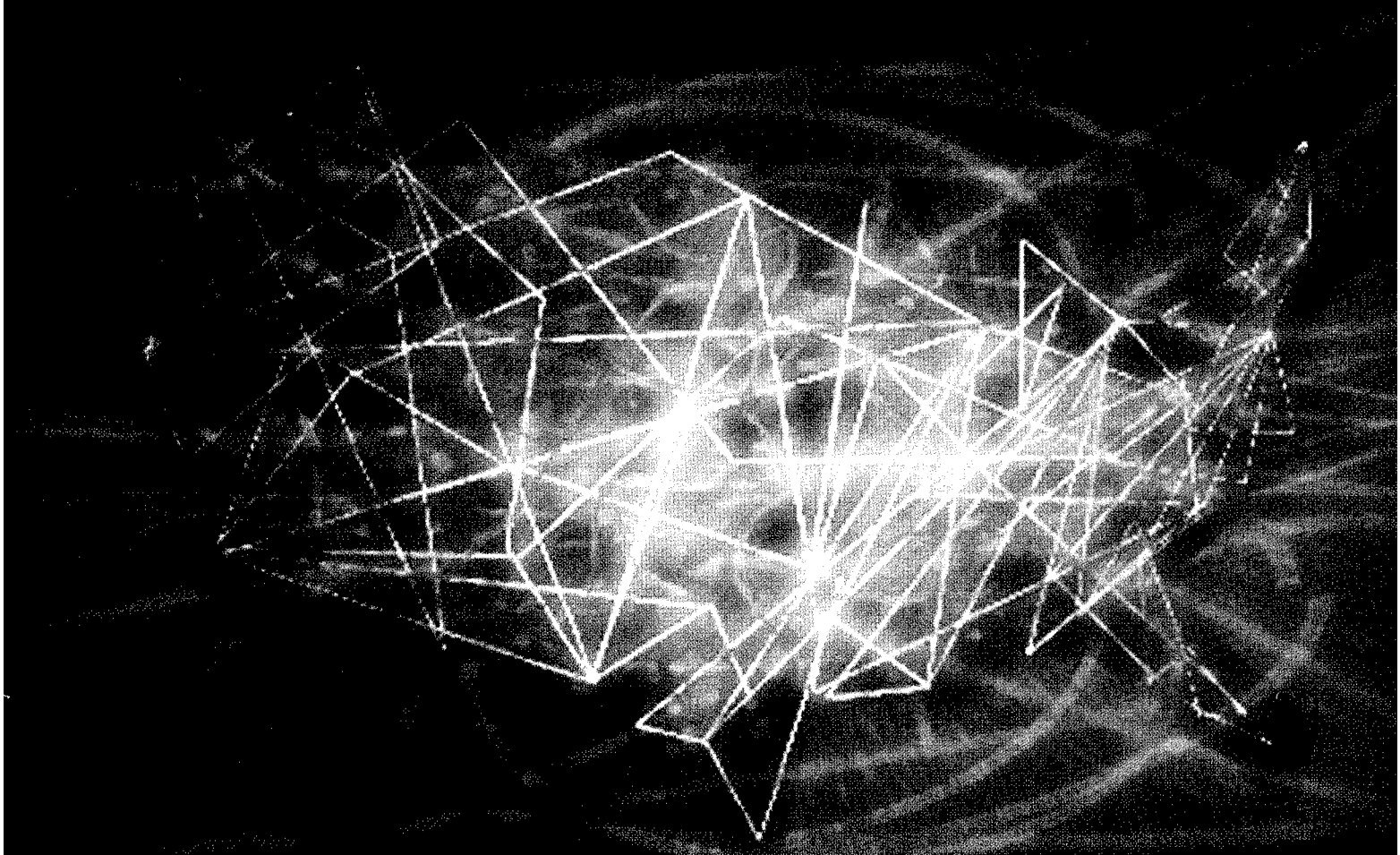
PB99-151383

National Transportation Science and Technology Strategy

National Science and Technology Council



REPRODUCED BY: NTIS
U.S. Department of Commerce
National Technical Information Service
Springfield, Virginia 22161

Committee on Technology

Subcommittee on Transportation Research and Development

About the National Science and Technology Council

President Clinton established the National Science and Technology Council (NSTC) by Executive Order on November 23, 1993. This cabinet-level council is the principal means for the President to coordinate science, space and technology policies across the Federal Government. NSTC acts as a "virtual" agency for science and technology (S&T). The President chairs the NSTC. Membership consists of the Vice President, Assistant to the President for Science and Technology, Cabinet Secretaries and Agency Heads with significant S&T responsibilities, and other White House officials.

Through the NSTC, Federal departments and agencies work cooperatively to ensure that Federal science and technology investments support national goals. NSTC Committees prepare R&D strategies that are coordinated across the Federal Government to form a comprehensive investment package.

Call 202-456-6100 to obtain additional information regarding the NSTC.

About the Office of Science and Technology Policy

The Office of Science and Technology Policy (OSTP) was established by the National Science and Technology Policy, Organization and Priorities Act of 1976. OSTP's responsibilities include advising the President in policy formulation and budget development on all questions in which S&T are important elements; articulating the President's S&T policies and programs; and fostering strong partnerships among Federal, State and local governments, and the scientific communities in industry and academe. The Director of OSTP also serves as Assistant to the President for Science and Technology, and manages the NSTC for the President.

Call 202-395-7347 to obtain additional information regarding the OSTP or see our web site at:

http://www.whitehouse.gov/WH/EOP/OSTP/html/OSTP_Home.html

DISCLAIMER

This document contains

tone-on-tone or color

graphs, charts and/or pictures

which have been reproduced in

black and white.

NATIONAL SCIENCE AND TECHNOLOGY COUNCIL

NATIONAL TRANSPORTATION SCIENCE AND TECHNOLOGY STRATEGY

Committee on Technology
Subcommittee on Transportation Research and Development

April 1999

This document is available on the World Wide Web at http://scitech.dot.gov

PROTECTED UNDER INTERNATIONAL COPYRIGHT
ALL RIGHTS RESERVED.
NATIONAL TECHNICAL INFORMATION SERVICE
U.S. DEPARTMENT OF COMMERCE

The purpose of this report is to help Congress and the Administration establish national transportation research and technology priorities and coordinated research activities. The report is intended to provide a planning framework for Federal, State, and local governments; academia; and industry in supporting national transportation goals. It also conveys to the science and technology community the types of research and research priorities being sponsored and considered by Federal agencies. The Administration is committed to a broad range of high-priority investments (including science and technology); to deficit reduction; and to a smaller, more efficient Federal Government. These commitments have created a very challenging budget environment – requiring difficult decisions and a well-thought-out strategy to ensure the best return for the Nation's taxpayers. As part of this strategy, this document does not represent the final determinant in an overall Administration budget decision-making process. The research programs presented in this report will have to compete for resources against many other high-priority Federal programs. If these programs compete successfully, they will be reflected in future Administration budgets.

THE WHITE HOUSE

WASHINGTON

Dear Colleague:

In 1997 the National Science and Technology Council (NSTC) released the first *Transportation Science and Technology Strategy* to provide a strategic planning process and framework for establishing national transportation research and development (R&D) priorities. This landmark document set forth an integrated set of directions for Federal transportation R&D, including strategic planning and assessment, private–public partnerships, enabling research, and education and training.

This *National Transportation Science and Technology Strategy* broadens these elements and incorporates an even greater role for the larger transportation community. Developed in close collaboration with State, local, and tribal agencies; academic institutions; and industry, this *Strategy* identifies both national goals and desired outcomes for transportation system safety, mobility and access, economic growth, the environment, and national security.

As our Nation enters the next century, science and technology will be critical to meeting the challenges created by our growing transportation activities. This *National Strategy*'s ultimate goal is to bring together all partners in the transportation enterprise—Federal, State, local, and tribal agencies; academic institutions; and the private sector—to ensure the safe, efficient, sustainable, and secure transportation system that America needs.

Sincerely,

Neal Lane

Neal Lane
Assistant to the President
for Science and Technology

Preface

History has given our generation the assignment of forging America's next great transition. As a Nation we are leaving behind the factory for the electronic marketplace, and will participate in an integrated global economy that will dominate the next Millennium. Transportation will play a key role in the functioning of that global economy and in the lives of all the citizens who will benefit from it.

President Clinton has been very clear about the role technological innovation plays in creating such economic success. He is on record as saying that "investing in technology is investing in America's future" and has promoted research and technology development activities throughout the Federal Government to create that future. The President's technology policy creates a new conceptual architecture which will move us from strength to strength as we create the safe, efficient, accessible, and convenient transportation system this Nation needs for the 21st century.

This *National Transportation Science and Technology Strategy* builds on the Federal Government's first science and technology strategy for its transportation research, issued in September 1997 by President Clinton's National Science and Technology Council. That document focused on Federal transportation research and identified key partnerships, enabling research, and educational activities to put transportation users first, and meet their developing needs. The current document goes beyond Federal Government activities and sets forth challenges for the entire transportation and technology community – Federal, State, local and tribal governments, industry, academia, labor, and professional associations – to address.

To assure our future prosperity we must create a 21st century transportation system that is efficient and supports economic growth while still being safe, secure, and environmentally friendly. We can reconcile these apparently conflicting goals if we are both visionary and vigilant; visionary about what is possible and vigilant about seizing the means to realize those possibilities. Programs and activities like those described in this *National Strategy* will go far in helping us transform our quality of life, our Nation, and our world.

Rodney E. Slater
U.S. Secretary of Transportation

NSTC Committee on Technology
Subcommittee on Transportation R&D

Chair:	
Mr. Mortimer L. Downey	Deputy Secretary, U.S. Department of Transportation
Vice-Chair:	
Mr. Spence M. "Sam" Armstrong	Associate Administrator for Aeronautics and Space Transportation Technology, National Aeronautics and Space Administration
White House Co-Chair:	
Dr. Duncan T. Moore	Associate Director for Technology, Office of Science and Technology Policy, Executive Office of the President
Executive Director:	
Dr. E. Fenton Carey	Associate Administrator for Research, Technology, and Analysis, Research and Special Programs Administration, U.S. Department of Transportation
Members:	
Mr. Gary Bachula	Acting Under Secretary for Technology, Technology Administration, U.S. Department of Commerce
Mr. Peter "Jack" Basso	Assistant Secretary for Budget and Programs, U.S. Department of Transportation
Mr. Thomas D. Collinsworth	Director, Military Traffic Management Command, Transportation Engineering Agency, U.S. Department of Defense
Mr. Eugene A. Conti, Jr.	Assistant Secretary for Transportation Policy, U.S. Department of Transportation
Mr. Michael Deich	Associate Director for General Government and Finance, Office of Management and Budget
Mr. David M. Gardiner	Assistant Administrator for Policy, Environmental Protection Agency
Mr. Thomas J. Gross	Deputy Assistant Secretary for Transportation Technologies, Energy Efficiency, and Renewable Energy, U.S. Department of Energy
Dr. Elbert L. Marsh	Deputy Assistant Director for Engineering, National Science Foundation
Consultant:	
Dr. Richard R. John	Director, Volpe National Transportation Systems Center, U.S. Department of Transportation
Ad Hoc Members:	
Ms. Kelley S. Coyner	Administrator, Research and Special Programs Administration
Ms. Jane F. Garvey	Administrator, Federal Aviation Administration
Mr. Clyde J. Hart, Jr.	Administrator, Maritime Administration
Mr. Gordon J. Linton	Administrator, Federal Transit Administration
Adm. James M. Loy	Commandant, United States Coast Guard
Dr. Ricardo Martinez	Administrator, National Highway Traffic Safety Administration
Ms. Jolene M. Molitoris	Administrator, Federal Railroad Administration
Dr. Ashish Sen	Director, Bureau of Transportation Statistics
Mr. Kenneth R. Wykle	Administrator, Federal Highway Administration

Table of Contents

Figures and Tables

Executive Summary

The National Science and Technology Council (NSTC) developed the first *Transportation Science and Technology Strategy* in 1997 to help Congress and the Administration establish national transportation research and technology priorities and coordinated research activities. Building upon this effort, this *National Transportation Science and Technology Strategy* broadens these elements and incorporates an even greater role for the larger transportation enterprise. It addresses key issues raised by the National Research Council's Transportation Research Board Study Committee on the Federal Transportation Research and Development (R&D) Strategic Planning Process. Moreover, it incorporates the views of State and local agencies, academic institutions, and industry, particularly those expressed at a May 27-28 meeting in Chicago on "Developing a National Transportation Science and Technology Strategy."

Like its predecessor, the current *Strategy* identifies a set of strategic goals and outcomes for safety, mobility and access, economic growth, the environment, and security based upon an assessment of transportation in 2025. These goals reflect efforts of the Administration and the National Research Council to identify goals and measures for transportation research, and are in agreement with the Department of Transportation's *Strategic Plan 1997-2002.*

This *Strategy* is not a description of all transportation research, nor is it a strategic plan. Rather, it provides a direction and a framework for transportation R&D in America. This national *Strategy* encompasses the earlier strategy's four-tiered approach: (1) strategic planning and assessment; (2) private-public technology partnerships; (3) enabling research; and (4) education and training. However, the current *Strategy* broadens the transportation community's involvement by (1) incorporating a greater role for State, local, and tribal agencies; academic institutions; and the private sector in the strategic planning and assessment process; (2) expanding the scope of several of the partnerships, clarifying their objectives, and adding two new partnerships; (3) establishing priorities within the enabling research areas and adding one additional area; and (4) augmenting the education and training initiatives.

STRATEGIC PLANNING AND ASSESSMENT

The institutionalization of an ongoing process for transportation strategic planning and system assessment enables policy makers and implementers at all levels to adjust the allocation of scarce resources to meet

changing requirements. Involving the establishment of a broad consensus within the larger transportation community, this process will:

- Establish and assess strategic research priorities in light of national goals in a changing external environment, ensuring that transportation R&D is defined from a long-term system perspective.
- Identify private-public technology partnerships that support strategic transportation goals in order to accelerate the deployment of research into application.
- Define a long-term enabling research agenda that supports future national goals and fosters the transportation breakthroughs of the next century.
- Develop education and training initiatives that ensure a capable and well-trained 21st century transportation work force.
- Within each area, establish meaningful, quantifiable "stretch" goals to assess the impact of research and technology investments on system performance and on the achievement of transportation goals over the next several decades.

PRIVATE-PUBLIC TECHNOLOGY PARTNERSHIPS

A critical element of this *Strategy* is the identification and elaboration of private-public partnerships in transportation technology. The previous strategy incorporated twelve partnerships that support one or more of the strategic transportation goals and that address recognized national needs, have a technology focus, could rely on the private sector for implementation, and require some Federal involvement.[1] Rather than formal research programs, the partnerships represent broad-based collaborative efforts in key technology areas. These efforts vary in terms of their scope and maturity: while some represent well-established R&D activities, others require further definition and coordination. Currently, the NSTC and its member agencies are defining the partnerships and broadening the participation of State, local, and tribal authorities; nongovernmental organizations; private companies; universities; trade and industry associations; and professional societies. Following the advice of this broader community, this national *Strategy* combines two partnerships identified in the previous version, both of which address sustainability; adds new partnerships on maritime safety and space transportation; and renames the partnerships for "smart" and next generation vehicles and for transportation security. The thirteen private-public technology partnerships are:

Aviation Safety Research Alliance

Next Generation Global Air Transportation

Next Generation Transportation Vehicles

National Intelligent Transportation Infrastructure

Intelligent Vehicle Initiative

[1] Although the *Strategy*'s focus is on science and technology, the NSTC recognizes that in many cases non-technological approaches may be equally beneficial to implement.

Transportation and Sustainable Communities

Transportation Infrastructure Assurance

Enhanced Goods and Freight Movement at Domestic and International Gateways

Monitoring, Maintenance, and Rapid Renewal of the Physical Infrastructure

Maritime Safety Research Alliance

Space Transportation Technologies

Accessibility for Aging and Transportation-Disadvantaged Populations

Enhanced Transportation Weather Services

ENABLING RESEARCH

Enabling research will make possible the next century's transportation breakthroughs and innovations. This *Strategy* includes six long-term research areas identified in the previous strategy, as well as one additional area, and indicates priorities within each. All of these areas support national goals, have rewards that are too widely spread for any one company to recover its investment and costs too great for one company to bear, and have benefits that are too far in the future to meet private investment criteria. Listed below along with their priorities, these research areas also have the potential to advance technology and performance both within individual transportation modes and across all modes.

Human Performance and Behavior: Priority Areas – Advanced Instructional Technology; Enhanced Alertness and Work Readiness; Humans and Automated Systems.

Advanced Materials: Priority Areas – Advanced Infrastructure Materials; Materials for Transportation Vehicles; and Advanced Manufacturing and Construction.

Computer, Information, and Communication Systems: Priority Areas – Spectrum Allocation; Global Positioning System Issues and Applications; Software Assurance and High-Confidence Systems.

Energy, Propulsion, and Environmental Engineering: Priority Areas – Advanced Energy Storage and Conversion; Alternative Transportation Fuels.

Sensing and Measurement: Priority Areas – Smart Structures and Vehicles; Micro/Nano Devices.

Tools for Transportation Modeling, Design, and Construction: Priority Areas – Transportation System Design Tools; Modeling and Simulation of System Performance and Impacts; Transportation and Logistic System Operations and Management.

Social and Economic Policy Issues: Priority Areas – Transportation Planning, Economics, and Institutions; Social Impacts of Transportation Systems and Operations; Transportation Trends and Projections.

TRANSPORTATION EDUCATION AND TRAINING

The Nation's investment in science and technology is critical to the transportation system's safety, efficiency, and capacity to support national goals. Equally important, however, is our continuing investment in human capital – the professionals and workers responsible for the planning, design, construction, operation, and maintenance of the transportation system and the educators and institutions that train them.

Significant changes in transportation demand a new emphasis on the evolving needs of the transportation work force. Under the Garrett A. Morgan Technology and Transportation Futures Program, the Department of Transportation is working closely with the Departments of Education and Labor; its partners in industry; State, local, and tribal governments; labor unions; professional organizations; and schools and universities to ensure that the next century's work force is equipped with the training and skills it needs. This *Strategy* defines four education and training components that support the broad goals of the Garrett A. Morgan program and that create awareness of transportation benefits and costs, build the professional capacity of industry and State/local transportation agencies, ensure a globally competitive work force, and prepare the next generation of transportation professionals with a multidisciplinary education:

Introduction of Transportation Concepts: Elementary and Secondary Education

Vocational and Technical Training

Transportation Degree Programs: International and Multidisciplinary

Mid-Career Transportation Training

This document is available on the World Wide Web at:

http://scitech.dot.gov

1 Vision and Mission for Transportation Science and Technology

Science and technology are vital to America's national interests. As stated in the National Science and Technology Council (NSTC) report, *Technology in the National Interest:* "Our ability to harness the power and promise of leading-edge advances in technology will determine, in large measure, our national prosperity, security, and global influence, and with them the standard of living and quality of life of our people."

Science and technology are particularly essential to our transportation system – today and in the future. America's transportation system comprises a vast network of highways, transit systems, railroads, waterways, airports, airways, seaports, pipelines, and information systems that safely and efficiently move people, goods, and ideas across the country and around the world. Comprising 11 percent of our Gross Domestic Product, transportation is critical to our national defense, our competitiveness in the world market, and our quality of life.

As the Nation enters the next century, science and technology will be critical to meeting the challenges created by our growing transportation activities. Transportation accounts for a third of U.S. greenhouse gas emissions. Congestion takes its toll in lost productivity, costing the Nation billions of dollars a year. About 42,000 people die in highway crashes each year, including more than 5,000 pedestrians. While flying is the safest of all major modes of transportation, continued growth in air traffic may lead to a dramatic increase in aviation accidents. Finally, though our transportation system is one of the safest and most extensive in the world, it is unable to provide optimal mobility for the elderly, the physically challenged, and the poor.

The goal for transportation science and technology is to meet these challenges by providing the innovations that will enable us to balance the sometimes competing values of safety, mobility and access, economic growth, environmental quality, and national security. Through science and technology, America can achieve a transportation system that is fast, safe, efficient, accessible, and convenient.

Developed by the Federal Government in close cooperation with States, local governments, industry, and academic institutions, this *National Transportation Science and Technology Strategy* provides a strategic planning process and framework for establishing national transportation research and development (R&D) priorities, including private-public partnerships, enabling research, and education and training. Like its predecessor published in 1997, this national *Strategy* supports the

Administration's strategic goals and vision for transportation science and technology:

> *A safe, efficient, sustainable, and secure transportation system that is international in reach, intermodal in form, intelligent in character, and inclusive in nature.*

This *Strategy* does not encompass all transportation research and development, nor is it a strategic plan for R&D. As the figure below shows, specific information on *Strategy* implementation is presented in a number of supporting documents:

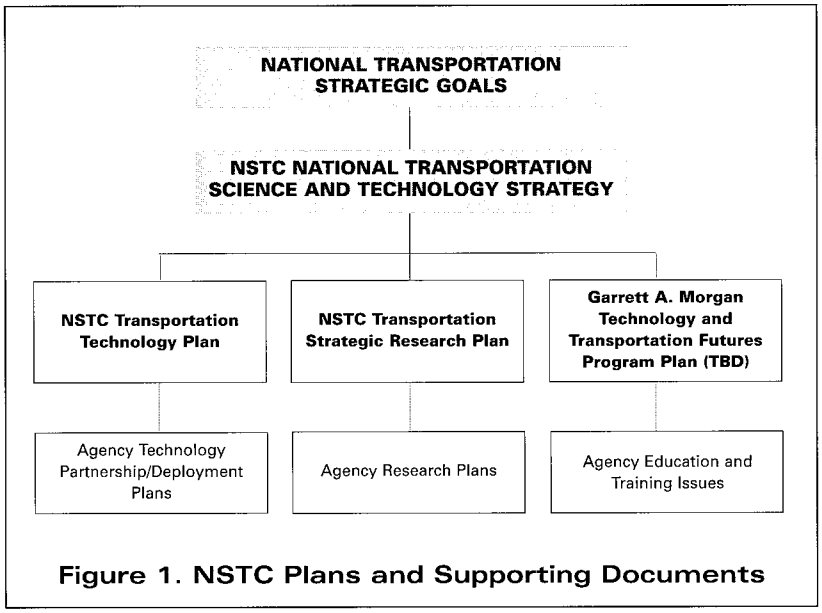


Figure 1. NSTC Plans and Supporting Documents

The transportation system envisioned in this *Strategy* can be achieved only through a strengthened partnership between the Federal Government and its State, local, tribal, academic, and private-sector partners. This *Strategy*'s ultimate goal is to build the partnerships, focus the research, and develop the informed and educated population that America needs to sustain its economic growth, ensure its national security, and enhance its quality of life through transportation in the 21st century.

2 Challenges for Transportation in 2025

Worldwide, a number of forces are converging to shape the direction of transportation over the next two decades. Understanding these global changes is critical to formulating a vision and goals for transportation in America and developing a *National Transportation Science and Technology Strategy*. Key among these changes are significant shifts in demographics, economic growth and globalization, growing urbanization and motorization, increasing concerns for safety and security, and changing technological trends. These worldwide issues will have a significant impact on America's transportation system and will present U.S. transportation decision makers with a dilemma: how to meet the increased demand for transportation while also addressing the sometimes conflicting values of safety, security, economic productivity, environmental quality, energy efficiency, and accessibility.

In the past, changing transportation needs have typically been met through innovations in three areas: (1) transportation vehicles; (2) the physical infrastructure that supports their use; and (3) the people who plan, design, build, operate, use, and maintain the vehicles and infrastructure and who plan and manage the transportation enterprise. More and more, the burgeoning demands on the transportation system will be met through a fourth means: the development and deployment of an information infrastructure that underlies and will integrate these three areas. In fact, one component of any strategy to meet transportation needs will be the stimulation of alternatives to physical travel, where such a substitution is appropriate and effective.

Each of the four areas of innovation will be key to meeting the issues and trends discussed below and are the foundation for the planning process, partnerships, enabling research, and education and training efforts that compose this national *Strategy*.

CHANGING DEMOGRAPHICS

Two major changes will influence the scope and character of world transportation demand in the 21st century: population growth in the developing world and the aging of the population in the industrialized world. As shown in Figure 2, world population is projected to grow to nearly 8.5 billion people by 2025. By far, most of this growth will be in cities, many of them in the developing world. The increased demand for transportation for this growing population will require the expansion of existing infrastructure and new transportation alternatives, presenting both opportunities for U.S. industries and challenges for transportation research and technology.

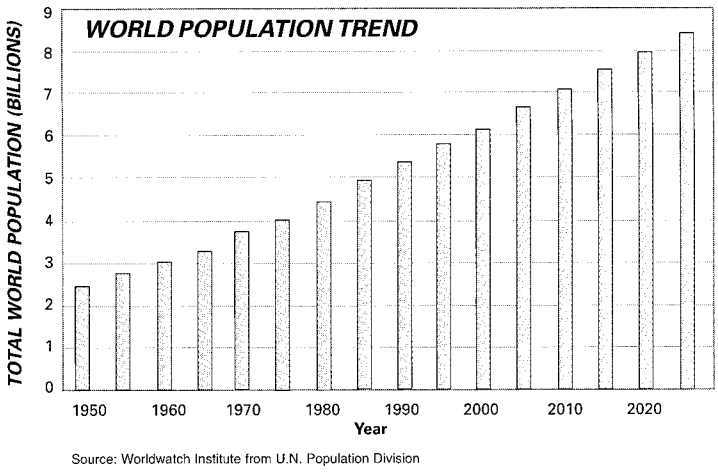


Figure 2. Growth in World Population

While industrialized countries' populations will stabilize and perhaps even decline, there will be further aging of these populations. Today, over 12 percent of the United States' and 14 percent of Europe's population is over 65. By 2025, more than 20 percent of the population in the industrialized world will be this age. The United States alone will experience far greater growth in its elder population: an estimated 53 million people will be over 65 in the United States by 2025. The fastest growing cohort will be those 85 and older. Ensuring mobility for many of these elders will require changes in transportation vehicles and infrastructure, as well as new forms of transit for those who are no longer able to drive.

ECONOMIC GROWTH AND GLOBALIZATION

Although there continues to be incredible poverty throughout the world, gross world product is steadily increasing in many countries, as shown in Figure 3. Even with the recent economic downturns in Russia, Latin America, and the Pacific Rim, more people have more disposable income, after paying for food, shelter, and other necessities, than in any other period in history. Combined with the influence of the mass media and telecommunications, this income has created a booming international travel and tourism market for U.S. companies. Should this trend continue, tourism will account for an even larger share of transportation demand, straining the capacity of many nations' transportation infrastructures and exacerbating needs for new capacity-enhancing technologies.

Even more significant will be the increases in international goods movement. Low-cost communication and transportation networks have already resulted in a global manufacturing and marketing enterprise.

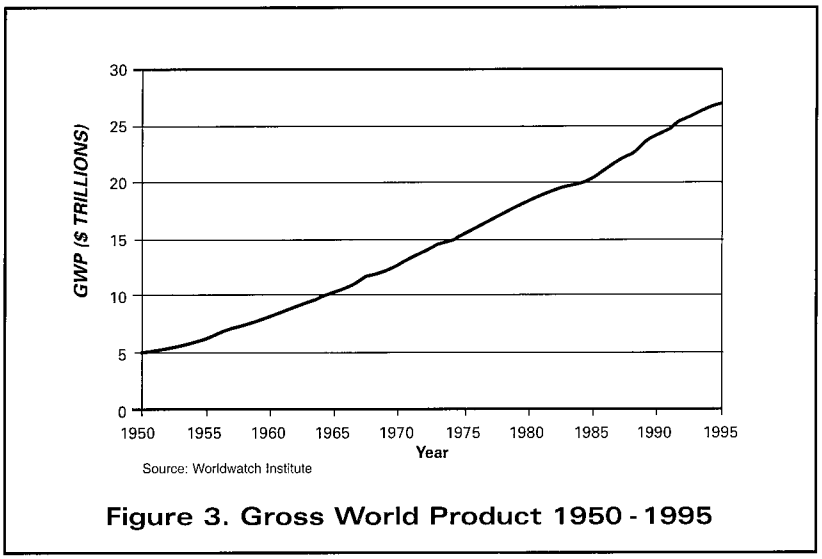


Figure 3. Gross World Product 1950 - 1995

Today, globalization is being furthered by the movement of manufacturing to industrializing nations and the "out-sourcing" of sub-component and parts production. This interdependent world economy will increase the demand for freight transportation facilities and place increasingly stringent cost and reliability requirements on freight transportation networks. Coupled with this, use of information networks for "virtual" conduct of business may reduce demands for some kinds of personal travel, while simultaneously increasing demands for other kinds of passenger and freight services.

URBANIZATION AND MOTORIZATION

About 45 percent of the world's population currently live in urban areas. By 2025, more than 60 percent of the projected 8.5 billion people in the world will be living in cities – many of them in megacities with populations of 10 million or more. Together with economic development, growth in the world's urban areas has led to a dramatic increase in the number of motor vehicles. As Figure 4 shows, in 1960 there were about 127 million vehicles registered in the world; by 1995 the world had 647 million vehicles. Some experts argue that the global fleet has been growing linearly since 1970, with each year bringing an additional 16 million vehicles worldwide. With this growth has come an increase in environmental and energy impacts – carbon emissions, petroleum consumption, air pollution, and congestion – and a need for cleaner, more efficient transportation vehicles and systems.

In the United States, the suburban sprawl made possible by current transportation systems has led to spatial disparities in the locations of employment centers and concentrations of urban poor – many of whom are required to find work under welfare reform. Today, nearly 70 percent of all U.S. jobs are in the suburbs. Other negative effects of our

sprawling metropolitan areas include the ruination of wetlands, habitat loss, contaminated runoff and the resulting groundwater pollution, loss of farmland, and increased vehicle emissions. Such impacts require a new emphasis on how "sustainable" transportation and land use can help to balance goals for economic growth, environmental quality, and social equity.

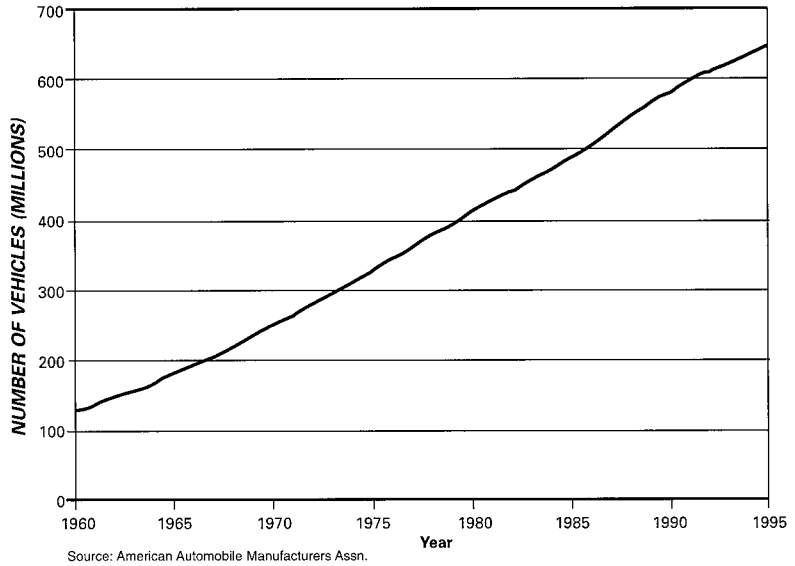


Figure 4. World Motor Vehicle Registrations

SAFETY AND SECURITY OF THE TRANSPORTATION SYSTEM

Over the next two decades, continued growth in world transportation demand will lead to heightened concerns for transportation safety and security. For example, along with growth in automobile use will come the potential for a dramatic increase in automobile-related deaths and injuries. This is particularly true for many countries in the developing world, where the number of motor vehicles is growing far faster than the physical, legal, and institutional infrastructures needed to accommodate them. Even in the United States and other industrialized countries, where safety records are typically good by historical standards, the private automobile will continue to present safety risks, requiring an emphasis on "intelligent" vehicles that may help drivers to avoid crashes. Another concern is the increased risk of injury for the growing number of "frail" elderly drivers and pedestrians.

Still other concerns will arise from the growth of air transportation and its increasing use for international travel. Greater demand for air travel will place additional stress on an already overburdened aviation sys-

tem. Countries will seek to accommodate demand by moving toward "free flight" – a dynamic air traffic management concept that allows pilots to choose their own routes, altitudes, and speeds in real time – and a global infrastructure for air traffic management. Questions may arise concerning the reliance of air systems on satellite and digital technologies, the increasing dependence on complex software-based aids and systems, the need for global standards and interoperability, and the security of such systems from "cyber-terrorism." Moreover, the attractiveness of aviation and other modes as a terrorist target will necessitate an integrated, systemwide approach to transportation security.

TECHNOLOGICAL TRENDS

One clear reality of the late 20th century is the power of technology and the advances that can be achieved when it is applied in the right way, to the right problems, at the right time, and in concert with more effective institutional relationships and a better understanding of the social forces that shape travel behavior, land use, and transportation needs.

The magnitude and pace of improvements in the next century will depend on the investment of energy, imagination, and public and private resources made at the close of the 20th century. By 2025, advances in computer, information, and communications technologies will have dramatically changed ways of organizing and managing transportation and business activities. With an evolved information infrastructure in place, alternatives such as telecommuting, video teleconferencing, remote shopping, banking, and research by computer will become serious alternatives to trip-making.

When trips are necessary, there will be an increasing number of potential alternatives for various transportation functions, each offering real benefits. The transportation vehicles manufactured 25 years hence can be expected to offer dramatic advances in sustainability, performance, and cost, based on refinement and innovation affecting almost every component. The Administration's Partnership for a New Generation of Vehicles (PNGV), for example, will yield significant improvements leading to lighter weight, lower cost materials, improved emission characteristics, and greatly lessened petroleum requirements. The logistics of freight movement also will be improved, as "mega-ships" are integrated into existing transportation systems and infrastructure.

In general, technological advances will be critical to ensuring that the overall transportation system is brought to its full potential in terms of life-cycle economics, energy efficiency, and minimal adverse societal impacts.

3 Strategic Goals and Outcomes

Based upon the assessment of the likely transportation scenario in 2025, and given the vision for transportation science and technology, this *Strategy* identifies a set of strategic goals and outcomes that encompass safety, mobility and access, economic growth and trade, the human and natural environment, and national security. These goals reflect efforts of the Administration and the National Research Council to identify strategic goals and measures for transportation research and are in agreement with the goals identified in the Department of Transportation's *Strategic Plan 1997-2002.* What follows is a discussion of the five major goals upon which this *Strategy* is based.

SAFETY

Strategic Goal: Safety

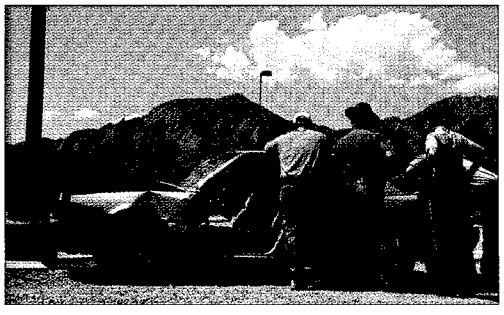
Promote the public health and safety by working toward the elimination of transportation-related deaths, injuries, and property damage.

Outcome Goals:

- Reduce the number of transportation-related deaths.
- Reduce the number and severity of transportation-related injuries.
- Reduce the rate of transportation-related fatalities per passenger-mile traveled and per ton-mile of total freight shipped (or vehicle-miles traveled).
- Reduce the rate and severity of transportation-related injuries per passenger-mile traveled and per ton-mile (or vehicle-miles traveled).
- Reduce the dollar loss from high-consequence, reportable transportation incidents.
- Reduce the number of reportable transportation incidents and their related economic costs.

A core transportation objective is to reduce deaths and injuries and to minimize the dangers associated with transportation. Worldwide, 250,000 people a year are killed in transportation accidents and over 10 million are injured. The fatality and injury rates in developing countries are three to four times those of the United States. As the number of motor vehicles in the developing world increases, world fatalities may reach 1 million per year, with 40 to 50 million injuries. Another consequence of transportation growth may be an increase in aviation accidents. Although the rate of these accidents is very low, it has been relatively constant over the past quarter century. Given this constant rate, continued growth in air travel could increase the occurrence of accidents to the point where the public no longer views aviation as a preferred mode of travel.

Today, about 42,000 people are killed each year on our Nation's highways in motor-vehicle-related crashes – including over 5,000 pedestrians – the equivalent of a DC-9 crashing and killing all of its occupants every day of the year. Many fatalities are caused by errors in driver judgment due to inadequate or untimely information necessary to avoid a collision.



Human error is the most pervasive fundamental problem and the greatest limitation to improving transportation safety and efficiency. Thus, a major focus of the transportation enterprise's research and technology activity is to understand the causes of, and determine the means to eliminate, human error as it relates to the safe operation of vehicles in all modes of transportation. This focus on crash avoidance will complement ongoing efforts in crashworthiness, which have proven extremely successful in reducing the severity and consequences of crash events.

MOBILITY AND ACCESS

Strategic Goal: Mobility and Access

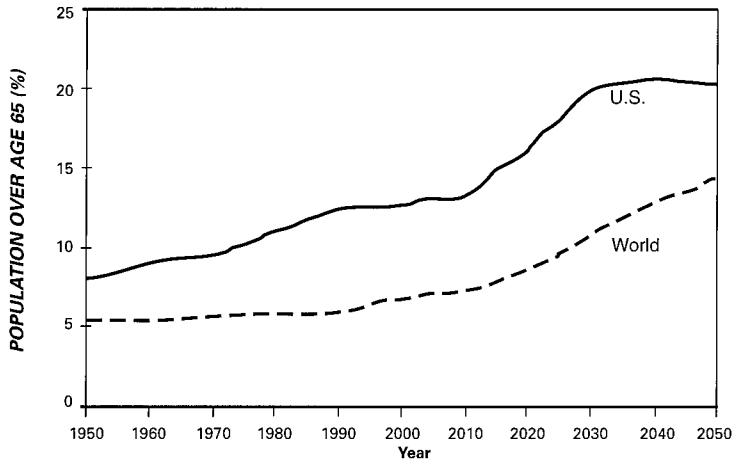
Shape America's future by ensuring a transportation system that is accessible, integrated, and efficient, and that offers flexibility of choices.

Outcome Goals:

- Improve the structural integrity of the transportation system.
- Balance new physical capacity with the operational efficiency of the Nation's transportation infrastructure.
- Increase intermodal physical, information, and service connectivity.
- Increase access to the transportation system for the movement of all people and freight.
- Provide preventive measures and expeditious response to natural and man-made disasters to ensure the rapid recovery of the transportation system.

As the United States competes successfully in world trade and our population changes, the increased demand for transportation puts pressure on the entire system. For example, the continued suburbanization and decentralization of population and employment centers has led to even greater dependence on motor vehicles, with resulting increases in road congestion. The application of logistics to production also puts pressure on the system, as more vehicles are needed to carry just-in-time inventories. Yet another challenge is to improve freight mobility to permit rural economic development and growth.

Among the transportation enterprise's primary missions is to help provide transportation to those who – because of age, disability, income, or personal preference – do not use an automobile. Estimates suggest that by 2025, 20 percent of the U.S. population will be over 65, as shown in Figure 5: the fastest growing group will be those least likely to have access to an automobile – those 85 and older. Those young or old with disabilities also have considerable mobility needs. Finally, welfare reform places renewed emphasis on the importance of mobility for those attempting to find and retain employment without an automobile.



Source: International Inst. for Applied Systems Analysis

Figure 5. The Aging of the U.S. and World Populations

The challenge will be to manage resources effectively – including preservation of the existing transportation infrastructure to provide mobility for all segments of the population and for the transport of U.S. goods and services.

ECONOMIC GROWTH AND TRADE

Strategic Goal: Economic Growth and Trade

Advance America's economic growth and competitiveness domestically and internationally through efficient and flexible transportation.

Outcome Goals:

- Reduce the real economic cost of transportation, taking into account changes in the efficiency and quality of transportation services.
- Ensure that improvements in transportation that advance America's economic growth and trade are done in a cost-effective manner consistent with the President's Executive Order on the cost-effectiveness of infrastructure investment.
- Reduce the average time for delivery of people, goods, and services to their destinations.
- Improve the reliability of the delivery of people, goods, and services to their destinations.
- Reduce trade barriers, support economic deregulation, and promote competition in domestic and international markets in transportation-related services.
- Improve the U.S. international competitive position by facilitating the export of domestic transportation goods and services.
- Accelerate desirable, sustainable, and cost-beneficial regional and local economic development through major transportation investments.
- Increase the education and public awareness of individuals in transportation-related fields.
- Increase the Nation's economic growth and trade through wise, cost-effective transportation investments.

International trade and tourism are areas of great significance to the world's economy, accounting for over one-tenth of the total global gross product.

Between 1994 and 2005, oceanborne trade is expected to increase at an average rate of 4.5 percent. Just-in-time goods movement – with the goal of minimum inventories – is increasing both the trips made by parts suppliers and final assemblers' deliveries to purchasers, creating the need for more efficient and reliable freight movement through urban and suburban centers. At the same time, the shift of manufacturing to the developing world and the increasing "out-sourcing" of component and parts production will necessitate increased freight movements during the manufacturing process itself.

Transportation decision makers at all levels will need to respond rapidly to demands for freight and passenger services. Yet, many officials are not aware of the significance of these issues to their regions' economies or of these activities' infrastructure and operational requirements. Officials will need better planning tools, information, and technologies if they are to consider the entire system in making major transportation decisions – including all modes and the connections among them, both locally and internationally, as well as alternatives to physical travel – and assess the impacts of such choices.

HUMAN AND NATURAL ENVIRONMENT

Strategic Goal: Human and Natural Environment

Protect and enhance communities and the natural environment affected by transportation.

Outcome Goals:

- Improve the sustainability and livability of communities through investments in transportation facilities.
- Reduce the amount of transportation-related pollutants and greenhouse gases released into the environment.
- Reduce the adverse effects of siting, construction, and operation of transportation facilities on the natural environment and communities, particularly disadvantaged communities.
- Improve the condition of our living marine resources.

One of the Nation's greatest transportation challenges will be to provide adequate capacity to meet demand in light of growing concerns about fossil fuel consumption, global warming, and urban air quality.

Current scenarios estimate that world demand for petroleum, by far the primary fuel source for transportation, could double by 2020 to as much as 150 million barrels a day. Fuel supplies to a nation could be disrupted over the short or long term by local conflicts or by natural disasters.

Moreover, as cities grow and the demand for transportation increases, the resulting growth places unsustainable pressure on land use, traffic congestion, and air and water quality. The emissions caused by petroleum consumption contribute to both human health problems and global climate change. Cars, trucks, and other vehicles are major sources of carbon monoxide and of volatile organic compounds and nitrogen oxides – precursors of ozone and acid rain. Highways have been blamed for erosive and contaminated runoff and ruination of wetlands. At the same time, communities have formed coalitions that vigorously protest the risks of hazardous materials transport, the damage to the environment from oil spills, and the adverse impacts of transportation noise. Because many hazardous-materials accidents and oil spills are

the result of human error, this goal is closely aligned with that for transportation safety.

NATIONAL SECURITY

Strategic Goal: National Security

Advance the Nation's vital security interests by ensuring that the transportation system is secure and available for defense mobility and that our borders are safe from illegal intrusion.

Outcome Goals:

- Reduce the vulnerability to and consequences of intentional harm to the transportation system and its users.
- Ensure readiness and capability of all modes of commercial transportation to meet national security needs.
- Ensure that transportation physical and information infrastructure and technology are adequate to facilitate military logistics during mobility, training exercises, and mobilization.
- Maintain readiness of resources necessary to support the President's National Security Strategy and other security-related plans.
- Reduce the flow of illegal drugs and of illegal aliens entering the United States.

An increasing number of terrorist threats, the growing dependence of transportation on petroleum and information technology, and the need to assure our defense mobility are key factors with the potential to compromise our national security.

In particular, the threat of hijacking and deliberate sabotage has become real and highly visible worldwide over the past few decades. In the aviation arena, for example, it is an enormous challenge to keep all weapons and explosive materials off an airplane carrying several hundred people and their highly varied luggage. At the same time, recent plots or actual attacks have been made against rail, subway, bus, and highway targets, both domestically and internationally.

Yet another potential security risk results from our continued reliance on foreign petroleum as a source for transportation fuel.

The security of transportation's information infrastructure is a third area of concern. A transportation system permeated with information technologies could prove highly vulnerable to attacks focused on introduction of false information into the system or interference with computer and communication systems. As transportation systems become increasingly integrated with information systems, the potential increases for widespread system disruption and personal injury as a result of such security breaches.

Finally, there is a critical need to ensure that our transportation systems and infrastructure are capable of providing adequate defense mobility and sustaining military mobilizations.

4 Elements of the National Transportation Science and Technology Strategy

The NSTC developed the first *Transportation Science and Technology Strategy* to help Congress and the Administration establish national transportation research and technology priorities and coordinated research activities. Based upon numerous outreach events, environmental scans, and an analysis of the transportation system's current and future strengths, weaknesses, opportunities, and threats, this document presented a vision, a likely 2020 scenario, and national goals and outcomes for Federal transportation science and technology.

Building upon this effort, this *National Transportation Science and Technology Strategy* broadens these elements and incorporates an even greater role for the larger transportation enterprise. It addresses key issues raised by the National Research Council's Transportation Research Board Study Committee on the Federal Transportation R&D Strategic Planning Process. More broadly, this *Strategy* incorporates the views expressed by State and local agencies, academic institutions, and industry, particularly those raised at a meeting held May 27-28 in Chicago on "Developing a National Transportation Science and Technology Strategy."

Like its predecessor, the current *Strategy* encompasses a four-tiered approach: (1) strategic planning and assessment; (2) private-public technology partnerships; (3) enabling research; and (4) transportation education and training. This approach parallels that outlined in the report of the March 1998 National Innovation Summit held at the Massachusetts Institute of Technology, which identifies five areas driving U.S. innovation: the talent pool, the national research base, capital availability, market vitality, and international market access.

This *National Transportation Science and Technology Strategy* broadens the transportation community's involvement in transportation R&D by (1) incorporating a greater role for State, local, and tribal agencies; academic institutions; and the private sector in the strategic planning and assessment process; (2) expanding the scope of several of the technology partnerships, clarifying their objectives, and adding two new partnerships; (3) establishing priorities within the enabling research areas and adding an additional area; and (4) augmenting the initiatives in education and training. This *Strategy* is not a description of all transportation research, nor is it a strategic plan. Rather, it provides a direction and framework for transportation R&D in America and describes a planning process, private-public partnerships, enabling research, and education and training that will advance our transportation system and our Nation. The *Strategy*'s elements are described in greater detail below.

STRATEGIC PLANNING AND ASSESSMENT

The institutionalization of an ongoing process for transportation strategic planning and system assessment enables policy makers and implementers at all levels to adjust the allocation of scarce resources to meet changing transportation requirements. As shown in Figure 6, this process, which involves the establishment of a broad consensus among and outreach to the different levels of government, industry, academia, and the public, will:

- Establish and assess strategic R&D priorities in light of national goals in a changing external environment, including international trends and market opportunities, ensuring that transportation R&D is defined from a long-term system perspective.
- Identify private-public technology partnerships that support the strategic transportation goals.
- Define a long-term enabling research agenda that supports future national goals and fosters the transportation breakthroughs of the next century.
- Develop education and training initiatives that ensure a capable and well-trained 21st century transportation work force.
- Within each area, establish meaningful, quantifiable "stretch" goals, or outcomes, to assess the impact of research and technology investments on system performance and on the achievement of transportation goals over the next several decades.
- Provide for peer and merit review of transportation-related R&D efforts to ensure their quality and relevance.

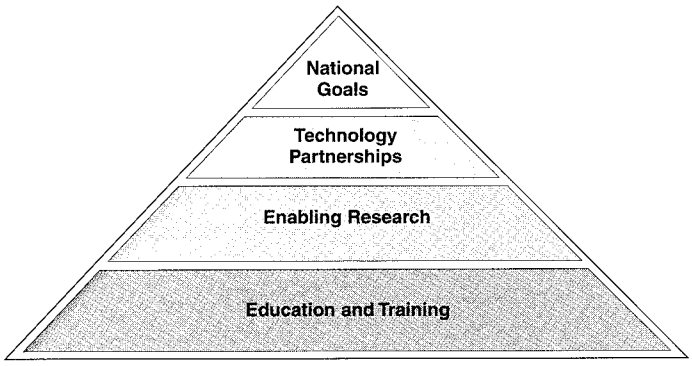


Figure 6. Strategic Planning Approach

Federal stewardship of the transportation enterprise can encourage decisions and actions by all parties contributing to seamless, efficient, and effective transportation, while balancing transportation needs against other national goals. Support for strategic planning and assessment within and among Federal, regional, State, local, and tribal agencies can be reinforced by:

- Working with individuals and agencies to expand awareness of the importance of strategic planning to their own activities.

- Providing information and tools for use in strategic planning and system assessment.
- Supporting the involvement of all governmental levels – as well as that of academic institutions, industry, and the general public – in planning and assessment efforts.
- Collaborating with agencies at all levels to recognize the goals embodied in legislation such as the Transportation Equity Act for the 21st Century (TEA-21), the Americans With Disabilities Act of 1990 (ADA), and the Clean Air Act Amendments of 1990.

PRIVATE-PUBLIC TECHNOLOGY PARTNERSHIPS

Criteria for Private-Public Partnerships:

- Addresses a real recognized national transportation system-level need.
- Has a technology focus: ideally a self-contained, readily implementable technology.
- The market for the technology exists: if successful, could rely on existing market forces and the private sector for widespread implementation.
- There is a need for a Federal role, with benefits to the Nation as a whole: could not proceed in a timely fashion without Federal involvement, support, or coordination, but also requires private sector cooperation and participation.

A critical element of this *Strategy* is the identification and elaboration of private-public technology partnerships in transportation.

One of the tenets of the President's Committee of Advisors on Science and Technology is that the Nation can best profit from its investments in research through the exchange of people and ideas among Federal agencies, State and local governments, industry, academic institutions, private citizens, and other stakeholders. The Science and Technology Caucus of the U.S. Senate holds that such efforts allow partners to leverage both their talents and resources, "creating a whole that is greater than the sum of its parts." Based on broad input from the transportation community, this *Strategy* incorporates thirteen technology partnerships that are consistent with the observations of the Senate Caucus and meet the following criteria identified by the President's Committee: (1) they address recognized national needs; (2) they have a technology focus; (3) they could rely on the private sector for implementation; and (4) they require some Federal involvement.[1] Each partnership also addresses one or more of the transportation goals identified in Section 3, as shown in Table 1.

Rather than formal research programs, the private-public partnerships identified in this *Strategy* represent broad-based collaborative efforts in key technology areas. These partnerships vary in terms of their maturity, with some representing well-established R&D activities and others requiring further definition and interagency coordination. Yet, all of the partnerships focus on the innovation process: getting technology into the marketplace cheaper, faster, safer, and in an environmentally friendly way. The Federal role in these efforts includes strategic planning; reducing barriers; promoting national technical standards; fostering venture capital and private sector investments; and stimulating creative financing of technology deployment.[2]

[1] Although the *Strategy's* focus is on science and technology, the NSTC recognizes that in many cases non-technological approaches may be equally beneficial to implement.

[2] All of the partnerships integrate ongoing activities with new components, developed within the Federal program development process and the overall limits established for Federal funding.

Federal-State Collaboration That Works: The U.S. Innovation Partnership

In 1992, the Carnegie Commission on Science, Technology and Government called for greater coordination among Federal, State, and local governments in national technology efforts.

In response, the Clinton Administration launched the State-Federal Technology Partnership, renamed the U.S. Innovation Partnership (USIP). The USIP brings together the Nation's Governors, Federal and State officials, members of Congress, and industry and academic leaders to meet the common goals of generating economic growth, improving schools and health care, protecting the environment, and reinventing government by effectively leveraging investments in science and technology. Among the USIP's priorities are:

Increasing Business Access to Technology Information
Through a partnership with the Ewing Marion Kauffman Foundation's Center for Entrepreneurial Leadership, the USIP will provide easier access for entrepreneurs to Federal and State technology information through the foundation's nationally known website: http://www.entreworld.org

Strengthening Small Business Innovation Research (SBIR)
The Federal SBIR program funds innovative research at small businesses across the U.S. Proposed by the State of Kansas, the State SBIR (SSBIR) would allow States to strategically leverage Federal SBIR dollars to commercialize technologies and create jobs within the State.

Supporting Reciprocity for Environmental Technologies
Regulatory reciprocity among States simplifies the compliance process and reduces the costs of bringing environmental technologies to market. The USIP supports efforts to negotiate reciprocal acceptance among State regulatory bodies of new technologies validated and tested by any one of them.

Expanding Manufacturing Extension Partnerships (MEP)
Another USIP priority is to expand the MEP, now operating in all 50 States and Puerto Rico, to help modernize the Nation's 381,000 small and mid-sized manufacturers.

Conducting "Idea to Market" Demonstrations
Building on the success of the MEP program, the USIP partners will jointly develop and pilot-test new models for quickly moving the ideas of inventors and researchers to the commercial marketplace.

Currently, the NSTC Technology Committee and its member agencies are engaged in the process of defining the partnerships and broadening the participation of State, local, and tribal authorities; nongovernmental organizations; private companies; universities; trade and industry associations; and professional societies. Following the advice of this broader community, the Committee has combined two partnerships identified in the previous strategy, both of which address sustainability; added new partnerships on maritime safety and space transportation; and renamed the partnerships for "smart" and next generation vehicles and for transportation security.

Table 1. Technology Partnerships and National Transportation Goals

PARTNERSHIPS	PRIMARY TRANSPORTATION GOALS SUPPORTED				
	Safety	Mobility and Access	Economic Growth	Environment	National Security
Aviation Safety Research Alliance	x		x		x
Next Generation Global Air Transportation	x	x	x	x	x
Next Generation Transportation Vehicles		x	x	x	
National Intelligent Transportation Infrastructure	x	x	x	x	
Intelligent Vehicle Initiative	x	x	x	x	
Transportation and Sustainable Communities	x	x	x	x	x
Transportation Infrastructure Assurance	x				x
Enhanced Freight Movement at Gateways		x	x		x
Monitoring, Maintenance, and Rapid Renewal of Infrastructure		x	x	x	
Maritime Safety Research Alliance	x	x	x		
Space Transportation Technologies	x		x	x	x
Accessibility for Aging and Disadvantaged Populations	x	x		x	
Enhanced Transportation Weather Services	x	x			

Figure 7 below shows the basic approach for integrating the research and technology efforts of the various Federal, State and local, and private-sector partners. Within this framework, the partners will first implement existing solutions as part of operational practices whenever possible. When solutions are not readily available, private-public technology partnerships will develop new approaches. At the same time, the partners will conduct enabling research in promising areas to provide the foundation for the major advances that will be needed to meet transportation goals in the next century.

The sections below provide brief summaries of the thirteen private-public technology partnerships.

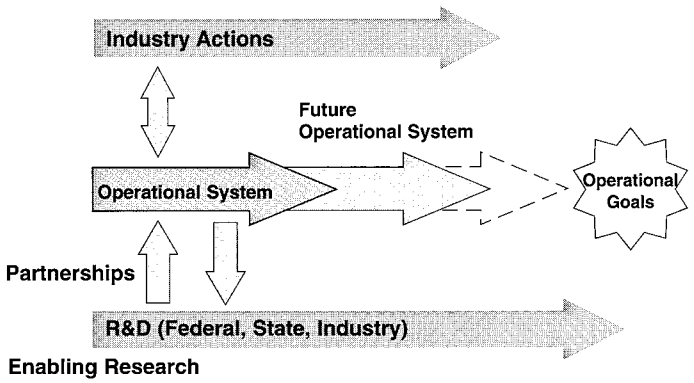


Figure 7. Private-Public Partnership Approach

Aviation Safety Research Alliance

Vision

An even safer aviation system that accommodates continued growth in air traffic while experiencing fewer aircraft accidents and related fatalities.

Goal

Identify methods that, when implemented, would reduce the fatal aviation accident rate by 80 percent by 2007, as compared to the 1990-1996 baseline.

Near-Term Outcomes

- Reduce the fatal aviation accident rate for commercial air carriers from a 1994-1996 baseline of 0.037 fatal accidents per 100,000 flight hours to 0.033 per 100,000 flight hours in 2000.
- Reduce the general aviation fatal accident rate from a 1994-1996 average of 1.67 fatal accidents per 100,000 flight hours.

Summary

This effort addresses the need to reduce the aviation accident rate as air traffic doubles over the next decade, as called for by the White House Commission on Aviation Safety and Security. Together with other partners, the FAA, NASA, and DOD will accomplish this through a coordinated program to (1) identify and conduct the research needed to meet the safety goal and (2) work with industry to deploy research results in the form of new safety technologies. This partnership is one element of a broader multimodal safety research alliance.

Aviation Safety Research Alliance: Technologies for Enhancing Safety

- Synthetic vision and advanced displays will alert pilots to safety hazards as they develop and enable them to take compensating actions.
- Using human-centered design principles to integrate terrain-avoidance data, world terrain databases and Global Positioning System (GPS) navigation will assure pilot alertness and improve routing accuracy.
- Technologies that communicate and display real-time weather information to airborne and ground-based users will reduce weather-related accidents.
- Improved materials in aircraft structures, airframes, and engines will extend their lives, reduce maintenance costs, and enhance crashworthiness.
- Advanced fire prevention, detection, and suppression will minimize loss of life and property when incidents occur.

Participants

Federal: DOD, FAA, NASA (lead agencies); DOE; NIST; NSF; NWS; U.S. Bureau of Mines.

Other: United Nations/International Civil Aviation Organization, aircraft and avionics manufacturers, airlines, aviation organizations, universities.

Next Generation Global Air Transportation

Vision

A safer, more efficient, environmentally compatible, and sustainable airspace system that meets future needs for global air transportation.

Next Generation Global Air Transportation: Technologies for Improving Mobility

- Improved digital communications will enhance system management and safety.
- GPS and augmentation will let aircraft fly point-to-point anywhere on the globe.
- Enhanced weather and situational information will let pilots select the optimal and safest routes.
- Airport planning and design technology will yield new procedures, equipment, and facilities to increase passenger and freight throughput.
- Integrating air traffic control and traffic flow management will improve service for air travelers while increasing system safety and capacity.

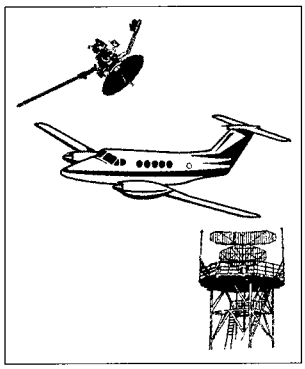
Goal

Achieve a global air transportation system that supports "free flight" and similar concepts and that (1) assures the most effective use of present and future air system capacity and (2) assures that system capacity is devoted to meeting the highest priority needs for it.

Near-Term Outcomes

- Reduce the rate of air travel delays by 5.5 percent from a 1992-1996 baseline of 181 delays per 100,000 activities to 171 per 100,000 activities in 2000.
- Increase the number of flight segments that aircraft are able to fly off ATC-preferred routes from 75 percent in 1996 to 80 percent in 2000.
- By 2000, reduce runway incursions to a level 15 percent below the 1997 baseline of 318 incursions, to at or below 270 incursions.

Summary



Anticipating the future growth in air traffic, this government-industry partnership is developing the air traffic management and communication, navigation, and surveillance systems required to make "free flight" a reality. "Free flight" refers to an airspace system that greatly increases user flexibility to plan and fly preferred routes, saving both fuel and time and affording more efficient use of airspace.

Participants

Federal: FAA, NASA (lead agencies); DOD; NSF; NWS; USCG.

Other: Airlines, aircraft and avionics industries, airport authorities, academia, International Civil Aviation Organization.

Next Generation Transportation Vehicles

Vision

A far more sustainable transportation system with fewer harmful environmental impacts and reduced dependence on fossil fuels.

Goal

Develop internationally competitive, domestically produced transportation vehicles that achieve unprecedented gains in fuel efficiency and in both environmental and operational performance, including reduced greenhouse gas emissions.

Near-Term Outcomes

- Reduce on-road mobile source emissions by 2 percent from 1999 to 2000, to a target level of 62.7 million tons as compared to the 1996 baseline of 65.9 million tons.
- Reduce greenhouse gas emissions from transportation in the United States.
- Reduce the Nation's vulnerability to oil price shocks by reducing transportation energy consumption as a function of gross domestic product.

Summary

This partnership addresses the problems of petroleum dependence, global warming, and pollution through research leading to the development of highway vehicles, ships, locomotives, and aerospace vehicles that are better designed and more efficient. It has four thrusts: (1) continue the PNGV and Advanced Technology Transit Bus activities and supplement them by also focusing on medium- and heavy-duty-vehicles; (2) demonstrate and develop the marine application of fuel cells; (3) support the development, test, and demonstration of non-electric high-speed rail technology; and (4) develop and demonstrate the next generation of aerospace vehicles, including aircraft with more efficient and cleaner engines.

Next Generation Vehicles: Technologies for Preserving the Environment

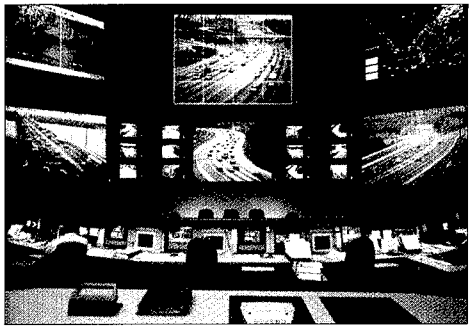
- Fuel cells and electric drives will dramatically improve energy efficiency and reduce emissions.
- New, lighter structural materials and designs will increase vehicle energy efficiency while enhancing safety.
- The PNGV will integrate into cars technologies such as hybrid electric drives, advanced emission controls, fuel cells, and lightweight materials, resulting in a tripling of fuel economy and near-zero emissions, while maintaining safety.

Participants

Federal: DOT (FAA, FHWA, FRA, FTA, MARAD, RSPA, USCG); DOD (Army, Navy, DARPA); DOC; DOE; and NASA – all lead agencies; also EPA and NSF.

Other: Vehicle, engine, and fuel-cell manufacturers; fuel producers; component suppliers; developers of fuel cells and other new energy-conversion technologies; shipyards; State and local authorities; universities.

National Intelligent Transportation Infrastructure



Vision

A truly seamless intermodal surface transportation system that accommodates private, public, and commercial vehicles; permits increasing communication and cooperation between infrastructure and vehicles; and utilizes relevant communication and information technologies to promote access and commerce.

Goals

Make the most effective use of the existing transportation system; reduce the costs of operating and using the surface transportation system; reduce travel time for all system users; increase productivity and improve customer service for highway and transit users; provide accurate system information to enable more effective transportation planning, operating policies, and pricing/control strategies; reduce traffic crashes and fatalities; and permit experimentation with, and demonstration of, policy-sensitive traffic control strategies.

Near-Term Outcomes

The National Intelligent Transportation Infrastructure (NITI) will contribute to the achievement of the following near-term objectives:

- By 2000, reduce delays on Federal-aid highways to 9 hours of delay per 1,000 vehicle-miles traveled, a decrease of 12 minutes from the 1996 level of 9.2 hours.
- Integrate intelligent transportation systems in 75 of the largest metropolitan areas by 2005. For 2000, the target is 50 areas compared to a 1997 baseline of 34 areas.

Summary

National Intelligent Transportation Infrastructure: Technologies for Enhancing Safety and Mobility

- Incident management will allow faster emergency response.
- Incorporating weather and other traveler information into traffic control systems and vehicles will improve safety while reducing congestion, fuel consumption, and highway maintenance costs.

The NITI refers to the integrated electronics, communications, and hardware and software elements that can support intelligent transportation systems (ITS). A communication and information "backbone," the NITI will enable ITS products and services to work together to save time and lives. It will allow surface transportation to be managed as a seamless entity by integrating transportation and management information systems and will provide the data needed for more effective transportation planning. This effort is closely related to the Intelligent Vehicle Initiative (IVI), described below.

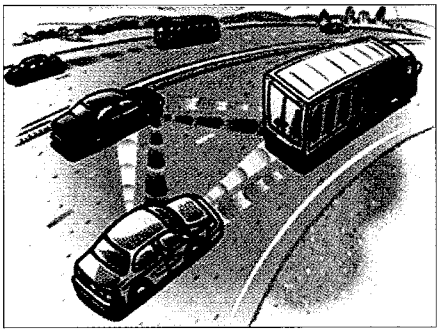
Participants

Federal: DOT (ITS Joint Program Office – lead agency, FHWA, FRA, FTA, MARAD, USCG); DOD (USACE); DOJ (INS); Treasury (Customs); NSF; USDA.

Other: State DOTs, MPOs, emergency response and law enforcement agencies, railroads, trucking companies, information systems vendors and manufacturers, ITS Service Centers.

Intelligent Vehicle Initiative

Vision



A roadway system where Americans operate in a significantly safer environment and enjoy greater mobility and efficiency, while enhancing and preserving the environment and character of the communities it serves.

Goals

Reduce the number of highway crashes and pedestrian casualties and the resulting injuries and fatalities; improve the effectiveness of intelligent systems to assure safe vehicle operation.

Near-Term Outcomes

- Reduce the rate of highway-related fatalities per 100 million vehicle-miles traveled from 1.7 in 1996 to 1.5 in 2000.
- Reduce the rate for injuries from 141 in 1996 to 124 per 100 million vehicle-miles traveled in 2000.

Summary

Intelligent Vehicle Initiative: Technologies for Enhancing Safety

- Adaptive cruise control and in-vehicle warning systems will reduce lane-change, rear-end, and roadway-departure crashes.
- Enhanced nighttime and bad-weather vision technologies will improve drivers' abilities to stay in lanes and distinguish pedestrians and animals in the road, particularly important for elderly drivers.
- Automatic crash and emergency notification will speed responses to crashes that do occur.

The IVI is a government-industry program to accelerate the development and commercialization of safety- and mobility-enhancing driver-assistance systems. Overall emphasis of the IVI is on four areas: (1) evaluation of the safety effectiveness and benefits of IVI products; (2) system prototyping; (3) field test evaluations of the most promising products; and (4) evaluation of user acceptance. Together with the initiatives for aviation and maritime safety, this partnership is part of a broader multimodal safety research alliance. Moreover, this effort is one element of an integrated intelligent transportation systems program that also includes the NITI.

Participants

Federal: DOT (ITS Joint Program Office – lead agency, FHWA, FTA, NHTSA, RSPA Volpe Center); DOD (TARDEC); NSF.

Other: Motor vehicle and trucking industries, fleet operators, State and local transportation and law enforcement agencies, emergency response organizations, universities and other research organizations, professional societies.

Transportation and Sustainable Communities

Transportation and Sustainable Communities: Technologies for Preserving the Environment

- Advanced forecasting, planning, and impact-assessment models will help to assess the impact of transportation choices on development, social equity, and the natural environment.

Vision

A transportation system that meets the needs for mobility and accessibility while balancing the current and long-term goals of economic growth, environmental quality, and social equity.

Goals

Integrate and coordinate existing research agendas to minimize duplication and research gaps while optimizing support for a sustainable transportation system; develop improved technical tools and models to analyze the impacts of transportation activities on both the natural and the social environment.

Near-Term Outcomes

- Reduce on-road mobile source emissions by 2 percent from 1999 to 2000, to a target level of 62.7 million tons as compared to the 1996 baseline of 65.9 million tons.
- Reduce greenhouse gas emissions from transportation in the United States.
- By 2000, increase to 11.68 percent the percentage of urban population living within a quarter mile of transit stops with service frequency of 15 minutes or less (non-rush hour) from a 1996 baseline of 11.22 percent.
- Minimize the adverse impacts of transportation projects on wetlands and replace at least 1.5 acres of wetlands for every 1 acre affected by Federal-aid highway projects where impacts are unavoidable.

Summary

This partnership explores how sustainable transportation and land use can help to achieve a balance among the often conflicting goals of economic growth, environmental quality, and sustainability. It furthers Federal agencies' efforts to work with each other and with other levels of government, the private sector, and the public to expand understanding of the consequences of transportation choices; develop better forecasting, planning, and assessment tools; conduct technology research; and develop sustainable community and transportation initiatives.

Participants

Federal: DOD (USACE); DOE; DOT (Office of the Secretary, BTS, FAA, FHWA, FRA, FTA, RSPA); EPA; HHS (CDC); HUD; Interior (National Parks Service); OMB – all lead agencies.

Other: State and local transportation/environmental agencies and organizations; public health agencies; MPOs; mayoral offices; environmental advocates; environmental technology manufacturers and vendors; transportation system design, engineering, and construction firms; materials manufacturers; vehicle and fuel manufacturers; universities.

Transportation Infrastructure Assurance

Vision

A transportation infrastructure that is secure from acts of terrorism and crime and that adapts rapidly to natural or intentional disruptions.

Goal

Develop a comprehensive approach to assessing threats to the security of transportation's physical and information infrastructure and to implementing integrated security technologies and procedures tailored to these threats.

Near-Term Outcomes

- Increase the detection of explosive devices and weapons that may be brought aboard aircraft.
- Get threat information to those who need to act within 24 hours, at least 90 percent of the time.

Summary

This partnership is developing and implementing measures to improve the security of transportation information systems, passenger and freight terminals, and other infrastructure, as well as of the people and cargo using or transiting them. At a minimum, it addresses (1) the physical security of transportation terminals; (2) the security of vital communication and information systems; and (3) the development and dissemination of information about security incidents and assessments of threats to transportation facilities and operations.

Transportation Infrastructure Assurance: Technologies for Ensuring Our Security

- High-confidence systems and software will minimize the vulnerability of intelligent transportation systems to "cyber" or computer-based threats.
- Advanced sensor technologies will detect theft and illegal drugs and promote more effective interdiction.
- CAT scan and "sniffer" technology will permit real-time detection of explosives at all transportation terminals.
- Better integration of transportation control systems will enable the system to adapt rapidly to natural or intentional disruptions.

Participants

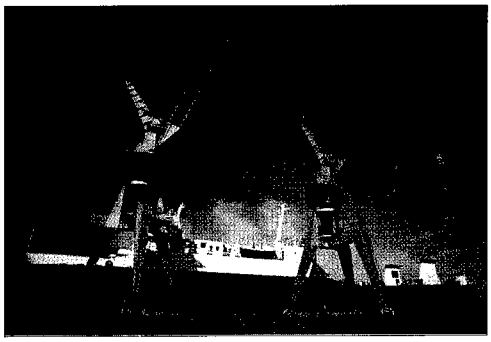
Federal: DOT (FAA, FHWA, FRA, FTA, ITS Joint Program Office, MARAD, RSPA, USCG); DOD; DOJ (FBI, INS, NIJ); Treasury (U.S. Customs) – all lead agencies.

Other: State and local law enforcement agencies; port and airport authorities; transportation service providers (airlines, bus lines, transit agencies, trucking companies, ship lines, railroads, parcel and freight companies).

Enhanced Goods and Freight Movement at Domestic and International Gateways

Vision

A more productive national economy afforded by a more flexible, efficient, and seamless freight transportation system.



Goals

Improve freight mobility at the Nation's land borders and ports; ensure diffusion of existing freight information technologies and networks; expedite the global flow of goods.

Near-Term Outcomes

- Reduce the percentage of ports reporting landside impediments to the flow of commerce from 41 percent in 1998 to 39 percent in 2000.
- Reduce delay at National Highway System border crossings per 1,000 vehicles processed in 2000.

Summary

Building on earlier investments in technology, port infrastructure, and freight terminals, this partnership facilitates intermodal freight applications of advanced information technologies. Major efforts focus on technology demonstrations and deployment of innovative logistics practices at our Nation's land border crossings, ports, and key freight corridors. Another element addresses the mitigation of community impacts resulting from rapid growth of freight movement in certain corridors and terminal locations.

Enhanced Goods and Freight Movement at Gateways: Technologies for Promoting Economic Growth

- Electronic toll collection will increase system efficiency and capacity.
- Dedicated short-range communications will speed administrative processing of people and freight movements and prevent illegal crossings at borders.
- "Smart" tags and cards will streamline paperwork associated with multimodal shipments.

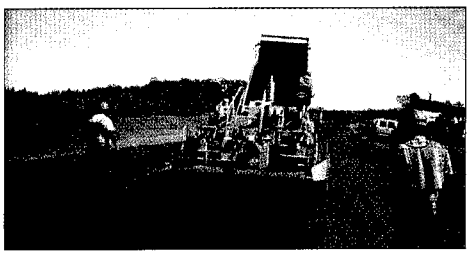
Participants

Federal: DOT (ITS Joint Program Office and Secretary's Office of Intermodalism – lead agencies, FAA, FHWA, FRA, MARAD, RSPA, USCG); DOC; DOD (MTMC); DOE; DOJ (INS); EPA; State; Treasury (U.S. Customs); USDA.

Other: National governments and international societies; State and local agencies; port and airport authorities; industry (air cargo companies, trucking companies, ship operators, railroads, parcel and freight companies, equipment manufacturers, vehicle manufacturers).

Monitoring, Maintenance, and Rapid Renewal of the Physical Infrastructure

Vision



A self-sustaining, environmentally compatible transportation infrastructure that is durable and efficient and that requires fewer human, economic, and environmental resources to produce, operate, and maintain.

Goals

Accelerate the comprehensive renewal and advancement of the Nation's aging transportation infrastructure using stronger, cheaper, and environmentally superior materials and more cost-effective delivery systems; reduce waste, pollution, and emissions generated in the production of infrastructure materials.

Near-Term Outcomes

- Increase the percentage of miles on the National Highway System that meet pavement performance standards for acceptable ride quality from 90.4 percent in 1996 to 91.8 percent in 2000.
- Reduce the percentage of bridges on the National Highway System that are deficient from 23.4 percent in 1997 to 22.5 percent in 2000.
- Maintain in good or fair condition at least 93 percent of runways at all commercial service airports and reliever airports, as well as selected general aviation airports.

Summary

Monitoring, Maintenance, and Rapid Renewal: Technologies for Improving Mobility

- Superpave and other new materials will improve highway durability, reducing both costs and congestion.
- Advanced computer-aided design and development tools will result in safer and more efficient highways and structures.
- Use of environmentally superior materials will reduce greenhouse gas emissions.

This partnership, also called PAIR-T (Partnership for the Advancement of Infrastructure and its Renewal-Transportation), will create an environment that fosters an unprecedented level of collaboration and synergy on infrastructure research, demonstration, testing, evaluation, and technology transfer to State and local agencies. The partners will collaborate on developing new technologies, accelerating market acceptance of existing products, and removing barriers to efficient technology transfer.

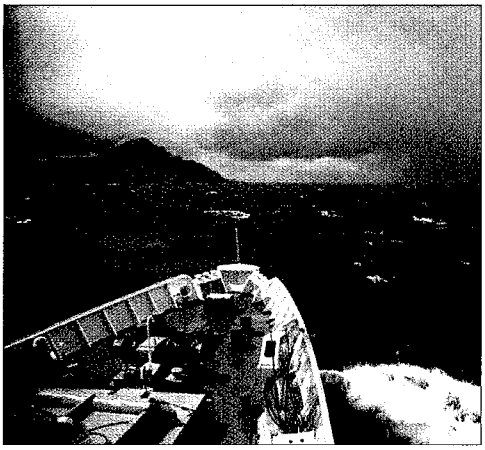
Participants

Federal: DOT (FHWA and RSPA – lead agencies, FAA, FRA, FTA, MARAD, USCG); DOC (NIST); DOD (USACE); NSF.

Other: Civil Engineering Research Foundation; State and local agencies; chemical, automotive, and material manufacturers; commercial freight, air transport, and insurance industries; infrastructure construction, planning, and management firms; communications, water, gas, and electric utilities; universities; industry and trade associations.

Maritime Safety Research Alliance

Vision



A maritime transportation system that is the world's safest and most cost-effective.

Goal

Reduce by 20 percent (1) collisions; (2) deaths and injuries from maritime casualties; and (3) the risk of passenger vessel casualties with major loss of life.

Near-Term Outcomes

- Reduce the number of high-risk passenger vessel casualties to 47 per 1,000 vessels in 2000 from a 1996 baseline of 48 per 1,000.
- By 2000, reduce the number of collisions, allisions, and groundings from a statistically derived baseline of 256 in 1998 to 246 or fewer.

- Reduce recreational boating fatalities from a 1997 baseline of 819 fatalities to 720 or fewer fatalities in 2000.

Summary

Maritime Safety Research Alliance: Technologies for Enhancing Safety

- Advanced training technologies will save lives by teaching mariners how to deal with contingencies such as severe weather and equipment failures.
- Improved small vessel designs and structures will reduce vulnerability to damage or loss.
- GPS navigation will reduce hazards to vessels associated with collisions or groundings.
- Real-time weather systems will allow mariners to prepare for or avoid storms.
- Integration of sea- and land-based intelligent systems will permit rapid response to emergency situations.

This partnership's focus is the prevention of maritime casualties through research and technology in the areas of human factors, vessel technology, and information systems. Work will address advanced training technologies for mariners; improved small vessel designs and structures; real-time weather systems; GPS applications; and integration of sea- and land-based intelligent systems for traffic management and emergency response. This initiative is part of a broader alliance that includes the Aviation Safety Research Alliance and the Intelligent Vehicle Initiative.

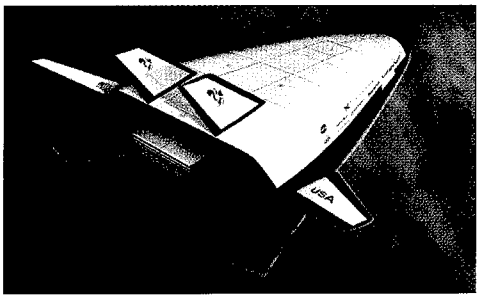
Participants

Federal: DOT (MARAD, USCG) and DOD (MTMC, Navy, USACE) – lead agencies.

Other: Maritime industry.

Space Transportation Technologies

Vision



Realization of the full potential for commerce, technology, and exploration in space.

Goal

Research, develop, verify, and transfer advanced aeronautics, space, and related technologies to support revolutionary space vehicles and launch systems.

Near-Term Outcomes

- Continue vehicle assembly of the X-33, a half-scale technology demonstrator of a full-scale, commercially developed reusable launch vehicle (RLV), in preparation for flight testing.
- Complete vehicle assembly and begin flight testing of the X-34, which will demonstrate technologies necessary for an RLV but will not be a commercially viable vehicle itself.

Space Transportation Technologies: Technologies for Promoting Economic Growth

- RLVs and related spaceport architecture will reduce dramatically the per-pound payload cost of commercial space transportation.
- Development of sensors and testing technologies will make possible intelligent integration and validation of space systems.
- Integrating technologies such as air-breathing propulsion, cryogenics, and advanced structures will produce significant efficiencies, enabling a cost-to-orbit measured in hundreds, rather than thousands, of dollars per pound.

Summary

Technologies that make space more accessible and cost-effective will strengthen existing aerospace companies and foster new space-based industries; improve our stewardship of the environment; and enhance our competitive position in the world marketplace. This partnership among NASA, the FAA, and industry will develop and demonstrate technology that supports full-scale, highly competitive reusable space launchers and related spaceport infrastructure.

Participants

Federal: FAA, NASA (lead agencies); DOD; NSF.

Other: U.S. commercial space launch providers, launch site operators, and satellite manufacturers and owners.

Accessibility for Aging and Transportation-Disadvantaged Populations

Vision

A transportation system that meets the mobility and accessibility needs of the elderly, the poor, persons with disabilities, and all other Americans without access to a private automobile.

Goals

Create model alternative transportation systems that serve the needs of the elderly and transportation-disadvantaged people while taking full advantage of existing services, resources, and development patterns; promote development of transit-compatible communities that integrate transit and pedestrian services for all users; provide opportunities for employing welfare recipients by preserving communities and enhancing transit.

Near-Term Outcomes

- By 2000, increase to 11.68 percent the percentage of urban population living within a quarter mile of transit stops with service frequency of 15 minutes or less (non-rush hour) from a 1996 baseline of 11.22 percent.
- Increase the percentage of key rail stations that are in compliance with the ADA from 19 percent in 1996 to 47 percent in 2000.
- Increase the percentage of bus fleets that are ADA-compliant from 63 percent in 1996 to 82 percent in 2000.
- Increase the number of employment sites that are made accessible by Job Access and Reverse Commute transportation services.
- Increase transit ridership from 39.0 billion passenger-miles in 1996 to 40.56 billion in 2000.

Accessibility for Aging and Transportation-Disadvantaged Populations: Technologies for Improving Mobility and Access

- Automatic vehicle location, geographic information systems, and electronic fare collection will improve flexibility, meeting the needs of those not served by existing transit systems.
- Integration of service providers will improve operating efficiency, optimizing use of existing capital and serving a broader community.

Summary

This partnership focuses on improving the mobility of the elderly and transportation-disadvantaged through better management of paratransit, advanced technologies, and livable communities. One component is developing, deploying, and testing a regional paratransit program that uses selected information technologies, including automatic vehicle location, geographic information systems, computer-aided dispatch, and electronic fare collection.

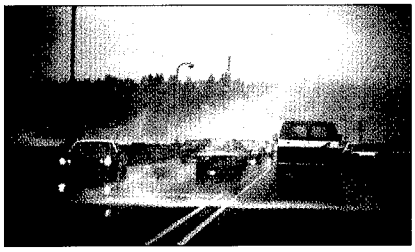
Participants

Federal: DOT (FTA – lead agency, Office of the Secretary, FHWA, ITS Joint Program Office, NHTSA, RSPA); DOL; EPA; HHS; HUD.

Other: State and regional agencies, MPOs, human service and employment agencies, housing authorities, public and private transit providers, information and communication system vendors, employers, universities.

Enhanced Transportation Weather Services

Vision



A transportation system that is significantly safer, with far greater capacity and efficiency, by reducing the impacts of adverse weather.

Goal

Develop seamless, cost-effective transportation weather information systems.

Near-Term Outcomes

- Reduce the rate of highway-related fatalities per 100 million vehicle-miles traveled from 1.7 in 1996 to 1.5 in 2000.
- Reduce the rate of highway-related injuries per 100 million vehicle-miles traveled from 141 in 1996 to 124 in 2000.
- Reduce the fatal aviation accident rate for commercial air carriers from a 1994-1996 baseline of 0.037 fatal accidents per 100,000 flight hours to 0.033 per 100,000 flight hours in 2000.
- Reduce the general aviation fatal accident rate from a 1994-1996 average of 1.67 fatal accidents per 100,000 flight hours.
- Increase access to the Nation's airports during adverse weather conditions by publishing 500 GPS approaches per year for the next two years, from a 1995-1998 baseline of 1,453 approaches to date. The target for 2000 is to complete at least 2,453 approaches total.

Summary

This partnership addresses the problems associated with adverse weather through the development of comprehensive weather information systems. One element, known as Foretell, will make use of state-of-the art weather radars, observing systems, and forecasting methods to demonstrate and evaluate an integrated weather information system – first within a "pilot" Midwestern region and eventually throughout North America. A second component is the Aviation Weather Analysis and Forecasting Program, which will improve access to and delivery of aviation weather information and reduce the consequences of weather events by generating weather observations, warnings, and forecasts with higher resolution and greater accuracy.

Enhanced Transportation Weather Services: Technologies for Enhancing Safety

- Integrated radars and observing systems, such as Road Weather Information Systems, Doppler radars, Automated Surface Observing Systems, and Advanced Weather Interactive Processing Systems, will permit far more accurate measurement and forecasting of weather conditions.
- Advanced dissemination techniques will present weather information in flexible formats.

Participants

Federal: DOT (ITS Joint Program Office, FAA, FHWA, FRA, RSPA – lead agencies); DOD (USACE); NOAA; NWS.

Other: Iowa DOT and other State DOTs, Environment Canada, weather technology manufacturers and integrators, vehicle suppliers, ITS Service Centers, aviation industry.

ENABLING RESEARCH

Criteria for Enabling Research:

- Supports long-term national transportation goals.
- Benefits too widely spread for any one company to recover its investment at a profit.
- Cost or risk is too great for any individual company to bear.
- Benefits are too far in the future to meet private investment criteria.

The 1996 General Accounting Office report, *Surface Transportation Research: Funding, Federal Role, and Emerging Issues,* concludes that the current Federal transportation research and development effort "gives too little emphasis to basic, long-term, high-risk surface transportation research." Although many Federal agencies conduct long-term research, such research typically is focused on agencies' specific missions – not on broader national needs. Moreover, the long-term nature and diffuse benefits of this research means that market forces may be insufficient to motivate private investment. Clearly, there is a Federal role in bringing together all elements of the transportation enterprise to conduct the enabling research, both short and long term, that will make possible the next century's transportation breakthroughs and innovations.

This *National Transportation Science and Technology Strategy* includes six high-priority research thrusts identified in the previous strategy, as well as one additional area. Each is consistent with the principles of the President's Committee of Advisors on Science and Technology and meets the criteria listed in the accompanying box. Moreover, as shown in Table 2, each research area contributes to meeting the national transportation goals identified in Section 3.

The research areas identified in this *Strategy* have the potential to advance technology and performance both within individual transportation modes and across all modes. All require Federal support as well as concerted efforts and partnerships among the various levels of government, private industry, and academic institutions. The seven enabling research areas are (1) human performance and behavior; (2) advanced materials; (3) computer, information, and communication systems; (4) energy, propulsion, and environmental engineering; (5) sensing and measurement; (6) tools for transportation modeling, design, and construction; and (7) social and economic policy issues.

Table 2. Enabling Research Areas and National Transportation Goals

RESEARCH AREAS	PRIMARY TRANSPORTATION GOALS SUPPORTED				
	Safety	Mobility and Access	Economic Growth	Environment	National Security
Human Performance and Behavior	x		x	x	x
Advanced Materials	x	x	x	x	x
Computer, Information, and Communication Systems	x	x	x	x	x
Energy, Propulsion, and Environmental Engineering			x	x	x
Sensing and Measurement	x	x		x	x
Tools for Transportation Modeling, Design, and Construction	x	x	x	x	x
Social and Economic Policy Issues	x	x	x	x	x

Human Performance and Behavior

For transportation systems to achieve high goals for performance and cost, their design, realization, and use must be based on (1) extensive knowledge of user needs; (2) limitations associated with human performance and behavioral characteristics; and (3) understanding of the many factors affecting the interaction between humans and automated systems.

Human error or inadequacy in vehicle or system operation, maintenance, or inspection is a leading factor contributing to safety and security problems. This arises in part because basic system design, operational procedures, or training programs do not take fully into account the characteristics of the people responsible for operating the system. Research in the behavioral sciences provides a critical foundation for building the needed transportation knowledge base to avoid such flaws.

A broadly based research program, using such tools as the National Advanced Driving Simulator, would yield results and methodologies for many modes of transportation, and for all public and private partners, enabling more efficient use of scarce resources. Among the current priority areas for research partnerships in human performance are those summarized below.

Advanced Instructional Technology

Summary: Even with a greatly improved understanding of human performance, training and education are critical for ensuring that vehicle operators are knowledgeable about their vehicles' safety systems and safe operational procedures. This research supports the development of interactive programs (such as CD-ROM video techniques and simula-

tion) to train and evaluate operators under a wider range of operational scenarios than is currently possible.

Participants: DOD; DOT (Office of the Secretary, FAA, FHWA, FRA, FTA, MARAD, NHTSA, USCG); NASA; NSF; State agencies; schools and universities; transportation service providers; industry.

Enhanced Alertness and Work Readiness

Summary: This effort would build on current research to study and quantify the effects of fatigue, work–sleep cycles, working environment and culture, boredom, and drug and alcohol use; response to emergency situations; testing of readiness to perform duties; and interactions among co-workers.

Participants: DOD; DOT (Office of the Secretary, FAA, FHWA, FRA, FTA, MARAD, NHTSA, USCG); NASA; NSF; State agencies; universities; transportation service providers; manufacturers.

Humans and Automated Systems

Summary: This effort would provide critical information for designing systems and technology that enhance, rather than hamper, performance. Examples of topics to be explored under a broad research partnership include human cognition and perception, reaction times, and visual acuity.

Participants: DOD; DOT (FAA, FRA, NHTSA, USCG); NASA; NSF; universities; vehicle and equipment manufacturers.

Advanced Materials

Technical advances in the defense and consumer sectors have produced a rich inventory of materials and associated structural concepts, tools, and techniques for their use. Enabling research in this area supports applications of these materials to transportation, advancing an understanding of their behavior and properties, demonstrating their safety and effectiveness and, often, reducing costs to a competitive level. Potential research partnerships are described below.

Advanced Infrastructure Materials

Summary: Research partnerships in this area would examine the properties and performance of materials and technologies with physical infrastructure applications. Examples include high-performance concrete, new steel alloys, innovative composite materials and adhesives, imaginative structural concepts, computer-aided design techniques, and automated construction and maintenance tools.

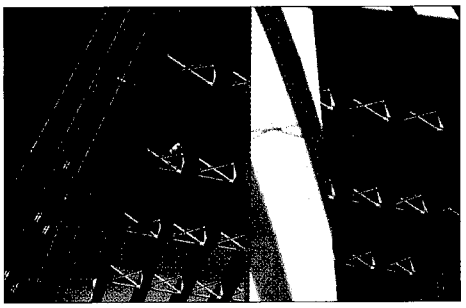
Participants: DOC (NIST); DOD; DOT (FHWA, FRA, MARAD); NASA; NSF; State agencies; manufacturers; universities.

Materials for Transportation Vehicles

Summary: This research looks at materials with potential use in the manufacture of aircraft, ships, and surface transportation vehicles, for example, the use in body structures of high-performance steel, aluminum, magnesium, and glass- and carbon-fiber composites. Such research partnerships would need to consider material cost, manufacturing processes, failure mechanisms, and environmental characteristics.

Participants: DOC; DOD (Army, Navy, DARPA); DOE; DOT (FAA, FRA, FTA, MARAD, NHTSA, RSPA, USCG); NSF; vehicle manufacturers; universities.

Advanced Manufacturing and Construction



Summary: This research would support the development of advanced technologies for infrastructure construction and materials manufacturing. A major focus would be work leading to technologies that improve the sustainability of materials production by reducing waste, pollution, and emissions generated in the manufacturing process.

Participants: DOC (NIST); DOD (DARPA); DOT (FHWA, FRA, MARAD); EPA; NASA; NSF; State agencies; manufacturers; universities.

Computer, Information, and Communication Systems

Worldwide, transportation is being transformed by the growing overlay of an information infrastructure on the existing physical infrastructure, creating a system in which information technologies and ready access to many types of information are integrated into virtually all transportation elements and functions. Effective and rapid exploitation of these innovations will require a substantial and ongoing enabling research and development effort associated with system concepts, characterization of alternative configurations and technical choices, and development and harmonization of a wide range of standards. Priorities for partnerships are summarized below.

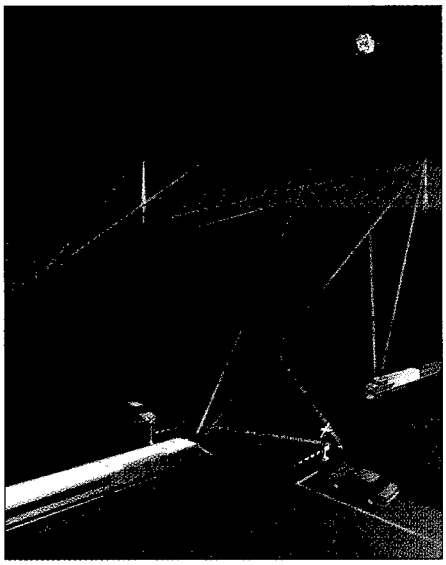
Spectrum Allocation

Summary: Research in this area would provide the technical and economic knowledge needed to support policy decisions regarding

allocation and efficient use of the electromagnetic spectrum and sophisticated mobile data communication technologies.

Participants: DOC; DOD; DOT (ITS Joint Program Office); NSF; State and local agencies; the telecommunications industry.

Global Positioning System Issues and Applications



Summary: Many important transportation applications use the highly accurate GPS for position finding and navigation. Among the areas this research would address are (1) the broad financial and institutional issues that must be resolved to assure that this system evolves in a manner that fully reflects the needs of civil transportation users and (2) the integration with GPS of geographic information system (GIS) and remote sensing technologies.

Participants: DOC; DOD (Air Force); DOT (ITS Joint Program Office, FAA, FHWA, FRA, FTA, USCG); NASA; NSF; transportation service providers and other GPS users; manufacturers of GPS-based equipment; GPS service providers; State and local agencies; universities.

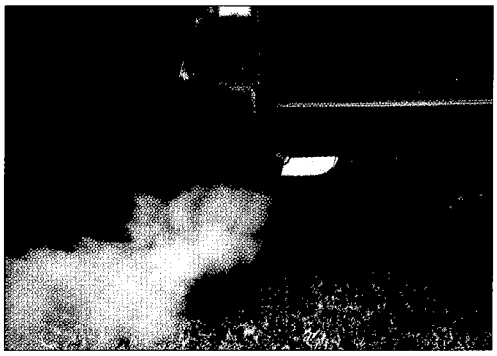
Software Assurance and High-Confidence Systems

Summary: The growing complexity of intelligent systems, and our ever-greater dependence on them, requires a high level of reliability, robustness, and security. Two critical areas for research partnerships are (1) system development, modeling, and verification techniques; and (2) high-confidence systems that protect and enhance the security and reliability of computer and communication networks.

Participants: DOD; DOT (ITS Joint Program Office, FHWA, FTA); NASA; NSF; State and local governments; manufacturers; universities.

Energy, Propulsion, and Environmental Engineering

Transportation contributes to many environmental problems. Because market forces tend to promote transportation research with near-term applications, there is a need for a Federal role in broad-based partnerships to explore long-term, high-risk strategies to address environmental issues, for example, the Administration's PNGV. Other cost-shared efforts in energy and environment include research on renewable fuel sources, low-emission propulsion systems, and advanced monitoring of transportation-related pollution and energy use. Among the high-priority areas for additional research partnerships are those listed below.



Advanced Energy Storage and Conversion

Summary: Among candidate technologies for energy storage, fuel cells perhaps offer the most significant potential benefits in terms of energy conversion and mitigation of adverse environmental impacts. This research would address the properties and characteristics of fuel-cell technology and potential applications to transportation vehicles.

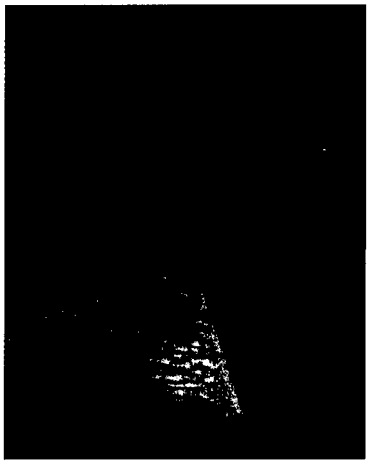
Participants: DOC; DOD (Army, Navy, DARPA); DOE; DOT (FTA, MARAD, NHTSA, RSPA, USCG); EPA; NSF; vehicle, engine, and fuel-cell manufacturers; State authorities; universities.

Alternative Transportation Fuels

Summary: A variety of petroleum alternatives hold promise for transportation, each with strengths and weaknesses in terms of economics, practicality, and indirect impacts. Research partnerships in this area would explore the costs, benefits, and safety and infrastructure requirements of these various alternative fuels.

Participants: DOD, DOE, DOT, EPA, fuel producers, universities, State and local agencies.

Sensing and Measurement



The wide range of information technologies now being incorporated into transportation systems has steadily increased the value of real-time monitoring and inspection of vehicles and infrastructure. Today, low-cost devices are available that make an extremely wide range of physical measurements and then are coupled to computer chips capable of generating warnings or adjusting operations. A virtually unlimited number of physical mechanisms and sensing concepts are potentially available, but devices of special importance to transportation will be identified and brought to fruition only to the degree that the transportation community makes these needs known and establishes their potential economic and operational value. Priorities for research partnerships are listed below.

Smart Structures and Vehicles

Summary: "Smart structures" – roads, bridges, runways, and others with a network of embedded sensors – can lower maintenance costs while improving safety and performance by continually providing detailed condition information. Likewise, "smart vehicles" sense their environmental and operating circumstances. This research would identify and quantify the potential benefits and costs of coupling sensing and computing in this manner.

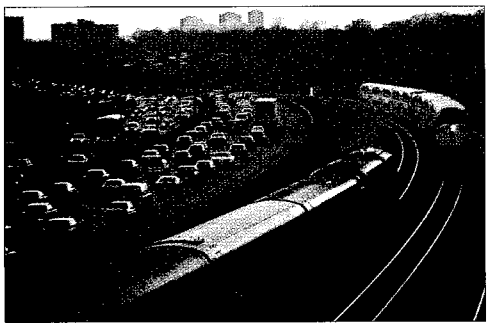
Participants: DOD (USACE); DOT (FHWA, MARAD, USCG); NASA; NSF; State transportation agencies; Civil Engineering Research Foundation; manufacturers; construction firms; universities.

Micro/Nano Devices

Summary: Partnerships in this area would support research and development of micro- and nano-scale devices with potential transportation applications, for example, sensors and micro-controllers for airbags, "smart" antilock brakes, engine controls, and vehicle vibration sensors.

Participants: DOD; DOT (NHTSA, RSPA); NSF; vehicle, component, and equipment manufacturers; universities.

Tools for Transportation Modeling, Design, and Construction



Enabling research in this area provides tools and procedures for simulation, modeling, design, and analysis of transportation systems and their components. Such research focuses on developing information and techniques to evaluate system design improvements, alternative operational concepts and strategies, and performance characteristics likely to result from innovations. Priority areas include:

Transportation System Design Tools

Summary: The focus of this research would be to develop improved tools and methods that support transportation system design, with an emphasis on process re-engineering. Including computer models and simulations (for example, the Transportation Analysis Simulation System, or TRANSIMS), as well as computer-aided design, such tools would be integrated across all institutions involved in the transportation design and planning process.

Participants: DOD (USACE); DOT (Office of the Secretary, FHWA, MARAD, USCG); NSF; State and local agencies; universities.

Modeling and Simulation of System Performance and Impacts

Summary: This research would provide the analytical methodologies and supporting data to forecast system use and impacts at the level of the individual vehicle. These tools would be capable of interfacing with real-time infrastructure condition reporting systems (see National Intelligent Transportation Infrastructure) to support both short- and long-term planning and would be applicable to transportation policy development, economic and contingency planning, and impact assessment.

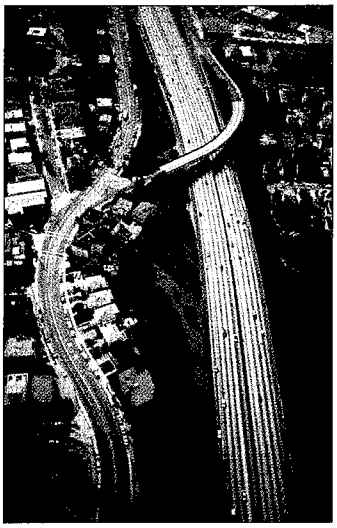
Participants: DOD (USTRANSCOM, MTMC); DOE (LANL); DOT (BTS, FAA, FHWA, FRA, FTA, MARAD, USCG); EPA; Federal Geographic Data Committee; State and local agencies; industry; universities.

Transportation and Logistic System Operations and Management

Summary: In this area, research partnerships would look at applications of information technology and other tools to support operation and management of transportation and logistic systems and to assure seamless integration across organizations, modes, and institutions.

Participants: DOD; DOT (FHWA, ITS Joint Program Office, MARAD, USCG); State and local agencies; port and airport authorities; transportation service providers; universities.

Social and Economic Policy Issues



Whether made in the public or private sector, transportation decisions must address a widening range of considerations: safety and environmental impacts, economic effects for the Nation as a whole and for various segments of the population, energy and petroleum consumption, and global competitiveness. Many stakeholders are involved, and the realities and uncertainties are complex. In particular, national policies place heavy burdens on State and local agencies for planning and decision making in many complicated areas related to transportation. There is a need for research leading to the development of a broad knowledge base that can support decision makers as they assess transportation options and alternatives. Some priority areas are:

Transportation Planning, Economics, and Institutions

Summary: The objective of this research would be to identify and characterize the needs and interests of all parties involved with the transportation system and to understand transportation's economic, financial, and institutional context.

Participants: DOC; DOE; DOL; DOT (BTS, FAA, FHWA, FRA, FTA, MARAD, RSPA, USCG); NSF; USDA; State and local agencies; international organizations; industry; universities.

Social Impacts of Transportation Systems and Operations

Summary: Research in this area would explore the complex relationship between transportation and society, including transportation's impact on wealth, poverty, and inequality; the social consequences of transportation innovations; transportation and race; and the relationship between mobility and well-being.

Participants: DOT (Office of the Secretary, BTS, FHWA, FTA, NHTSA, RSPA); EPA; HHS; HUD; NSF; USDA; State and local agencies and organizations; not-for-profit organizations; foundations; industry; universities.

Transportation Trends and Projections

Summary: The inherently long lifetime of transportation vehicles and infrastructure – sometimes measured in centuries – requires a forward-looking perspective in transportation planning and investment. This research activity would examine the likely consequences of current trends and project realistic future scenarios that bear on the supply of and demand for transportation services.

Participants: DOC; DOD; DOE; DOL; DOT (BTS, FAA, FHWA, FRA, FTA, MARAD, RSPA, USCG); NSF; State and local agencies; international organizations; industry; universities.

TRANSPORTATION EDUCATION AND TRAINING

The Nation's investment in science and technology is critical to the transportation system's safety, efficiency, and capacity to support national goals. Equally important is our continuing investment in human capital – the professionals and workers responsible for the planning, design, construction, operation, and maintenance of the transportation system and the educators and institutions that train them.

The Federal Government has long supported transportation education. Current programs administered by DOT are crucial to ensuring the professional capacity of the transportation enterprise. The University Transportation Centers, the Eisenhower Transportation Fellowship Program, the Aviation Education Program, and the National Highway, Transit, and Maritime Institutes are representative of the Federal Government's continuing investment in transportation education and professional enhancement.

Transportation today is undergoing great change – experiencing advances in technology, undergoing organizational transformation, and becoming more global along with the world economy. These changes require that current and future generations of transportation professionals and workers respond to a more complex and dynamic environment:

> **Advanced Technology:** Transportation technology once focused on traditional building materials, standard construction techniques, and combustion-engine-powered vehicles. Newly developed and deployed technologies reflect advances in telecommunications, information systems, energy storage, and advanced electronics and materials. The transportation profes-

Criteria for Education and Training:

- Creates general public awareness of transportation benefits.
- Builds professional capacity of industry and State/local transportation agencies.
- Ensures a globally competitive work force.
- Prepares the next generation of transportation professionals with a multidisciplinary education.

sional and worker must be educated and trained to adapt these technologies to the existing transportation infrastructure. Moreover, these technologies require a supply of new and retrained workers to operate and maintain these systems, as well as educators who are ready to impart this new knowledge.

Organizational Transformation: The transportation organizational environment continues to change. The Intermodal Surface Transportation Efficiency Act (ISTEA) granted more decision-making authority to State agencies and metropolitan planning organizations, and TEA-21 continues this trend. The movement toward intermodal planning, finance, and operations has resulted in many changes, including highway departments evolving into State "transportation" departments. These new agencies are only now learning to address the competing needs of regional mobility and societal concerns. The combined impacts of devolution and transportation agency changes demand that transportation professionals learn the most effective and innovative management techniques.

Globalization: Transportation continues to reflect a global economy. Manufacturing and logistics chains now rely on the transportation operations and facilities of many countries. Likewise, increased world business and leisure travel requires that transportation professionals be aware of changing customer needs. Japan, France, and Germany, for example, require their university transportation students to work in transportation abroad prior to graduation so that they have a better understanding of global transportation operations.

These changes demand a new emphasis on the evolving needs of the transportation work force. Under the Garrett A. Morgan Technology and Transportation Futures Program, the Department of Transportation is working closely with the Departments of Education and Labor; its partners in industry; State, local, and tribal governments; labor unions; professional organizations; and schools and universities to ensure that the next century's work force is equipped with the training and skills it needs. This *Strategy* defines four education and training components, discussed below, that support the broad goals of the Garrett A. Morgan program and meet the criteria listed in the accompanying box:

Introduction of Transportation Concepts: Elementary and Secondary Education

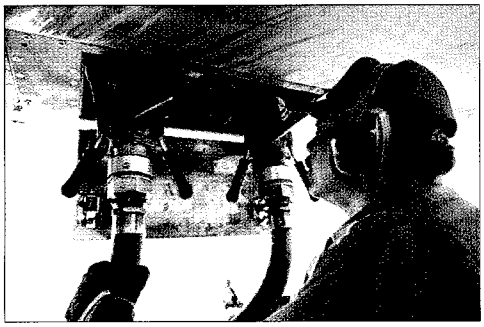
Transportation permeates every aspect of the Nation's economy, yet little effort is made to show elementary and secondary students the connection between their studies and the transportation systems around them or to assist teachers with incorporating transportation into their curricula. Many students are lost to the transportation profession simply because they have been given no incentive to pursue subjects, such as mathematics and science, that are essential to advancing in the field.

Of even greater importance is the school system's responsibility to produce citizens capable of making informed choices in a democracy. This Nation is shortchanging itself and its posterity when it fails to provide its young people with the knowledge of how transportation systems connect them to each other and the world. Of equal importance is informing students of how our transportation choices affect both our human and our natural environment.

Summary: This initiative would stimulate collaborative partnerships to assist educators in developing and delivering transportation education modules that are fully integrated into the curriculum for each grade level.

Participants: Department of Education; Department of Transportation (FAA, FHWA, FRA, FTA, MARAD, RSPA, USCG); industry; labor unions; schools and teaching colleges; local boards of education.

Vocational and Technical Training



Transportation has been and continues to be a major source of the Nation's jobs. Moreover, a well-trained and efficient work force of technicians, operators, builders, and maintainers is crucial to the transportation system's safety, efficiency, and global competitiveness.

Summary: This initiative would support collaborative investments with vocational schools, community colleges, and industrial training institutes to ensure a steady supply of capable workers to the transportation enterprise.

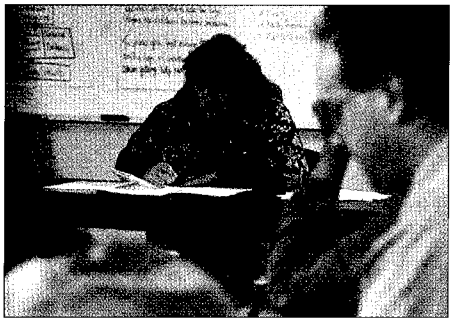
Participants: Department of Education; Department of Labor; Department of Transportation (FAA, FHWA, FRA, FTA, MARAD, RSPA, USCG); State, local, and tribal agencies; vocational schools, community colleges, and training institutes; labor unions; industry.

Transportation Degree Programs: International and Multidisciplinary

In the face of increasing globalization, the Nation's institutions of higher learning must prepare their graduates to deal with transportation as a complex organization of systems with global dimensions. Government and industry must join with universities to develop multidisciplinary programs focused on identifying and resolving transportation issues in an increasingly international arena.

Summary: This initiative would build upon existing DOT programs to foster the development of transportation degree programs based on multidisciplinary curricula.

Participants: Department of Transportation (FAA, FHWA, FRA, FTA, MARAD, RSPA, USCG); State, local, and tribal agencies; industry; labor unions; universities.



Mid-Career Transportation Training

Organizational transformations and changes in technology have left many transportation professionals and workers unprepared. Where technologies and training once changed every 20 years, today the half-life of rapidly advancing technologies may be anywhere between three and five years. Such rapid development requires the education of current workers and professionals in the latest technological advances and related applications. Likewise, transportation managers require the management tools necessary to meet their new responsibilities and evolving missions.

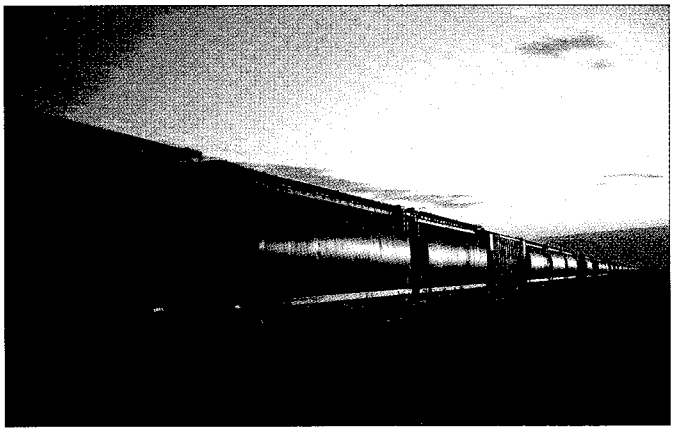
Summary: As a broad partnership between government and industry, this effort would develop multidisciplinary materials and programs to ensure that the current generation of transportation workers and professionals has the capacity to apply the most innovative technologies and techniques.

Participants: Department of Defense; Department of Education; Department of Labor; Department of Transportation (FAA, FHWA, FRA, FTA, MARAD, RSPA, USCG); State, local, and tribal agencies; airport and port authorities; vocational schools, community colleges, and training institutes; universities; labor unions; industry.

5 Conclusions

This *National Transportation Science and Technology Strategy* provides a direction and framework for the research and development needed to build the transportation system of the 21st century. Its premise is that Federal agencies can speed the introduction of transportation innovations only through broad-based partnerships with State, regional, local, and tribal agencies; the transportation industry; and academic institutions. In laying out a framework for the next century, this *Strategy* presents a vision of transportation in 2025 and, based on that assessment, identifies strategic goals for transportation safety, mobility and access, economic growth, the environment, and national security. To achieve these goals, it outlines priorities in four key areas: a strategic planning process, private-public technology partnerships, enabling research, and education and training. The next step is for transportation stakeholders to work together to further define and implement these elements through the *Transportation Technology Plan*, the *Transportation Strategic Research Plan*, and the Garrett A. Morgan Technology and Transportation Futures Program. Federal agencies will take the lead in implementation and engage in ongoing outreach to coordinate their efforts with their partners' planning processes.

Implementation of this *Strategy* is critical to our transportation system and our vitality as a Nation. It will allow us to meet increased demand while balancing the sometimes competing values of safety, security, economic productivity, environmental quality, and mobility. Moreover, the *Strategy* supports the Administration's vision for transportation: that of a safe, efficient, sustainable, and secure system that is international in reach, intermodal in form, intelligent in character, and inclusive in nature. Such a transportation system is indeed possible in our near future. However, it can be realized only with the active participation of the agencies, businesses, and institutions composing our Nation's vast and innovative transportation enterprise.



Appendix A

OUTREACH EVENTS IN SUPPORT OF STRATEGY IMPLEMENTATION ACTIVITIES

Symposium on Advanced Multimodal Transportation Weather Services, September 28, 1998, U.S. DOT Volpe Center, Cambridge, MA.

"Dangers of Chemical and Biological Toxins," September 17, 1998, U.S. DOT Volpe Center, Cambridge, MA.

"Transportation Logistics for the 21st Century," panel at the 1998 Conference of the International Society of Logistics, August 25-27, 1998, Seattle, WA.

"Nowcasting and Prediction for Urban Zones," meeting sponsored by the U.S. Weather Research Program, August 24-26, 1998, University of California at Los Angeles, Los Angeles, CA.

Second Meeting of the National Research Council/Transportation Research Board Committee on the Federal Transportation R&D Strategic Planning Process, July 6-8, Washington, DC.

Workshop on the Partnership for the Advancement of Infrastructure and its Renewal (PAIR) Through Innovative Products and Processes, June 30, 1998, Washington, DC.

Annual Meeting of the North American Free Trade Agreement Working Group #4, June 18-19, 1998, Montreal, Canada.

"Intermodal Freight Identification Technology: Current Application and Future Needs," June 9-10, 1998, Reston, VA.

National Governors' Association/NSTC Meeting on "Developing a National Transportation Science and Technology Strategy," May 27-28, 1998, Chicago, IL.

National Cargo Security Council Annual Conference, May 6-7, 1998, Miami, FL.

Workshop on Implementing the Partnership for the Advancement of Infrastructure and its Renewal-Transportation (PAIR-T), April 7, 1998, Washington, DC.

Meeting of the Impacts and Use Assessment Committee, U.S. Weather Research Program, March 31-April 2, 1998, National Center for Atmospheric Research, Boulder, CO.

"Macroeconomic Impacts of Freight Globalization," session at the Annual Meeting of the Transportation Research Board, January 13, 1998, Washington, DC.

"Transportation and Sustainable Communities," session at the Annual Meeting of the Transportation Research Board, January 14, 1998, Washington, DC.

"Defining Next-Generation Smart Paratransit for the Elderly," December 8, 1997, Massachusetts Institute of Technology, Cambridge, MA.

Garrett A. Morgan Education Roundtable, October 30, 1997, Washington, DC.

Appendix B

ACRONYMS AND ABBREVIATIONS

ADA	Americans With Disabilities Act
ATC	Air Traffic Control
BTS	Bureau of Transportation Statistics
CDC	Centers for Disease Control
DARPA	Defense Advanced Research Projects Agency
DOC	U.S. Department of Commerce
DOD	U.S. Department of Defense
DOE	U.S. Department of Energy
DOJ	U.S. Department of Justice
DOL	U.S. Department of Labor
DOT	U.S. Department of Transportation
EPA	U.S. Environmental Protection Agency
FAA	Federal Aviation Administration
FBI	Federal Bureau of Investigation
FHWA	Federal Highway Administration
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
GIS	Geographic Information System
GPS	Global Positioning System
HHS	U.S. Department of Health and Human Services
HUD	U.S. Department of Housing and Urban Development
INS	U.S. Immigration and Naturalization Service
ISTEA	Intermodal Surface Transportation Efficiency Act of 1991
ITS	Intelligent Transportation Systems
IVI	Intelligent Vehicle Initiative
LANL	Los Alamos National Laboratory
MARAD	Maritime Administration

MEP	Manufacturing Extension Partnership
MPO	Metropolitan Planning Organization
MTMC	Military Traffic Management Command
NASA	National Aeronautics and Space Administration
NHTSA	National Highway Traffic Safety Administration
NIJ	National Institute of Justice
NIST	National Institute of Standards and Technology
NITI	National Intelligent Transportation Infrastructure
NOAA	National Oceanic and Atmospheric Administration
NSF	National Science Foundation
NSTC	National Science and Technology Council
NWS	National Weather Service
OMB	Office of Management and Budget
OSTP	Office of Science and Technology Policy
PAIR-T	Partnership for the Advancement of Infrastructure and its Renewal-Transportation
PNGV	Partnership for a New Generation of Vehicles
R&D	Research and Development
RLV	Reusable Launch Vehicle
RSPA	Research and Special Programs Administration
SBIR	Small Business Innovation Research
SSBIR	State Small Business Innovation Research
TARDEC	U.S. Army Tank-Automotive Research, Development, and Engineering Center
TEA-21	Transportation Equity Act for the 21st Century
TRANSIMS	Transportation Simulation Analysis System
USACE	U.S. Army Corps of Engineers
USCG	United States Coast Guard
USDA	U.S. Department of Agriculture
USIP	U.S. Innovation Partnership
USTRANSCOM	U.S. Transportation Command

ABSTRACT

The National Science and Technology Council (NSTC) Committee on Technology, Subcommittee on Transportation Research and Development (R&D), has created a *National Transportation Science and Technology Strategy* that builds on the earlier strategy published in 1997. Like its predecessor, the *National Strategy* is intended to help Congress and the Administration establish national transportation R&D priorities and coordinated research activities. The *National Strategy* articulates goals for transportation system safety, mobility and access, economic growth, the environment, and national security. It proposes the broader involvement of State, local, and tribal agencies; academic institutions; and private industry in national transportation R&D strategic planning and system assessment, private-public technology partnerships, enabling research, and transportation education and training.

For additional copies and further information, contact:
National Science and Technology Council Executive Secretariat
202-456-6100 (phone) 202-456-6026 (fax)

This document is also available on the NSTC Home Page via link from the OSTP Home Page at:

http://www.whitehouse.gov/WH/EOP/OSTP/html/OSTP_Home.html