such experiments.

Many such projects employ single financing techniques, while others combine techniques to obtain the greatest benefits from the flexibility allowed under such programs as the FHWA's Test and Evaluation 045 (TE-045) program (a program which allows for the testing of many of the Innovative Financing ideas generated). Incentives for using Innovative Financing, and ones which have been realized, include the ability to complete projects more quickly as well as the opportunity to begin more projects. Moreover, Federal dollars have leveraged additional dollars and private investment in infrastructure has grown.

The primary goals of Innovative Financing are to: create incentives for the States to take full advantage of ISTEA's financing opportunities; to learn what new financing strategies and policies work best and make necessary changes; to assist the States in their efforts to leverage their current funding and produce additional funds - both public and private; and to move projects into construction more quickly than under traditional financing procedures.

Innovative Financing, working within the existing statutory framework, allows many of the existing restrictions and requirements to be waived and gives local decision makers greater flexibility and authority. Such experimentation is critical in that the current system of paying for projects only through grant reimbursement is increasingly being considered outdated; the "red tape" required slows projects and increases costs, making it difficult for States and localities to involve private investors.

These innovative financing tools, designed to make more funds available to transportation providers, include leveraging tools such as: Flexible Match; Bonds and Debt; ISTEA Section 1012 Loans; and ISTEA Section 1044 Toll Investment Credits. Other innovative tools used, referred to as cash flow tools, include: advance construction; partial conversion of advance construction; phased funding and tapering.

As an example of *Flexible Match*, the Maine Department of Transportation is constructing an intermodal truck-to-rail transfer facility near the Town of Fairfield. Located about one mile from the Interstate, the facility will provide for the transfer of truck freight from major U.S. highways to key rail lines, both in Maine and throughout New England. Under the Innovative Financing effort, a private rail company is contributing material, equipment, and services for use in the project. The State is crediting the value of the rail contributions toward the State's share of project costs. The rail contribution saves the State $1.57 million, which can be used elsewhere for transportation.

Bond and Debt Financing is demonstrated by the Conway Bypass project in South Carolina. The South Carolina DOT plans to build a link between U.S. 17 and other major roads that lead to the Grand Strand/Myrtle Beach area, increasing access to the State's largest tourist area. FHWA is applying the TE-045 ISTEA Section 1012 loan approach to a non-toll facility with a dedicated revenue repayment source. This loan for the estimated construction cost of the project provides cash to service the bonds supporting the project. Bond principal and interest on the project will be repaid using TE-045 flexibility. By combining Innovative Financing and innovative contracting, this project is expected to save over $100 million, with construction accelerated by 20 years. Local sales tax revenues will also fund a portion of the project.

As an example of the *ISTEA Section 1012 Loan*, the Texas Department of Transportation has constructed an 8-lane bridge and supporting facility between Laredo, Texas and Nuevo Laredo, Mexico. The project includes a loan of $11 million from the State to the City of Laredo. The loan financing the bridge, which is expected to cut congestion brought about by

the increased traffic expected from NAFTA, will be paid for by toll revenues and rental income from other users of the facility.

The Maryland Department of Transportation used *Section 1044 Credits* earned from toll revenue expenditures to make needed highway capital improvements. Under an innovative approach to the Section 1044 Maintenance of Effort requirement, the State has used about $18.9 million in toll credits in FY 1995 based on a prospective Maintenance of Effort test. State credits will be used as the State share for funds on the I-70 project near Frederick, Maryland among others. This frees up State funds (which may otherwise have been required to meet matching requirements) for use on other projects.

The Butler County Highway in Ohio is an example of using *Advance Construction*. The Ohio DOT will construct a four-lane, 10.3-mile road and extra lanes on the Interstate to accommodate a proposed interchange. The project, which costs $95 million, is based on State legislation that established a transportation improvement district in the area. Because of the good prospect of future Federal funds, the State can borrow more easily to finance the project and, as a result of Advance Construction eligibility and flexibility, the State can obtain better financing for an intergovernmental loan and/or private bonds for the project.

Interstate route improvements in Pennsylvania, including three major reconstruction projects along high-volume interstates and expressway routes, are currently being financed through *Partial Conversion of Advance Construction* funds. The Federal share of all three projects is approximately $45 million. The State will partially convert Advance Construction projects, saving as much as 5 percent of the State's FY 1995 obligational authority and making it possible to advance other "ready-to-go" projects earlier in the authorization period.

In New Jersey, a new viaduct will be constructed and three bridge decks replaced using *Phased Funding*. In this way, the State can spread costs over two years and make more efficient use of Federal funds, enabling the project to begin a year early. Phased Funding will enable several other bridge replacement-eligible projects which might otherwise have been delayed six to eight months to be obligated at a significantly faster pace.

The Michigan DOT has utilized *Tapering Non-Federal Matching Shares* in their recent widening of a State truck line aimed at increasing capacity to alleviate congestion problems. The project costs for Phase II are approximately $70 million with authorized Federal participation of $57.3 million. Tapering will enable Michigan to achieve better cash flow management during the riskier early project stages.

On November 28, 1995 Congress enacted P.L. 104-59, the National Highway System Designation Act. Sections 311, 313, and 322 of this Act take innovative financing one step further by making permanent the financing technology demonstrated under TE-045. In addition, Section 350 established a 2-year State Infrastructure Bank (SIB) Pilot Program that will allow States to recycle transportation funding and leverage additional investment in

transportation infrastructure over a long-term period. The Department views the SIB Pilot as a means of advancing a multiple financing strategy.

While many of the early projects utilizing Innovative Financing have been ones to build new roadways, other modes, including transit, rail, and aviation, have high potential. For example, airport construction, which relies on the capital markets for as much as three-quarters of its funding, has long been a model for involving the private sector in public projects.

As an example, Northern Southern Railroad recently paid to add a third track on a rail right-of-way in Cincinnati, greatly reducing rail congestion. The Railroad will be reimbursed for this over time through the State's ISTEA allocation using Advance Construction Funding.

Three FTA grantees, the Chicago Transit Authority (CTA), the Bi-State Development Agency (Illinois and Missouri) and New Jersey Transit (NJT), recently concluded innovative financing transactions that together generated nearly $57 million dollars in additional transit revenues. All three are U.S. tax-based transactions involving U.S. taxpayers. While the transactions confer certain tax deferment and depreciation benefits, they will nonetheless be "tax-positive" to the Treasury, and earn approximately $65 million as a result. The CTA entered into a U.S. leveraged sale/leaseback (Pickle" lease) of approximately $831 million in rail cars. CTA transferred title to the vehicles to a private investor, and will lease them back over a 20-year period. The CTA has received approximately $47 million in profits. Bi-State concluded a similar Pickle lease of $59 million in rail cars, and received $3.8 million in profit. NJT closed a Pickle lease of some $125 million in locomotives and rail cars, and received $6 million in profit. The lease terms allow the grantees to maintain control and use of the equipment in mass transit service, as required by Federal law. They regain title to the equipment at the end of the lease period.

Transit Equipment and Construction Contracts

Although DOT-assisted transit programs follow the common grant management rule, FTA maintains a circular, (C 4220.1C, "Third Party Contracting Guidelines") to assist grantees and regional offices in interpreting the procedures that are specifically applicable to transit agency procurements. The circular and its referenced laws and regulations emphasize that all procurement transactions are to be conducted in a manner providing full and open competition. In addition, 49 USC 5323(h) and 49 USC 5307(d)(1)(E), formerly sections 3(a)(2)(C) and 9(e)(3)(E) of the Federal Transit Act of 1964, as amended, forbid the use of Federal grant or loan funds to support procurements utilizing exclusionary or discriminatory specifications.

However, grantees are encouraged to use "value engineering" clauses and may use procurement by competitive proposals in lieu of sealed bids. (Value engineering clauses cover situations where a contractor comes up with an idea, after the work has begun, that saves money. The clause, most often utilized in construction projects, allows for the

contractor and government to share the savings.) The competitive proposal method allows consideration of such factors as technical risks, life cycle costs, technical performance, and management approach, as well as initial costs. However, because of State and local regulations most authorities continue to rely on definitive specifications and low-bid contracting, or on low-bids for life cycle costs. Life cycle costs refer to initial and future costs such as maintenance, reconstruction, rehabilitation, restoring, and resurfacing costs over the life of the project.

Unlike the high-volume construction programs of FHWA, most new rail starts, busways, downtown people movers, and urban rail modernization programs have been acquired as systems with contracts tailored individually for the unique circumstances of each project. For purposes of programmatic or technical approvals, major transit programs are often divided into phases; however, separate contracts for design and construction contracts are not required. A variety of design-build methods have been used by transit authorities, including turnkey projects.

Acquisitions by DOT

All DOT organizations that acquire supplies and services are governed by DOT's Transportation Acquisition Regulation (TAR) and Transportation Acquisition Manual (TAM) that implement and supplement the Federal Acquisition Regulation (FAR).[1] Together these documents provide a detailed set of rules governing all phases of acquisition, including procedures to contract for all products and services, including R&D.

In addition to contracts, DOT employs more flexible cost-shared vehicles like Broad Agency Announcements (BAAs), grants to research institutions, cooperative agreements, other transactions, and Cooperative Research and Development Agreements (CRADAs) to leverage the limited R&T resources available. While the use of CRADAs had been somewhat limited in the past, the FAA - among other modes - has been quite active in using these agreements as the benefits of using them are increasingly realized. CRADAs are cost-sharing vehicles that, through encouraging early industry buy-in, ultimately promote the development of commercially viable products and services. The public and the Department have benefitted considerably from the results of long-standing cooperative research programs with universities, industry and professional associations (e.g., AASHTO, AAR, APTA), and the Transportation Research Board of the National Research Council.

Contracting in the Electronic Age

DOT has increasingly been using such tools as the Internet to both ease and expedite many of the government's contracting and grant procedures. From posting information ranging from university research grants to contract solicitation and award, the Internet is increasing

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[1]Section 348 of the Department of Transportation and Related Agencies Appropriations Act, 1996 (Pub. L. 104-5c) exempts the FAA from many governmentwide procurement statutes and regulations.

accessibility and, in many ways, promoting the advanced technologies aspired for with the passage of ISTEA.

Among the vast grant- and contracting-related items that are housed on the Internet are: experimental university R&D programs; university transportation-related R&D grants; grant management requirements; contract solicitations and awards; and information on the uses of DOT contracts, grants and cooperative agreements, among other items. With such information readily accessible, the government has essential access to current university and private sector research, enabling both better and quicker assessment of available research and technologies. At the same time, the Internet provides universities and the private sector access to the latest information and opportunities in DOT's contracting and grant environments.

In a climate where it is increasingly felt that federally-sponsored research and development should be pushed toward cooperative funding, the Internet--by increasing information flow--is enhancing the opportunity for such partnerships. For example, the Department's FY 1996 SBIR Program Solicitation was made available this year on the World Wide Web (WWW) site for the Volpe National Transportation Systems Center.[2] Many other DOT RFPs and CBD notices are now available through the Department's WWW site,[3] and a wealth of procurement information can be accessed via the Small Business Administration (SBA) WWW site.[4]

Other items on the Internet that have enabled DOT's contract and grant information to reach a wider audience are the posting of such items as: Executive Orders; various recent rules and regulations changes that affect the grant and contracting environment; and contract reporting requirements, among others. This has been a significant benefit in that all modes now have a common and accessible vehicle to turn to for updated policies and procedures. This has been helpful in setting more uniform standards across the modes.

Recent Federal Actions on Procurement Laws and Regulations

Federal Acquisition Streamlining Act of 1994 (PL 103-355)

On October 13, 1994, President Clinton signed the Federal Acquisition Streamlining Act of 1994 into law. Most of the provisions of the Act are being implemented through changes to the Federal Acquisition Regulation. There are over 90 sections of the law that were

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[2]The site address is http:\\www.volpe.dot.gov. The closing date for this solicitation is May 1, 1996.

[3]http:\\www.dot.gov

[4]http:\\www.sbaonline.sba.gov

addressed through that process. Key provisions affecting R&D procurements that are in effect include:

- Clarification of the agency authority to execute multiple-contractor task- and delivery-order contracts. Within DOT, such model processes were pioneered at RSPA's Volpe Center. The Center's multiple contractor resource base (known as the OMNI program) has been used for over eight years to obtain technical support for projects managed by the Volpe Center. This practice has now been adopted by OST on behalf of all operating administrations.

- On acquisitions of less than $2,500 or 0.1% of total project cost, whichever is greater for Buy America provisions, the requirements to reserve procurements for small business and to comply with provisions of the Buy America Acts have been eliminated.

When fully implemented and translated into rules, other provisions of the Act will undoubtedly assist in accelerating the adoption of advanced technologies developed as a result of programs authorized by ISTEA.

49 CFR Parts 18 and 19, The Grant Management Rules

In April 1995, the Office of the Secretary issued a final rule amending 49 CFR Part 18, raising the dollar threshold for small purchases to $100,000. The NPRM also proposes to raise the threshold for DOT approval of several grantee agency actions. Although not aimed primarily at stimulating new technologies, the changes are intended to reduce the administrative burden on grantees, and may accelerate the acquisition of studies and expert assistance necessary to introduce technological innovations. With passage of the Federal Acquisition Streamlining Act of 1994, a new simplified acquisition threshold for universities and not-for-profit institutions under CFR Part 19 was set at $100,000.

23 CFR Parts 420 and 511, State Planning and Research Program Administration

On July 22, 1994, FHWA published a final rule amending these sections to grant States greater responsibility and flexibility for the management and oversight of their research, development, and technology transfer initiatives supported with FHWA planning and research funds. The rule also reflects the requirements in 23 USC 307(c) for research, development and technology transfer activities.

23 CFR Part 637, Quality Assurance Procedures for Construction

On June 29, 1995, FHWA published a final rule that revised its general requirements for quality assurance procedures for construction on Federal-aid highway projects (60 *Federal Register* 33712). The revision permits use of contractor testing results in the overall

acceptance program and could permit more rapid introduction of advanced construction and testing techniques.

Interim Policy Statement on Life-Cycle Cost Analysis (LCCA)

On July 11, 1994, the Federal Highway Administration (FHWA) published an interim policy statement on life-cycle cost analysis for public comment (59 Federal Register 35404). The interim policy responds to ISTEA requirements to consider life cycle costs in the design and engineering of bridges, tunnels, and pavements. The policy also implements the Presidential Executive Order 12893 of January 26, 1994, "Principles for Federal Infrastructure Investments," that requires benefits and costs to be measured and discounted over the full life cycle of each project. Subparts B and C of the final rule on implementation of ISTEA management systems (23 CFR 500.207 500.307) require use of LCCA for bridge and pavement management systems. LCCA contracting provides an incentive to contractors to adopt new materials and technologies, and monitoring of integrity and prioritization of maintenance, which improve the durability of infrastructure and save costs in the long run.

To support preparation of the policy statement, FHWA and the American Association of State Highway and Transportation Officials (AASHTO) held a jointly sponsored symposium in December 1993, to learn more about LCCA practices among States and to identify research, training, technical assistance, and policy-related needs to improve LCCA practices. Issues and research needs identified at the symposium were: how to establish the appropriate analysis period, how to value and properly consider user costs, and how to choose the appropriate discount rate.

Participants in the symposium identified research data needed to predict pavement and bridge performance and forecast future traffic. One significant point brought out was that "...the results of LCCA may favor selection of improvements with higher initial costs in order to achieve significant long-term savings in overall investment requirements. It may indicate, for instance, that more projects warrant reconstruction rather than rehabilitation strategies, that early intervention with preventive maintenance is cost effective, or that somewhat higher designs or levels of service may be appropriate for some facilities." Aside from the important information gathered at the symposium, offering incentives to encourage use of newest technologies may also promote greater creativity among the States.

Comments on the interim policy statement were submitted in October of 1994. Taking these into consideration, FHWA plans to release a final LCCA policy statement this summer. FHWA will develop training and technical assistance materials to supplement analysis techniques developed by AASHTO in the National Cooperative Highway Research Program.

Department of Transportation and Related Agencies Appropriations Act, 1995, P.L. 103-331

Section 329A of the FY 1995 DOT Appropriations Act authorizes the Secretary of Transportation to enter into grants, cooperative agreements and other transactions with any

entity in execution of the Technology Reinvestment Project (TRP) conducted by the Department of Defense Advanced Research Projects Agency. The language was necessary because several of the Department's administrations did not have statutory authority to enter into "grants, cooperative agreements, or other transactions" and may be called upon to accept interagency funds transfer, award and manage TRP projects.

National Highway System Designation Act of 1995

Under the National Highway System Designation Act of 1995, the Secretary is required to establish a program for Life-Cycle Cost Analysis and Value Engineering Analysis. The Act mandates that the Secretary "establish a program to require States to conduct an analysis of the life-cycle costs of each usable project segment on the National Highway System with a cost of $25,000,0000 or more." Analysis of the life-cycle costs refers to "a process for evaluating the total economic worth of a usable project segment by analyzing initial costs and discounted future costs such as maintenance, reconstruction, rehabilitation, restoring, and resurfacing costs, over the life of the project segment."

The Act also states that the Secretary must "establish a program to require States to carry out a value engineering analysis for all projects on the National Highway System with an estimated total cost of $25,000,000 or more." Value engineering analysis refers to a systematic process of review and analysis of a project during its design phase by a multidisciplined team of persons not involved in the project. The team's objective is to provide suggestions for reducing the total cost of the project and providing a project of equal or better quality. The outcome of such analysis may include suggestions for combining or eliminating otherwise inefficient or expensive parts of the proposed design for the project or the total redesign of the proposed project using different technologies, materials or methods.

Current Studies and Task Force Efforts

Current studies, coordination activities, and experimental programs aimed at contracting procedures are listed in the following table:

	Program	*Lead Agency*	*Completion Date*
1.	Study of Procurement Law Governing Acquisition of ITS Research, Development, and Technology	FHWA Chief Counsel	March 1996
2.	Innovative Contracting Procedures - Special Experimental Project N.14	FHWA Engineering	Ongoing

3.	Study of Approaches for Increasing Private Sector Involvement in the Highway Innovation Process	Transportation Research Board	May 1996
4.	FTA Buy America Regulations	Federal Transit Administration	July 1995
5.	FTA Turnkey Methods	Federal Transit Administration	1995
6.	FTA Third Party Contracting Requirements	Federal Transit Administration	October 1995: Circular 4220.1c issued Report: FTA Third Party Procurement "Best Practices" Manual

Several projects listed in the second edition of this Plan have now been completed, and are therefore not included in this edition. A brief description of each of the remaining projects is provided in the paragraphs that follow.

1. Study of Procurement Laws Applicable to ITS.

This project focuses on State and local procurement law governing acquisition of ITS research, development, and technology. Its objectives are to conduct legal research and analysis and develop alternative models to streamline and improve current procurement processes. The study will also examine methods for harmonizing Federal requirements relating to procurements funded through Federal grants and cooperative agreements. The study contract was awarded in September 1994.

Procurement procedures to be examined include:

- Types of contracts appropriate for various phases of ITS deployment; alternative award procedures.
- Allocation of rights in intellectual property created in the course of ITS contracts.
- Allowable costs and audit.
- Organizational conflicts of interest.

2. Innovative Contracting Practices (SEP 14).

The objective of Special Experimental Project No. 14 (SEP 14) is to identify, for trial evaluation and documentation, innovative contracting practices which have the potential to reduce life cycle costs to State Highway Agencies (SHAs) while maintaining product quality and an acceptable level of contractor profitability.

The project was initiated by FHWA's Office of Engineering in 1991 during preparation of TRB Circular Number 386 on innovative contracting practices. The circular reported findings of a task force that was formed in 1988 to explore innovative contracting practices used by SHAs, consultants, and construction contractors. The task force requested FHWA to establish an experimental project on innovative contracting practices, which could be used to evaluate and validate the task force findings.

FHWA field offices and the SHAs have been invited to submit conceptual proposals that they believed might be suitable for evaluation. Projects have been approved in design\build contracting, cost-plus-time bidding, lane rental, and a variety of warranty mechanisms. The cost-plus-time bidding and lane rental approaches have demonstrated definite beneficial application in reducing construction time for initial projects that have high road user delay impacts. For this reason, these techniques have proven their suitability for use as nonexperimental, operational practices. Also, the FHWA has completed a rulemaking effort to revise the prohibitive warranty regulation (23 CFR 635.413) to permit States to use warranty clauses in Federal aid contracts.

3. TRB Study of Approaches for Increasing Private Sector Involvement in the Highway Innovation Process.

Providing highway transportation in the United States is a joint public and private sector enterprise. This market relationship is highly unique and has generated many constraints on the private sector's desire and ability to innovate and provide products and services that continually enhance the highway system. This persistent problem prompted TRB in 1990 to establish a special task force to explore means by which the highway community can take positive steps to expand opportunities and incentives for private sector innovation. The task force generated several proposals for enhancing innovation, including the idea of a collective private industry council or forum to provide advice and assistance to the public sector on advancing measures that enhance research and innovation in the highway field. The proposal was of interest to both the public and private sectors, which provided funding for a TRB study of the concept.

The study is being conducted by a special TRB committee which consists of experts in the highway field from both the public and private sectors. The committee has focused its attention on finding ways to increase the private sector's incentive and opportunity to innovate, believing that even modest enhancements in this area will yield many new and valuable highway products and services. The committee recognizes that changing the set of

incentives offered to private industry will require reevaluation and revision of many long-established and deeply ingrained highway business practices. Hence, in exploring alternative approaches for building momentum for such change, the committee has been studying the feasibility of a public/private sector forum that would, on a continuing basis, provide an opportunity for progressive leaders in the highway community to devise and advance strategies aimed at improving the climate for innovation in the highway industry.

In meeting for the final time in November of 1995, the study committee further defined the concept of a strategic forum and its organizational prospects. A final report recommending the establishment of such a strategic forum is anticipated in March-April 1996.

4. FTA Buy America Regulations.

On July 24, 1995, FTA issued a general public interest waiver, under 49 U.S.C. 5323(j)(2) and 49 CFR 661.7(b), from its Buy America requirements for "small purchases" made by its grantees with FTA financial assistance, including capital, planning and operating assistance. The small purchase threshold, as defined in the common grant rule at 49 CFR 18.36(d), recently amended (60 FR 19639, April 19, 1995), is currently $100,000. FTA found this waiver to be in the public interest because it simplifies government procedures and streamlines government procurement requirements, consistent with the President's National Performance Review, Executive Order 12931 (Federal Procurement Reform) and the Federal Acquisition Streamlining Act of 1994.

5. FTA Turnkey Methods.

To advance new technologies and lower the cost of constructing new transit systems, ISTEA authorized FTA to conditionally award funding for Turnkey Projects before Federal requirements have been met on the project so long as the award is made without prejudice to the implementation of those requirements. The law, 49 U.S.C. Section 5226(a), defines a "Turnkey System Project" as one under which a recipient of FTA funds contracts with a consortium of firms, individual firms, or vendors to build a transit system that comports with specific performance criteria, and which is operated by the vendor for a period of time. State and local governments can obtain assurances of Federal funding earlier in the procurement process without assuming the risk of wasting funds expended to meet Federal requirements because the project is ultimately denied Federal funding. ISTEA also requires FTA approval of an initial demonstration of Turnkey demonstration projects to develop regulations applicable to Turnkey Systems Projects. Through a National competition, four projects were selected.

6. FTA Third Party Contracting Requirements.

Effective October 1, 1995, FTA revised its third party contracting guidelines by the adoption of revised Circular 4220.1C, Third Party Contracting Requirements. The Circular contains

only the minimum requirements contained in the Common Grant Rules, 49 CFR Part 18, Uniform Administrative Requirements for Grants and Cooperative Agreements to State and Local Governments, and 49 CFR Part 19, Uniform Administrative Requirements for Grants and Agreements with Institutions of Higher Education, Hospitals, and Other Non-Profit Organizations, related Executive Orders, statutes, and FTA policy statements.

Provisions interpreting these third party contracting requirements, as well as recommended contracting practices, will be contained in the FTA Third Party Procurement "Best Practices" Manual. Development of this manual is expected to begin in early April of 1996. The revised Circular will empower FTA grantees to exercise greater flexibility and discretion in the procurement process. In addition to a reduction of requirements and increased grantee flexibility, the following significant changes were implemented by the Circular. A new self-certification process was created which eliminates the need for submission of supporting documentation.

Compliance with FTA requirements is now determined post-grant through the "Triennial Review," and the "Procurement System Reviews." All pre-award reviews of proposed contract awards were deleted, in favor of periodic, post-grant reviews. The small purchase threshold was increased to $100,000. A relaxation of construction payment bond requirements, removal of progress payment restrictions, and a removal of the 50% limitation on option quantities are other features of this Circular. The Circular authorizes grantees to use the General Service Administration's (GSA) Federal Supply Schedule (FSS) to procure goods and services. However, GSA must first issue guidelines to implement the process prior to grantees being granted access to place orders against the FSS contracts. GSA advises that, because of recent developments in the DBE community, the program may be implemented on a limited or pilot basis to segments of the grantee population. Consequently, GSA now projects that full scale implementation could take another 18 months.

Appendix A: Index of Near-Term R&D Funding and Staffing Plans

Title	Admin.	Funding			FTE			Page	Notes
		FY 1996	FY 1997	FY 1998	FY 1996	FY 1997	FY 1998		
Section III. Chapter 2: Physical Infrastructure									
Highway Safety	FHWA	8,509	8,768	NA	22.80	23.80	NA	85	[17]
Pavement Research Program	FHWA	17,099	23,200	NA	24.00	24.00	NA	87	[1]
Structures Research Program	FHWA	12,558	22,000	NA	15.00	15.00	NA	88	
Environmental Research	FHWA	5,317	5,593	NA	5.00	5.00	NA	89	
Right-of-Way Research Program	FHWA	408	322	NA	0.25	0.25	NA	90	
Technology Assessment and Deployment	FHWA	12,499	14,846	NA	27.00	27.00	NA	91	
Local Technical Assistance Program	FHWA	8,866	10,100	NA	2.00	2.00	NA	91	[2]
National Highway Institute	FHWA	4,153	6,000	NA	15.00	15.00	NA	92	
Strategic Highway Research Program Implement	FHWA	20,000	20,000	NA	16.00	16.00	NA	93	
Applied Research & Technology	FHWA	41,000	41,000	NA	NA	NA	NA	94	[12]
Seismic Research & Development Program	FHWA	2,000	2,000	NA	2.00	2.00	NA	96	
Fundamental Properties of Asphalt	FHWA	3,000	0	NA	2.40	2.40	NA	96	
Timber Bridge Research Program	FHWA	875	0	NA	1.00	1.00	NA	97	
Track, Structures, and Train Control	FRA	7,082	8,967	NA	5.00	3.00	NA	98	
Intermodal Development	MARAD	NA	300	NA	NA	NA	NA	99	
Environmental Protection	MARAD	NA	75	NA	NA	NA	NA	101	
New Rail Vehicles and Infrastructure	FTA	3,000	500	NA	NA	NA	NA	102	
Pipeline Safety Research	RSPA	2,142	2,144	NA	NA	NA	NA	102	
Section III. Chapter 3: Information Infrastructure									
ITS -- Research and Development	FHWA/NHTSA	36,166	42,935	NA	NA	NA	NA	113	
ITS -- Automated Highway Systems (AHS)	FHWA	14,000	30,700	NA	2.00	2.00	NA	115	
ITS -- Architecture and Standards	FHWA	0	7,050	NA	NA	NA	NA	116	
ITS -- Operational Tests	FHWA/NHTSA	31,052	28,125	NA	NA	NA	NA	117	
ITS -- Evaluation	FHWA	0	4,000	NA	1.20	1.20	NA	119	
ITS -- Mainstreaming	FHWA	0	950	NA	NA	NA	NA	120	
ITS -- Model Deployment	FHWA	0	100,000	NA	NA	NA	NA	121	
ITS -- Commercial Vehicle Operations	FHWA	13,750	0	NA	NA	NA	NA	121	
ITS -- Program Support	FHWA	10,034	10,000	NA	NA	NA	NA	122	
ISTEA Section 6058 Funds	FHWA	98,827	113,000	NA	NA	NA	NA	123	
Crash Avoidance--Driver/Vehicle Performance	NHTSA	0	4,000	NA	NA	NA	NA	124	
Industry Competitiveness	MARAD	NA	280	NA	NA	NA	NA	125	
Hazardous Materials Research	RSPA	1,542	1,161	NA	2.20	2.20	NA	125	
Emergency Transportation	RSPA	67	68	NA	NA	NA	NA	127	
Navigation	FAA							127	[18]
Waterways Safety and Management	USCG							127	[18]

Appendix A: Index of Near-Term R&D Funding and Staffing Plans

		Funding			FTE				
Title	Admin.	FY 1996	FY 1997	FY 1998	FY 1996	FY 1997	FY 1998	Page	Notes
Section III. Chapter 4: Next-Generation Vehicles & Fuels									
Motor Carrier Research	FHWA	7,390	7,774	NA	9.00	9.00	NA	130	
Safety Systems	NHTSA	5,910	6,500	NA	20.36	19.94	NA	131	
Biomechanics	NHTSA	5,890	7,450	NA	15.27	14.96	NA	132	
Heavy Vehicles	NHTSA	517	597	NA	5.09	4.99	NA	132	
Partnership for a New Generation of Vehicles	NHTSA	0	5,000	NA	3.39	3.32	NA	133	
Equipment, Operations & Hazardous Materials	FRA	5,560	5,820	NA	7.00	7.00	NA	134	
Safety of High Speed Ground Transportation	FRA	9,378	7,169	NA	1.00	1.00	NA	134	[3]
Next Generation High-Speed Rail	FRA	24,151	26,526	NA	2.50	4.00	NA	135	[4], [20]
Shipyard Revitalization	MARAD	NA	734	NA	NA	NA	NA	135	
New Bus Vehicles and Infrastructure	FTA	5,295	6,800	NA	NA	NA	NA	137	
Advanced Bus Propulsion Systems	FTA	5,500	6,900	NA	NA	NA	NA	137	
Modular Fuel Cell System for Ship and Heavy	USCG							138	[18]
Section III. Chapter 5: Human-Centered Transportation									
Commercial Vehicle Operator Human Factors	FHWA							140	[5]
Highway Safety Research	NHTSA	5,069	4,833	NA	NA	NA	NA	142	
Maritime Safety	MARAD	NA	175	NA	NA	NA	NA	144	
Safety and Security	FTA	1,100	1,100	NA	NA	NA	NA	145	
Aviation Human Factors	FAA							145	[18]
Marine Safety: Human Factors Analysis	USCG							146	[18]
Section III. Chapter 6: System Assessment									
Policy Research	FHWA	5,401	5,681	NA	6.00	8.00	NA	148	
Transportation Planning Research	FHWA	5,769	8,300	NA	4.00	5.25	NA	150	[6]
National Advanced Driver Simulator	NHTSA/FHWA	2,000	14,500	NA	5.09	4.99	NA	151	[15]
Fatal accident reporting system (FARS)	NHTSA	4,585	5,251	NA	6.79	6.65	NA	152	
National Accident Sampling System (NASS)	NHTSA	9,200	9,675	NA	8.48	8.31	NA	153	
Data Analysis	NHTSA	1,415	2,100	NA	22.05	21.60	NA	153	
State Data Program	NHTSA	1,550	3,850	NA	15.27	14.96	NA	154	
Occupant Protection Survey	NHTSA	0	300	NA	0.42	0.42	NA	154	
Special Crash Investigations	NHTSA	315	331	NA	1.00	1.00	NA	154	
Technology Transfer Programs	NHTSA	40	40	NA	NA	NA	NA	155	
National Security	MARAD	NA	200	NA	NA	NA	NA	155	
Transit Services Management Innovation	FTA	1,430	1,000	NA	NA	NA	NA	156	
Rural and Specialized Transportation	FTA	2,270	2,300	NA	NA	NA	NA	156	
Metropolitan / Rural Policy Development	FTA	650	1,000	NA	NA	NA	NA	157	
Planning and Project Development	FTA	1,900	1,200	NA	NA	NA	NA	158	
Human Resources	FTA	155	500	NA	NA	NA	NA	159	
National Transit Institute	FTA	3,000	3,000	NA	NA	NA	NA	159	[10]
Rural Transit Assistance Program	FTA	5,200	5,200	NA	NA	NA	NA	160	

		Funding			FTE				
Title	Admin.	FY 1996	FY 1997	FY 1998	FY 1996	FY 1997	FY 1998	Page	Notes
Section III. Chapter 6: System Assessment (continued)									
Research and Technology	RSPA	3,257	7,488	NA	NA	NA	NA	160	[7]
Regulatory and Economic Policy Research	OST							161	[18]
International and Aviation Policy Research	OST							162	[18]
Bureau of Transportation Statistics	BTS							163	[8]
Section III. Chapter 7: University Research. Coop. Initiatives									
University Transportation Centers	FHWA/FTA	11,247	12,000	NA	NA	NA	NA	169	[9], [10]
University Research Institutes	FHWA	5,466	6,250	NA	NA	NA	NA	170	[10]
Transit Cooperative Research Program	FTA	8,250	8,250	NA	NA	NA	NA	172	[10]
Eisenhower Transportation Fellowship Program	FHWA	2,000	2,000	NA	1.00	1.00	NA	173	[11]
State Planning & Research Program	FHWA	62,983	72,015	NA	NA	NA	NA	174	[11], [19]
Section III. Chapter 8: R&D Admin., R&D Facilities Rehab. & Maint.									
Administration	FHWA	9,275	9,275	NA	NA	NA	NA	177	[11]
Administration	NHTSA	18,022	10,983	NA	NA	NA	NA	177	[10]
Administration	FRA	1,695	2,189	NA	2.00	2.00	NA	177	[13]
Administration	MARAD	NA	242	NA	0.00	3.00	NA	177	[10]
Administration	FTA	2,164	2,130	NA	NA	NA	NA	177	[14]
Fairbank Building Renovation	FHWA	0	500	NA	0.20	0.25	NA	177	[11]
Truck Dynamic Test Facility	FHWA	713	0	NA	0.50	0.50	NA	178	[11]
Vehicle Research and Test Center	NHTSA	777	800	NA	NA	NA	NA	179	[13]
R&D Facilities	FRA	400	420	NA	1.00	1.00	NA	180	[11]

		Funding			FTE				
Title	Admin.	FY 1996	FY 1997	FY 1998	FY 1996	FY 1997	FY 1998	Page	Notes
Surface Transportation--Operating Administration Subtotals									
Subtotal -- FHWA	FHWA	444,357	612,384	NA	NA	NA	NA		
Subtotal -- NHTSA	NHTSA	55,290	72,210	NA	NA	NA	NA		
Subtotal -- FRA	FRA	48,266	51,091	NA	NA	NA	NA		
Subtotal -- MARAD	MARAD	NA	2,006	NA	NA	NA	NA		
Subtotal -- FTA	FTA	45,914	45,880	NA	NA	NA	NA		
Subtotal -- RSPA	RSPA	7,008	10,861	NA	NA	NA	NA		
Total Surface Transportation R&D Funding Requirements		600,835	794,432						[16]

Notes

1. *includes $8,308k in FY 1996 funding for the Long-Term Pavement Performance Program*
2. *funded in part through ISTEA*
3. *A portion is classified as Physical Infrastructure activity ($1,728k in FY 1996).*
4. *A portion is classified as Physical Infrastructure activity ($7,750k and $3,000k in FY96 and FY97, respectively).*
5. *funded under Motor Carrier Program (Sec. III, Ch. 4)*

6. reflects replacement of ISTEA funds for TRANSIMS
7. A portion of this funding is for Information Infrastructure activity ($200k in FY 1997).
8. not funded as R&D
9. includes FHWA ($5,247 in FY 96, $6,000k in FY 97) and FTA ($6,000 in FY 96 and FY 97) funding
10. considered a System Assessment activity
11. considered a Physical Infrastructure activity
12. FTE to administer FHWA's Applied Research & Technology Program are located in various FHWA offices.
13. considered a Next-Generation Vehicles Activity
14. considered a Human-Centered Transportation Activity
15. includes $4,000k in FY 1997 FHWA funding
16. total R&D funding requirements for FHWA, NHTSA, FRA, MARAD, FTA, and RSPA
17. "NA" = not available at time of publication
18. Within the context of this report, funding and staffing for this activity are not considered "surface transportation".
19. This funding represents a 2.0% set-aside of State Federal-highway apportionments.
20. in FY 97, supplemented by a $1,420k trust fund carryover, for a total FY 97 project funding level of $27,946k

APPENDIX B. LIST OF ACRONYMS

A.

AAA	=	American Automobile Association
AASHTO	=	American Association of State Highway and Transportation Officials
ABS	=	Antilock Braking System
ADA	=	Americans with Disabilities Act of 1990
AHS	=	Automated Highway System
ARPA	=	Advanced Research Project Agency
ATMS	=	Advanced Traffic Management System
ATP	=	Advanced Technology Program
AVI	=	Automatic Vehicle Identification
AVL	=	Automatic Vehicle Location

B.

BART	=	Bay Area Rapid Transit
BTS	=	Bureau of Transportation Statistics

C.

CAD	=	Computer-Aided Design
CAAA	=	Clean Air Act Amendments
CADRE	=	Critical Automated Data Reporting Elements
CALTRANS	=	California Department of Transportation
CBD	=	Commerce Business Daily
CDROM	=	Compact Disc-Read Only Memory
CDS	=	Crashworthiness Data System
CFR	=	Code of Federal Regulations
CTPP	=	Census Transportation Planning Package
CVO	=	Commercial Vehicle Operations

D.

DOC	=	Department of Commerce
DOD	=	Department of Defense
DOE	=	Department of Energy
DOJ	=	Department of Justice
DOT	=	Department of Transportation

E.

ECDIS	=	Electronic Chart Display Information System
EPA	=	Environmental Protection Agency
ETMM	=	Electronic Toll and Traffic Management

F.

FAA	=	Federal Aviation Administration
FAR	=	Federal Acquisition Regulation
FARS	=	Fatal Accident Reporting System
FEMA	=	Federal Emergency Management Agency
FHWA	=	Federal Highway Administration
FRA	=	Federal Railroad Administration
FRP	=	Federal Radionavigation Plan
FTA	=	Federal Transit Administration
FTE	=	Full-time equivalent
FY	=	Fiscal year

G.

GAO	=	General Accounting Office
GES	=	General Estimates System
GIS	=	Geographic Information Systems
GPRA	=	Government Performance and Results Act
GPS	=	Global Positioning System

H.

HHS	=	Department of Health and Human Services
HPMS	=	Highway Performance Monitoring System
HSGT	=	High Speed Ground Transportation
HSR	=	High Speed Rail
HSRC	=	Highway Seismic Research Council

I.

IITF	=	Information Infrastructure Task Force
IMO	=	International Maritime Organization
ISTEA	=	Intermodal Surface Transportation Efficiency Act
ITS	=	Intelligent Transportation System *(formerly IVHS)*
IVHS	=	Intelligent Vehicle Highway System

L.

LCV	=	Longer Combination Vehicles
LTPP	=	Long-Term Pavement Performance

M.

MARAD	=	Maritime Administration
MDP	=	Moving Deformable Barriers
MPO	=	Metropolitan Planning Organization

N.

NAC	=	National Automotive Center
NADS	=	National Advanced Driving Simulator
NASA	=	National Aeronautics and Space Administration
NASS	=	National Accident Sampling System
NAFTA	=	North American Free Trade Agreement
NCEER	=	National Center for Earthquake Engineering Research
NCHRP	=	National Cooperative Highway Research Program
NDE	=	Non-Destructive Engineering
NHS	=	National Highway System
NHTSA	=	National Highway Traffic Safety Administration
NHS	=	National Highway System
NII	=	National Information Infrastructure
NIST	=	National Institute of Standards and Technology
NOAA	=	National Oceanic and Atmospheric Administration
NSC	=	National Security Council
NSF	=	National Science Foundations
NSTC	=	National Science and Technology Council

O.

OMB	=	Office of Management and Budget
OMC	=	Office of Motor Carriers
OST	=	Office of the Secretary of Transportation
OSTP	=	Office of Science and Technology Policy

P.

PAR	=	Police Accident Report
PRS	=	Performance-Related Specifications
PNGV	=	Partnership for a New Generation of Vehicles

R.

R&D	=	Research and Development
R&T	=	Research and Technology
RFI	=	Request for Information
ROW	=	Right-of-Way
RSPA	=	Research and Special Programs Administration

S.

SAE	=	Society of Automotive Engineers
SBA	=	Small Business Administration
SBIR	=	Small Business Innovation Research
SHRP	=	Strategic Highway Research Program
SP&R	=	State Planning and Research

T.

TCRP	=	Transit Cooperative Research Program
TPR	=	Transit Planning and Research
TRB	=	Transportation Research Board
TRP	=	Technology Reinvestment Project
TTC	=	Transportation Test Center

U.

USC	=	United States Code
USCG	=	United States Coast Guard
USGS	=	United States Geological Survey
UTC	=	University Transportation Centers

V.

VMT	=	Vehicle Miles Travelled
VME	=	Vehicle Motion Environment
VNTSC	=	Volpe National Transportation Systems Center
VTS	=	Vessel Traffic System

W.

WWW	=	World Wide Web

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