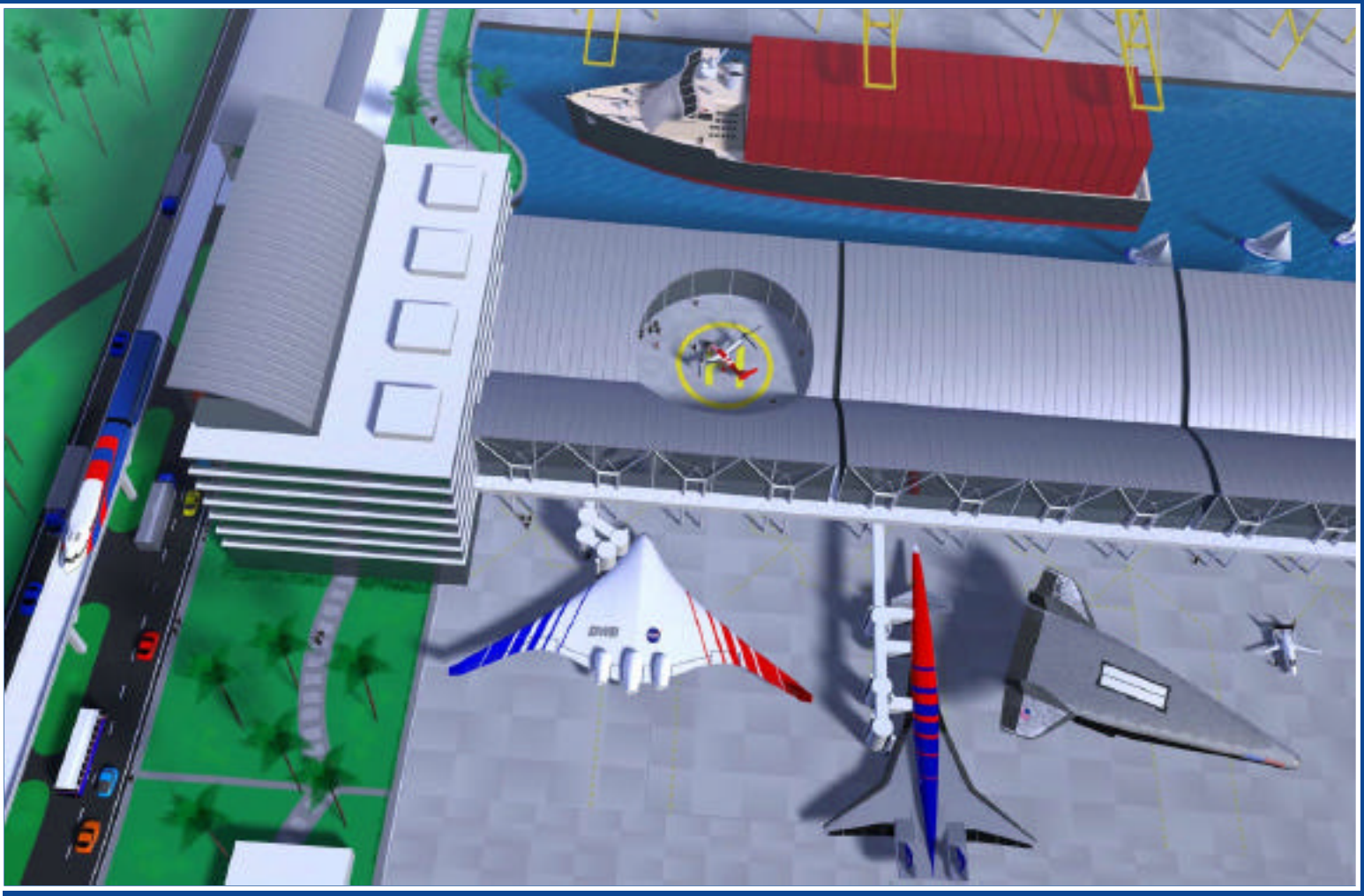

# VISION 2050:
# An Integrated National Transportation System

**The Federal Transportation Advisory Group (FTAG) was established by the National Science and Technology Council (NSTC) under the auspices of the Federal Aviation Administration (FAA) Research, Engineering and Development Advisory Committee (REDAC) and the National Aeronautics and Space Administration (NASA) AeroSpace Technology Advisory Committee (ASTAC). Its members are from the National Research Council (NRC) Transportation Research Board (TRB) and National Academy of Engineering, Aeronautics and Space Engineering Board (ASEB) as well as several federal advisory committees, including the FAA REDAC, NASA ASTAC, and the U.S. Department of Transportation (DOT) Marine Transportation System National Advisory Council (MTSNAC). These bipartisan groups advise the government and the transportation community on transportation-related issues. This report is a product of the FTAG and does not necessarily represent the position of the U.S. Department of Transportation or other federal agency or department.**

**Vision 2050 – An Integrated National Transportation System**
**Published February 2001**

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# Foreword from the Federal Transportation Advisory Group

Our transportation system is critical to the Nation's economy and our quality of life. The United States has long enjoyed one of the best and most efficient transportation systems in the world, but it is now facing significant challenges.

Parts of our transportation system are already approaching gridlock: airline delays are increasing; urban highways and transit systems are congested; and major ports, waterways and freight railway lines are facing capacity constraints. Transportation demand—both passenger and freight—is predicted to double in the next 20 years and triple within 50 years, with no major increases in capacity on the drawing board. Innovative solutions are required now, in order to meet this anticipated demand while achieving other national policy goals.

Major transportation improvements take decades to deploy. Therefore, the time to begin planning and investing in our next generation transportation system is now. Delay will result in continued deterioration, increasing congestion, and rising costs.

We believe a new vision for transportation is necessary. The federal government must provide leadership in this effort. Working with its public and private-sector partners, its role is to act in the public's interest: sustaining our economy, preserving our national security, and enhancing the quality of life of our citizens. The federal government also plays a major role in establishing national policy, creating an environment that fosters innovation, and funding the long-term research, education and infrastructure needs of the country.

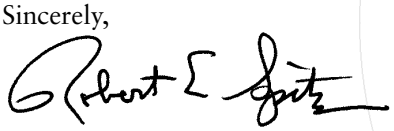
However, the federal government cannot achieve the improvements the American people deserve and expect without the direct interest and involvement of all transportation stakeholders. It needs to work closely with the transportation community—state and local governments, industry, labor, non-governmental organizations, academia, and the public at large—to take the bold steps necessary to make this vision a reality.

This document prescribes a bold transportation vision that we believe the Nation should pursue today to prevent crisis in the future. This vision has three interlinked elements that must be addressed simultaneously and intermodally. The document also identifies technology, concepts, and research that will enable the Nation to start moving toward that vision. Our national transportation vision is:

- An integrated national transportation system that can economically move anyone and anything anywhere, anytime, on time;
- A transportation system without fatalities and injuries; and
- A transportation system that is not dependent on foreign energy and is compatible with the environment (e.g., with respect to noxious emissions, greenhouse gases, noise).

We call upon the President to make transportation one of his top priorities. We recommend that the President form a bipartisan commission to help define a national transportation strategy and the bold actions that will enable the United States to have an integrated, intermodal national transportation system by the year 2050.

Sincerely,



Robert E. Spitzer
Chair, Federal Transportation Advisory Group

"Our national transportation vision is:

- An integrated national transportation system that can economically move anyone and anything, anywhere, anytime, on time;
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## Executive Summary

Transportation is critical to our Nation's economy and our quality of life, and the United States has long enjoyed one of the best and most efficient transportation systems in the world. But today, we are straining its capacity limits, producing delays and congestion. Fatalities and injuries are unacceptably high, devastating lives and reducing productivity. The system forces our dependence on foreign petroleum and pollutes our environment.

Transportation demand—both passenger and freight—is predicted to double in the next 20 years and triple within 50 years with no major increases in the Nation's capacity planned. Innovative solutions are required now in order to meet this anticipated demand while achieving other national policy goals.

Incremental short-term and modal-oriented solutions, though needed, will not solve these long-term problems. The solution lies in new technology and concepts, such as information technology, nanotechnology, energy-efficient and environmentally friendly technologies, renewable fuel sources such as hydrogen and biotechnology. But, major transportation improvements take decades to deploy. Therefore, we must act now. Any delay could adversely impact our economy and quality of life for generations.

This vision document proposes a bold vision for transportation in the year 2050, much like the interstate highway system envisioned by President Eisenhower in 1956 that transformed America into a mobile society.

*Our national transportation vision is:*

- *An integrated national transportation system that can economically move anyone and anything, anywhere, anytime, on time;*
- *A transportation system without fatalities and injuries; and*
- *A transportation system that is not dependent on foreign energy and is compatible with the environment (e.g., with respect to noxious emissions, greenhouse gases, and noise).*

The document recommends actions that the President should take now, if the Nation is to deal effectively with the capacity crisis and start moving toward the vision of an integrated national transportation system. This leadership is of the utmost urgency and importance. Transportation is a national problem that requires Presidential leadership and a national team—the Congress, state and local government, industry, labor, academia and non-governmental organizations—working together to solve successfully.

Many of the actions listed below are inter-institutional in nature, because the federal government is currently neither organized nor incentivized to develop the integrated national transportation system the Nation needs in the 21st Century.

*1. Presidential Leadership.* Declare that improving the Nation's transportation system is a top priority. Form a bipartisan commission to determine the steps necessary to achieve the vision laid out in this document.

*2. National Strategy*. Develop a *National Transportation Strategy* by January 2002 to guide transportation policy and investments.

*3. Multi-modal Leadership.* Create a permanent Federal Advisory Committee, that reports directly to the Secretary of Transportation, with representatives from all stakeholders to provide guidance on national transportation policy issues from a long-term, systemic perspective.

*4. National System Architecture.* Form a non-profit, public-private sector organization, like ITS America, to help the government define and maintain a national transportation system architecture.

*5. People.* Determine transportation work force needs over the next 50 years and develop a plan for ensuring that the required work force is available.

*6. Research.* Significantly increase funding for long-term, high risk enabling research over the next 10 years. Create a civilian Advanced Research Projects Agency to stimulate and demonstrate high-risk, high-payoff transportation technologies and concepts with the transportation sector to accelerate their deployment.

*7. Infrastructure.* Work with the transportation sector to implement the partnership for the advancement of infrastructure renewal and operational improvements. Integrate civilian and commercial transportation into our defense system's global information grid. Ensure adequate resources and expertise to maintain and operate the Nation's information infrastructure for transportation. Determine the infrastructure required for an economy based on non-carbon fuels and identify transition issues.

*8. Partnership.* Foster partnership arrangements throughout the transportation community to provide incentives to work together to eliminate the social, institutional and cultural barriers that hinder success, especially in the areas of multi-modal and information technology partnerships.

*9. Legal and Regulatory Framework.* Create a government-university-industry task force to identify ways to eliminate the regulatory and legal barriers to innovation in transportation.

*10. Capital.* Create a transportation investment fund with the transportation sector that would provide the research and development necessary to spur innovative and system-level solutions in transportation.

*The Nation needs a new transportation vision for the next 50 years. Its economic strength and the quality of life of all Americans depend on it. We call upon the President to lead this effort.*

"Transportation is a national problem that requires Presidential leadership and a national team—the Congress, state and local government, industry, labor, academia and non-governmental organizations—working together to solve it successfully."

## I. Introduction—Transportation Vision 2050

This document describes the vision of an integrated national transportation system that will enable the Nation to sustain its economic growth and enhance the quality of life of Americans now and through the year 2050 and beyond. It defines a vision that has three interlinked elements with supporting technology, concepts, and research that, if pursued, will make the desired system possible. The document also proposes actions that the President should take in order to start this transformation.

This comprehensive vision will help guide our Nation's investment in transportation and serve as a catalyst to spur cooperative action by all members of the transportation community. Because the federal government cannot achieve this vision by itself, this document was developed by representatives from all transportation modes; from federal, state, regional and local government; and from industry, non-government organizations, academia, and user communities.

Accomplishing systemic change, especially in the Nation's massive and complex transportation infrastructure, will take decades. Therefore, this document not only provides guidance for the period through the year 2050 but also identifies *work that has to begin today*, if we are to be successful. The document calls for a sustained national commitment to achieve the vision.

“Transportation is the foundation of our entire economy and quality of life.”

## II. Transportation Challenges—Today and in the Future

Transportation is the foundation of our entire economy and quality of life. Everything we eat, drink, and consume is transported to us from somewhere else. Transportation takes us to work, on vacations, and to recreational activities. It is an integral part of our health care system, providing emergency transportation and delivery of medical services and supplies. Transportation brings us the materials we use at work and distributes the products of our labor to the customer.

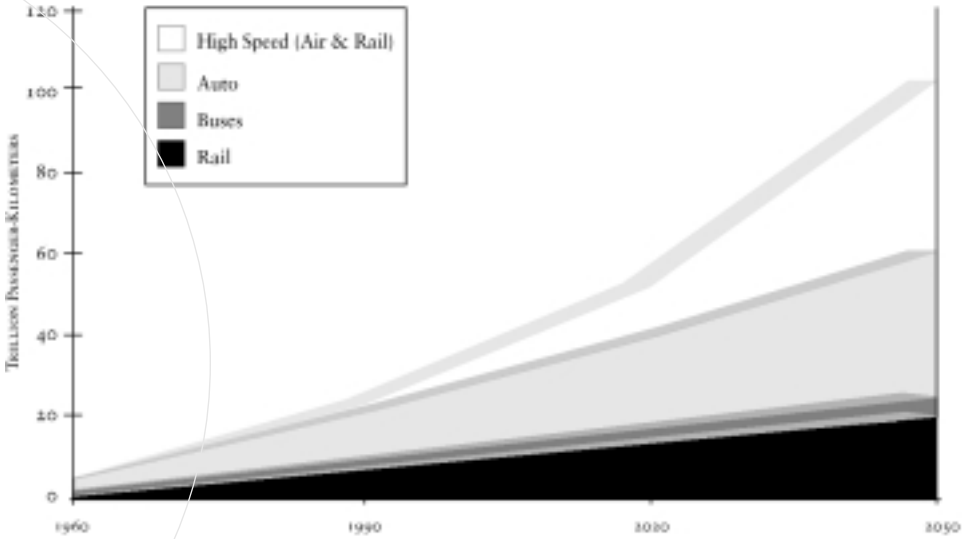
Transportation links us to the global economy, allowing us to import and export both goods and materials. The transportation industry employs nearly 10 percent of the Nation's work force and accounts for more than 11 percent of the Gross Domestic Product (GDP)[1] . As impressive as these numbers are, however, the more important reality is that the U.S. economy depends on transportation.

Although our current transportation system is the best in the world, there are problems on the horizon. Demand for transportation services is increasing, and there are no plans for major new investments in the Nation's physical infrastructure. Parts of our system are already showing the signs of this growing demand, with increasing congestion and delays. Growing demand for transportation brings increased concerns about safety, security, and energy use, as well as environmental concerns. We are rapidly using up the technological gains we made during the Cold War. We need to make sure that we are investing in the innovative technologies and concepts that will provide us with the new "seed corn" we will need to meet the demands for transportation services in the future.

### Mobility and Congestion

There have been numerous projections of national and global transportation demand, each one based on a specific set of conditions and assumptions. What is common across all of them—except for those that posit a major world crisis in the near future—is that the overall volume of both passenger and freight movements is heading upward. One recent estimate that studied passenger travel in all areas of the world since 1960 suggests that total world passenger kilometers will more than double between 1990 and 2020, and will double again by 2050, to 103 trillion passenger kilometers. (See Chart 1.) In Chart 1, the high speed category refers to high speed rail plus air.

**Chart 1: World Passenger Volume 1960–2050**




*Source: Schafer and Victor, "The Past and Future of Global Mobility", Scientific American, October 1997, p. 39.*

Based on the fact that total freight volume has risen at twice the rate of population over the past forty years, U.S. domestic freight demand is projected to triple from 3.2 trillion ton-miles in 1990 to 9.5 trillion ton-miles in 2050. (See Chart 2.) Charts 1 and 2 assume current levels in prices and service and corresponding increases in supply or capacity.

International freight is also expected to grow during these same periods, possibly even faster than domestic freight movement. This growth will stress our highway and rail connections with Canada and Mexico and will place additional demands on seaports and their intermodal connections, demands that they are not prepared to handle today.

Thus, total transportation volume might increase more than triple between today and the year 2050. Meanwhile, transportation congestion is growing worse and translates into $75 billion in lost productivity each year. Our transportation system will not be capable of handling such a staggering increase in demand without adopting radically different approaches.

Unlike the interstate highway system, which was planned in the 1950's to increase supply or physical capacity, the national infrastructure has no new major projects planned for it. Currently, significant delays in major infrastructure projects result from concerns over their impact on the environment and the quality of life of nearby populations, as well as the sheer expense of such massive undertakings. Recent major additions to the physical infrastructure—such as the Boston Central Artery Project ('The Big Dig')—required

several decades of planning and construction. Hence, we need to act now to prevent gridlock in the future. Both new technology and improved operations will become increasingly critical.

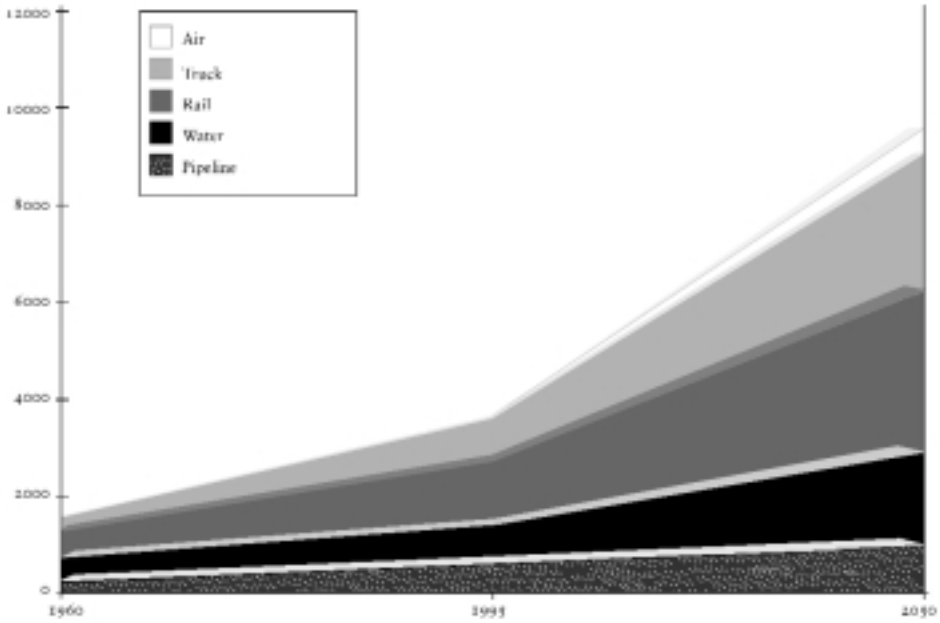
### Safety and Security

Transportation-related crashes, incidents, and mishaps take a high toll in lives and productivity, and have a serious impact on our national economy. Transportation accounts for more than 40,000 Americans killed and 3.5 million injured each year. Over 90 percent of these are on the Nation's highways.

Although these totals are down somewhat from their peaks in the 1970s, they have not been reduced significantly over the last 15 years. In addition, we have approached safety primarily from the viewpoint of mitigating the results of the incidents, with insufficient focus on preventing them in the first place.

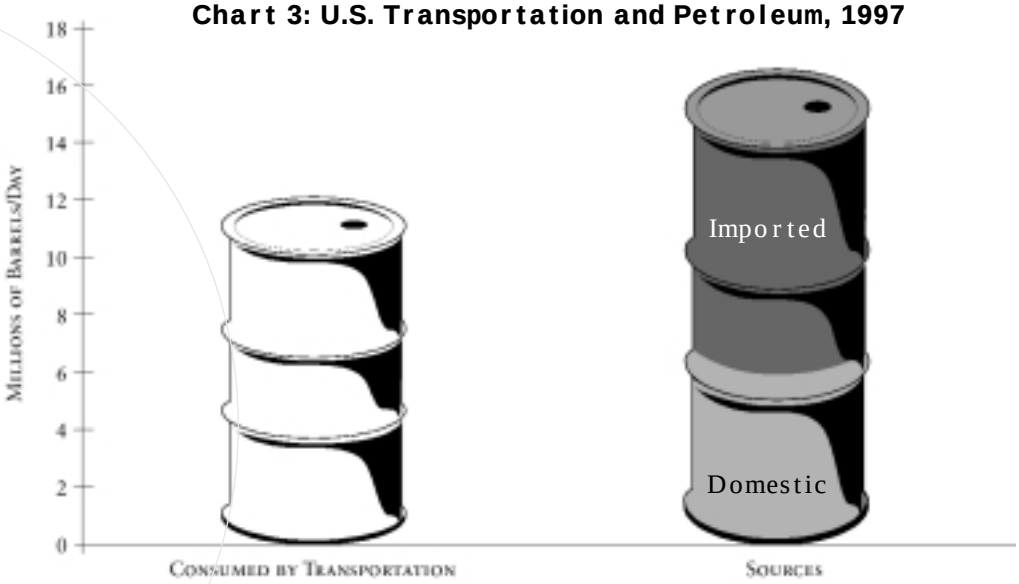
According to recent National Highway Traffic Safety Administration (NHTSA) estimates, traffic crashes cost the Nation about $150 billion in lost productivity and property damage.[2] Steadily mounting volumes of traffic present a challenge to continuing this downward trend. If these rates cannot be significantly lowered, it is likely that the total number of transportation-related deaths and injuries, and the economic costs of these accidents in the U.S., will again start to increase. Such a trend would increase the cost to the Nation in lives and money, increasing public outcry for improved safety.

**Chart 2: U.S. Domestic Freight Volume 1960–2050**




*Source: Volpe Center, M. Safford, 2000.*

**Chart 3: U.S. Transportation and Petroleum, 1997**




*Source: U.S. DOT, NTS 1999, p. 282.*

The other transportation modes have safety concerns as well. Rail passenger and freight operations account for 932 deaths per year, 90 percent of which are due to trespassers and grade crossing accidents. Marine activities account for 908 deaths per year, with 808 of these resulting from recreational boating. Aviation averages 683 deaths per year. In most years, the majority of these are in general aviation. Human error and lack of situational awareness cause between 70 and 90 percent of all transportation-related crashes and incidents and deserve more emphasis in our safety research investments in all modes.

The negative consequences of crashes and incidents can extend beyond deaths and injuries. When hazardous materials are involved, adverse effects on public health and safety and on the environment can be extensive. Further, even relatively simple mishaps can cause economic damage amounting to tens or even hundreds of millions of dollars, such as was the case with the Exxon Valdez.

Concern for the security of the transportation system from terrorist threats has also increased steadily during the past two decades. Hijackings in the 1970s and the bombing of Pan American Flight 103 in December 1988, with the loss of 270 lives, have focused national policy and development initiatives on measures to counter terrorist acts against U.S. carriers and travelers. But as aviation security tightens, there are concerns that other modes may be targeted.

Furthermore, the threats are becoming more diverse and pervasive than in the past, and now include cyber-attacks, the use of deadly chemical

and biological agents such as sarin gas, portable missiles, and weapons of mass destruction. As transportation demand increases and the system becomes more integrated to meet the demand, security will become more difficult and more constrictive to traffic flow, unless new techniques and methods are developed to mitigate the vulnerabilities.

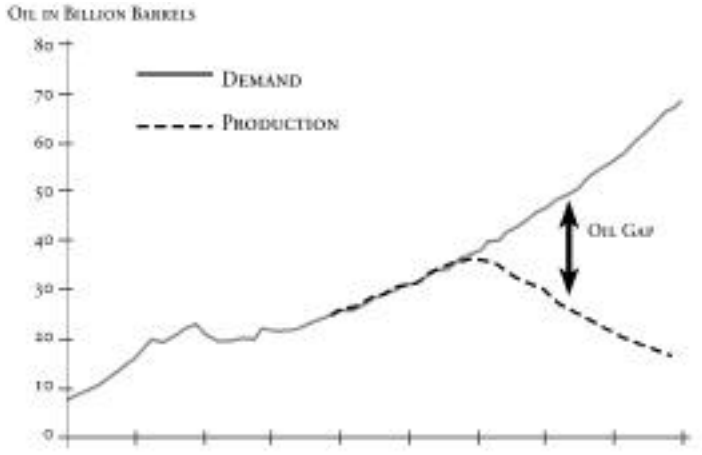
### Energy and Environmental Compatibility

The U.S. transportation system consumes approximately 12.5 million barrels of oil each day.[3] This is roughly equivalent to all domestic oil production plus one-half of oil imports. In effect, this makes our Nation's transportation enterprise dependent on foreign sources of energy. Reducing the amount of foreign oil consumed in transportation would help our economy and reduce our vulnerability to uncertain foreign oil sources. (See Chart 3.)

Although exact calculations vary somewhat, most experts agree that the total world output of conventional oil will peak around 2020 at approximately 35 billion barrels per year, and then begin a long-term decline. (See Chart 4).

However, the world's unconventional petroleum reserves of heavy oil, tar sands and oil shale are many times larger—by some estimates up to 100 times larger—than conventional oil reserves. At the current conventional oil cost of about $30 per barrel, these unconventional sources become economically feasible.[4] Thus, it is possible that petroleum fuels will remain available and reasonably priced for the indefinite future.

**Chart 4: Projected Total Conventional Oil Production, 1960–2050**




*Source: Birky, Greene et al "Future U.S. Highway Energy Use: A Fifty Year Perspective", prepared for the U.S. Dept. of Energy, December 4, 2000 draft, p. 5.*

Unfortunately, the environmental consequences of continuing to rely on petroleum fuels may be unsustainable. Increasing petroleum consumption immediately raises concern over the health of the global ecosystem as well. Annual world carbon emissions from these fuels are projected to more than double: from the current 1 billion metric tons to more than 2.5 billion metric tons in 2050. (See Chart 5).

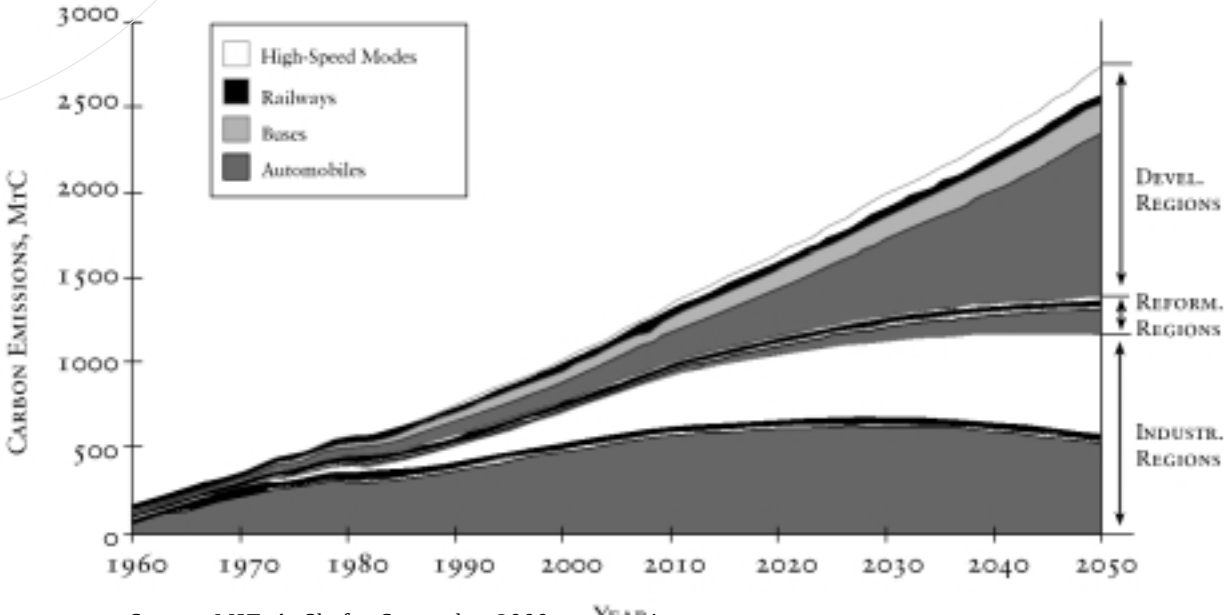
Meanwhile, transportation fuel continues to be a major contributor to poor air quality. Despite technology gains over the past three decades, our transportation system still accounts for about 30 percent of all emissions of volatile organic compounds, 40 percent of ozone-forming pollutants, and about 80 percent of carbon monoxide emissions, and is a significant source of fine particulate matter emissions.[5] The impact of

fuel spills and runoff on land and water quality is an additional concern.

Looking forward, changes in fuels, vehicles, and practices could yield significant local and global benefits in the areas of energy security and the environment. However, practical solutions for reducing greenhouse gas emissions within the transportation sector might be elusive in the short term. Moving to non-carbon-based fuels and very efficient vehicles would allow the United States to eliminate its dependence on unreliable foreign sources while improving local air quality and reducing the emissions of greenhouse gases. Although this shift may not have a major impact for at least 20 years, we still need to start making these adjustments now if we are to avoid potential environmental catastrophe.

Community noise concerns are constraining highway projects, aircraft operations, and airport expansions in and around most of our major cities. Since 1990, the country has spent more than $500 million annually to install sound barriers along major highways and acoustic insulation in residences near airports.[6] Transportation must reduce the noise impact on communities if we are to provide full service to the traveling public and cargo customers.

**Chart 5: World Carbon Emissions Projections: 1960–2050**




*Source: MIT, A. Shafer, September 2000 presentation*

## III. Vision: An Integrated Transportation System for the 21st Century

Transportation is about mobility—moving people, goods, and ideas anywhere, anytime, on time at an affordable price. It is about providing safe, reliable, economical, and environmentally friendly mobility for all Americans; enhancing their quality of life; and enabling them to do what they want to do when they want to do it. In order to provide this capability in the future, the transportation system needs to be:

- *Integrated*, providing our citizens and businesses with seamless, convenient, safe and secure service anywhere in the United States and in the world;
- *International*, connecting us to the rest of the world;
- *Intermodal*, functioning as one seamless transportation system that provides convenient connections and transfer facilities in and among all modes, maximizing passengers' and shippers' options for convenience, efficiency, and reduced costs;
- *Inclusive*, providing safe, reliable, affordable, and convenient service to all of our citizens, wherever they may live, work, travel, or ship;
- *Intelligent*, enabling the integration and transformation of our system into a more efficient international, intermodal, and inclusive service; and,
- *Innovative*, creating an environment that will enable America to transform new technologies, concepts, and ideas into new transportation products, processes, and services more quickly and less expensively.

Building on this, the vision of an integrated transportation system in the year 2050 is:

- *An integrated national transportation system that can economically move anyone and anything anywhere, anytime, on time;*
- *A transportation system without fatalities and injuries; and,*
- *A transportation system that is not dependent on foreign energy and is compatible with the environment (e.g., with respect to noxious emissions, greenhouse gases, noise).*

The current national transportation system is made up of three sets of transportation services—land (e.g., pedestrian, highways, transit, motor carriers, rail, pipelines), water (e.g., ports, waterways, pipelines), and aerospace (e.g., aviation; commercial, civil and military space). These three elements are connected intermodally (as depicted by the overlaps in Figure 1) to provide for the efficient and effective transport of people and goods between two or more places.

### Integrated Transportation System

The highest level of intersection occurs when land, water, and aerospace modes overlap, such as major international hubs in New York City, Seattle, and Los Angeles. This is true intermodal service, providing transportation options that could maximize convenience and efficiency with seamless transition among all three services.

Technologies for gathering, storing, processing, displaying, using, communicating, and managing information—sensory, temporal, geographic, environmental, situational, status—are becoming pervasive and are revolutionizing transportation. All facets of transportation—vehicles and infrastructure—are incorporating information technology in their design, development, operations and use, not only making individual modes more efficient but also improving the efficiency of the system as a whole.

The information revolution will ultimately be as important to transportation as the invention of the automobile and jet engine. And though the course of this revolution is not clear, it is providing unprecedented opportunities to develop an integrated national transportation system that will improve safety and mobility of people and goods while reducing its impact on the environment and energy consumption. The consequences of this revolution will only accelerate as we move further into the knowledge age.

"Information technologies are also reshaping our transportation demand. New ways of working, innovative business models, and lifestyle changes are changing our needs for transportation—and the ways in which we satisfy them."[7] Information technologies provide the capability to deliver certain products and services as well as provide some human interaction without the need for physical transportation or travel. This includes e-commerce, telecommuting, tele-presence and other forms of tele-operations and substitution. For some, this revolution represents the birth of a fourth, "virtual" mode of transportation. Regardless, it does reinforce the importance of information technology to the future success of an integrated transportation system.

*"Moving anyone and anything anywhere, anytime, on time!"*

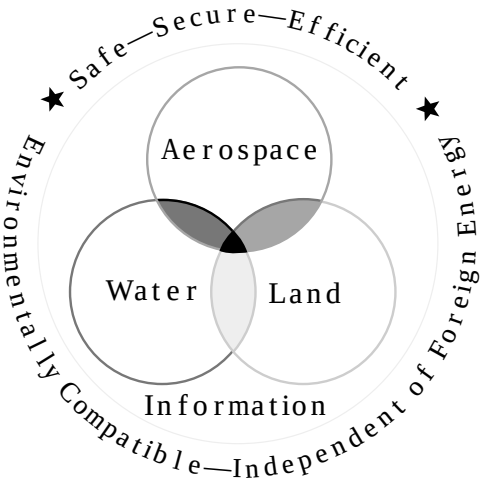



**Figure 1—Concept of Future Integrated Transportation System**

## IV. Technology and Concepts to Support the Vision

We realize that it will be difficult to achieve the transportation vision outlined in this document. But we also realize that America is a mobile society, and its people will accept nothing less than the freedom to move themselves and their goods safely and securely wherever and whenever they want to, without an adverse impact on the environment.

We also expect that new technology and concepts will emerge that will help us achieve these goals and objectives. In 1900, for example, automobiles and powered flight were viewed as the dreams of a few, but within 10 years—not 50—Henry Ford was mass-producing the Model T and the Wright Brothers had demonstrated that human beings could fly.

#### Mobility Vision for 2050

*We will develop an integrated transportation system capable of economically moving anyone and anything anywhere, anytime, on time.*

The key to providing this level of mobility is to take a holistic, global, and integrated view of transportation services and operations. Such an approach will result in a system that is actually a system of systems, with multiple interfaces and shared information and infrastructure elements. Unless we adopt this new approach, we will continue to spend hundreds of billions of dollars in the coming decades on old, mode-specific concepts that cannot even handle today's demands, let alone those of the future. The Nation needs a new, integrated, systems-architecture approach to transportation planning and operations that will maximize public and private-sector investments in meeting both our transportation needs and our societal needs. The following are some options for achieving this:

- Reduce demand for some kinds of transportation by replacing physical movement with "virtual" movement of people and goods where appropriate (telecommuting, e-commerce, etc.).
- Improve system and modal efficiency by providing reliable and seamless transportation options and common, quality information for all modes.
- Improve operational management by creating new inter-institutional arrangements–both formal and virtual–often crossing public and private lines to overcome current jurisdictional and sectoral fragmentation.
- Develop efficient and effective means for selecting and completing infrastructure projects, especially information infrastructure, that add to transportation system capacity without causing an impact on other important areas of life (land use, the environment, etc.).
- Rationalize system design and operations at a level above the individual modes, to improve the flow of people and goods at intermodal transfer points (sea to rail, land to air, etc.).

- Improve the availability of transportation services by increasing the coverage of feeder connections and by expanding from a hub-and-spoke system to a distributed network for national, regional, and line-haul services.

Technology will be a major factor in defining, developing, and implementing an integrated national transportation system, including:

- *Tools for system definition and transition.* High performance computing will enable us to develop large-scale models and simulations of the transportation system. These tools will enable usto assess system performance, conduct trade-off studies and define potential transition paths to an integrated system before developing and fielding operational systems.
- *System optimization.* Large-scale information networks, such as the Department of Defense's global information grid, will enable us to exploit underused assets to increase capacity or expand service coverage. Distributed computing techniques will enable system-level and in-vehicle real-time trip planning, tracking, and decision support systems to facilitate best-value decisions based on an assessment of all options. High-confidence systems and high-bandwidth communications will ensure connectivity among all system elements, regardless of the environment or security threats.
- *Modal optimization.* Intelligent vehicles will be able to monitor and adapt to their environment, ensuring operator safety and comfort. Automated vehicle operations and decision-support tools will enable vehicle-centric route optimization, increasing system-level safety and efficiency.
- *Next generation of vehicles.* High fidelity collaborative and engineering environments with human interfaces will enable industry to simulate an entire product life cycle, dramatically cutting development costs and schedules. New materials, structural designs, and propulsion systems—including alternative fuels—will lead to the development of new classes of super-efficient, intelligent, reliable, and environmentally friendly vehicles.

### Safety and Security Vision for 2050

*We will eliminate transportation-related fatalities and injuries.*

In the face of projected growth in demand for transportation services, achieving these safety and security goals will require a proactive approach to prevent crashes, incidents, and mishaps from occurring. The approach will require system concepts and procedures that compensate for human error, physical malfunction, and environmental disruptions. The following are some options for achieving this:

- Develop a better understanding of human behavior and performance when operating or using transportation systems.
- Pursue a human-centered systems design and operations philosophy that will enable transportation systems to adapt to their human operators rather than depending on operators to adapt to them.

- Consider vehicle, infrastructure, human, and environmental issues simultaneously when designing and developing transportation systems.
- Ensure that education and skills training is provided to improve the performance of all transportation users and operators.
- Ensure that no transportation service is ever denied if it is critical to meeting our national security objectives.
- Protect the transportation system from terrorist attack and from being used to introduce weapons of mass destruction and other threatening contraband.

A broad spectrum of technology will be required to achieve this, including:

- *Human-centered systems.*[8] Human error and situational awareness are the leading contributors to transportation-related safety problems, accounting for between 70 and 90 percent of all crashes and incidents in all modes. They also contribute to operational inefficiencies that reduce overall system performance. The application of advanced micro-sensors, processors, and expert systems will enable systems to adapt to and compensate for human error and facilitate task completion, so that operators can focus on task performance and not be distracted by the technology.
- *Lifetime learning.* Advanced instructional technology, such as computer-based instruction and simulation, will provide all operators and users with the skills they need to operate safely in all situations. This is particularly true for young drivers, who do not have the experience to react appropriately to certain driving situations, and for older drivers, who have the experience but are losing their reflexes.
- *Prevention.* Smart sensors, microprocessors, and adaptive control systems will enable vehicles to monitor their own performance, their environment, and their operators in order to avoid crashes, mishaps, and incidents. Intrusion detection technologies will be able to monitor information systems and networks continuously, warning operators and users of potential system problems or cyber-attacks before they manifest themselves in system degradation.
- *Automation.* Automated aids and intelligent advisors will elevate the operator to a systems manager who directs the desired outcome rather than controlling system elements, improving both safety and performance. Automation will also provide a safety net that automatically brings a disabled vehicle to a safe haven and activates recovery actions.
- *Protection.* Materials with a high strength-to-weight ratio based on nanotechnology will enable new vehicle designs that can withstand crashes and protect the passengers against injury. New detection methods will be able to sense and identify trace amounts of explosives and chemical and biological agents in a totally non-intrusive way, to protect all transportation modes against terrorists without constraining traffic flow

### Energy and Environmental Compatibility Vision for 2050

*We will develop a transportation system that is not dependent on foreign energy and is compatible with the environment (e.g., with respect to noxious emissions, greenhouse gases, noise).*

Sustaining U.S. economic growth while making significant reductions in transportation-related energy consumption and environmental impact will require a transition to efficient zero-emission vehicle technologies and renewable fuels. It will also require a shift to quieter vehicle designs, as well as changes in operations and land use to eliminate the impact of remaining vehicle noise. The following are some options for decreasing energy use and improving the environment:

- Increase the efficiency of energy use and the transportation system.
- Encourage the use of demand-reduction strategies (e.g., telecommuting) and more environmentally benign modes of transportation.
- Move from carbon-based fuels to non-carbon-based fuels.
- Continue an emphasis on attenuating the negative impact of transportation services and facilities on the environment, such as community noise.
- Promote land-management planning techniques that integrate transportation and development concerns, making new urban and rural growth patterns more compatible with transportation.

Technology will be a major factor in achieving this, including:

- *Quiet and efficient transpor tation.* New materials, active/passive noise attenuation technologies, drag reduction and flow management, and new vehicle types (e.g., electric, fuel cells) will enable vehicles to operate efficiently with little noise, and possibly even below ambient noise conditions. Large-scale information networks will enable us to exploit underused assets to increase transportation efficiency and service coverage.
- *Clean transportation.* Advanced battery and fuel cell technology, electric power trains, and advanced designs will eliminate noxious emissions from most surface vehicles. Depending on the method chosen, transitioning to hydrogen fuel would bring multiple benefits for all modes. Several technological issues must still be resolved to use hydrogen as a fuel, such as the best method of generating and storing hydrogen fuel and implementing a nationwide infrastructure for delivering the fuel to vehicles. Success in this effort, however, could both eliminate transportation's contribution to greenhouse gases and end the Nation's dependence on foreign sources of energy for transportation.
- *Energy and Environmental Planning.* Advanced modeling and simulation tools will enable the planning for local, regional, and national transportation systems, expedite decision making, and enable smart use of the existing infrastructure (e.g., airports) and energy resources while preserving existing wetlands, parklands, historic areas, and other environmentally sensitive sites.

## V. Investments in Research—Enabling Tomorrow's Transportation Breakthroughs

Attaining the vision of an integrated transportation system will require investments by the government and industry in key enabling research areas. The Council on Competitiveness reports that a handful of critical factors are highly and positively correlated with the success of a nation's innovation system , including:

- The size of the labor force dedicated to research and development and other technically oriented work;
- The amount of investment directed at research and development;
- The resources devoted to higher education; and,
- The degree to which national policy encourages investment in innovation and commercialization.[9]

Increasing the federal budget for transportation research and development, as desirable as that would be, is insufficient. Encouraging private research and development investments, particularly on long-term projects, and attending to the vitality of basic research at universities both need to be part of the solution. It is imperative that the federal government, and the states, work with academia and the private sector to leverage the total federal research investment for the benefit of the transportation system as a whole.

The following research areas, if supported by sufficient resources and effort, could dramatically transform transportation in the future:

- Human performance and behavior;
- New computer, information and communications systems;
- Advanced material and structural technologies;
- Energy, propulsion and environmental engineering advances;
- Sensing and measurement technologies;
- Analysis, modeling, design and construction tools; and,
- Social, economic, and institutional policy issues

The Department of Defense, Department of Energy (DOE), and the National Aeronautics and Space Administration (NASA) make the largest federal research investments in these areas today. Thus, the Department of Transportation and its stakeholders need to work with these agencies to leverage their investments for the benefit of the transportation system as a whole. In addition, the transportation enterprise needs to work with the scientific community, especially the National Science Foundation, DOE, NASA, and the Defense Advanced Research Projects Agency (DARPA), to investigate emerging research areas that will likely revolutionize transportation system performance in the future. These areas include information technology, nanotechnology, fuel sources (e.g., hydrogen), energy-efficient and environmentally friendly technologies, and biotechnology.

Developing the right kinds of technological advances to meet demands for transportation services in the future will require many bright, well-educated people. The U.S. must rebuild its dwindling pool of scientists and engineers. This will require investments in primary education, as well as a major effort to provide transportation-related technical training at the undergraduate and graduate level. Involving universities in transportation-related research activities will enhance the capabilities of these institutions, increase the size of the labor force dedicated to research and, at the same time, help prepare the work force of the future.

## VI. A Call to Action

We cannot wait until the transportation system becomes gridlocked to take action. Solutions will take decades to realize. We must act today to avoid major problems in the future. The federal government—acting on behalf of the public—must provide the leadership; policy guidance; and investments in research, education, and infrastructure necessary to achieve the vision proposed in this document. But the federal government cannot achieve this vision alone.

There are broad, complex, and inter-related elements essential to creating an innovative environment in transportation that will enable the Nation to sustain its economic growth and the quality of life of all Americans. These elements include leadership and commitment from the transportation community at large and an overall system architecture to guide and sustain changes in the system over the next century.

The availability of human capital, cutting-edge research, and innovative system concepts and infrastructure; the legal, regulatory, and capital conditions necessary to transition ideas into wealth-creating products and services; and access to international markets and manufacturing capabilities are all essential parts of the process. In addition, because thousands of government, industry, labor, non-governmental, and academic institutions play key roles in developing, maintaining, and operating the Nation's transportation system, alliances are critical. Some of these alliances must be formalized into new institutions to better operate our transportation system. These alliances will require shared governance among the stakeholders and a new decision-making framework that changes focus:

- From exclusive to inclusive participation;
- From single to multiple goals;
- From local and regional to national and international;
- From short-term to long-term;
- From "winner take all" to shared gains;
- From power control to power sharing; and,
- From authoritarian to facilitative leadership.

Weakness of any of the essential elements will diminish the others and, indeed, hinder the Nation's ability to meet the challenges of its transportation system. Most of the elements of change are beyond the purview of science and technology alone; they need to be addressed in a systemic way by the entire transportation community if the Nation is to realize the benefits of the scientific and technological revolution currently under way.

In order to make this transformation and to realize the improvements that are necessary in our transportation system, the Federal Transportation Working Group recommends that the President take the following actions. Most of the actions are institutional in nature, because the federal government is not organized and incentivized today to develop an integrated national transportation system.

***Presidential Leadership Matters.*** *Presidential leadership is needed now.* This leadership is of the utmost urgency and importance. Transportation is a national problem that requires Presidential leadership and a national team—the Congress, state and local governments, industry, labor, academia, and non-governmental organizations—working together to solve these issues successfully.

*Recommendation 1.* The President should declare that improving the nation's transportation system is a top priority. He should form a bipartisan commission to examine ways in which the Nation can address the pressing transportation problems facing our country: congestion, safety and security, and energy and environmental compatibility. The commission should build on the vision laid out in this document and should define a bold action agenda to achieve it.

***National Strategy Matters.*** The Department of Transportation *Strategic Plan*, which is required by the Congress, addresses only the Department's responsibilities in meeting national transportation needs. The Nation needs a national strategy that includes all stakeholders in its development and defines the national goals and objectives, as well as the actions necessary to achieve the vision laid out in this document.

*Recommendation 2a.* Working with the Presidential Commission, the Secretary of Transportation should lead a bipartisan effort to develop a *National Transportation Strategy* by January 2002, to guide transportation policy and investments. The *Strategy* should provide a framework for future mode-specific transportation authorizations, such as TEA-21 and AIR-21.

*Recommendation 2b.* The Assistant to the President for Science and Technology should lead a national effort to develop a 25-year innovation roadmap for achieving the vision laid out in this document. The roadmap should be completed by March 2002, and should contain detailed plans for transportation system research and technology, including cross-cutting as well as land, water, aerospace, and information elements.

***Multi-Modal Leadership Matters.*** The federal government does not have an advisory group that can provide the Congress, the President, the Secretary of Transportation, and other Cabinet members with advice from all of the transportation modes and organizations; advice they need to establish national transportation policy and to guide federal investments. As a result, federal transportation policy tends not to take a long-term, systemic view of transportation-related challenges and opportunities, but it needs to do so.

*Recommendation 3.* The Secretary of Transportation should create a permanent Federal Advisory Committee, that reports directly to the Secretary, made up of representatives from all transportation modes and user groups, to provide guidance to the President, the Secretary of Transportation, and other Cabinet members on national transportation policy issues.

***National System Architecture Matters.*** The integrated transportation system needed to achieve the

vision described in this document will not become a reality unless there is an overall architecture for the future transportation system and a viable transition plan from our current systems to the new integrated system. An integrated transportation system would actually be a system of systems with multiple interfaces and would share certain infrastructure elements, such as communications, navigation, and information systems.

*Recommendation 4.* The Secretary of Transportation should have the Director, Office of Intermodalism, work with the transportation community to form a non-profit, public-private sector organization, like ITS America, to help the government define and maintain an architecture for a national transportation system.

*People Matter.* The robustness of the transportation system is based not only on technology and infrastructure, but also on human capital. Investments in human capital are important to maintain the competence of our current work force—mechanics, pilots, operators, policy makers, planners, and construction workers—as well as to develop the next generation of transportation professionals who will develop and support future innovations in transportation.

*Recommendation 5.* The Secretary of Transportation, in coordination with the transportation community, should conduct an assessment of future work force and education needs, and develop a comprehensive lifetime learning program through the Nation's universities and community colleges, to double the number of individuals able to pursue careers in transportation in 10 years.

*Research Matters.* Achieving the vision laid out in this document will require investments by the federal government in key enabling research, innovative transportation system concepts, and advanced technology development. Section V. of this document lists enabling research that, if—if supported by sufficient resources and effort,—could dramatically transform transportation in the future.

*Recommendation 6a.* The President and the Congress should significantly increase the funding for long-term, high-risk, transportation-related research over the next 10 years as is being recommended for other federal research. The federal transportation research portfolio needs to address critical technical and operational problems facing transportation today, as well as invest in areas that could provide the transportation breakthroughs of the 21st century, such as information technology, nanotechnology, fuel sources (e.g., hydrogen), energy efficient and environmentally friendly technologies, and biotechnology.

*Recommendation 6b.* The President and the Congress should create a civilian counterpart to the Defense Advanced Research Projects Agency, to stimulate and demonstrate high-risk, high-payoff transportation technologies and concepts with the transportation sector and to accelerate their deployment and operational use.

*Infrastructure Matters.* The existing physical infrastructure for surface transportation has slowly evolved over decades of incremental additions and improvements. Recent large-scale transportation projects—such as the Boston Central Artery/Tunnel ('Big Dig')—have taken decades from inception to completion. The global transportation vehicle fleet and the Nation's information and energy infrastructures also represent a massive financial investment that will remain operational for many decades. If new technologies and concepts are to be fielded, improved methods must be found for accelerating their deployment, implementation and renewal.

*Recommendation 7a.* The Secretary of Transportation should work with the transportation sector to implement the Partnership for the Advancement of Infrastructure and its Renewal—Transportation (PAIR-T). The purpose of the industry-led PAIR-T initiative is to revitalize and renew our Nation's infrastructure by eliminating the barriers that impede the introduction and widespread use of innovative technologies and concepts.[10]

*Recommendation 7b.* The Secretary of Defense and Secretary of Transportation should develop a plan for integrating transportation into the global information grid. The Department of Defense is developing the grid to manage its assets (including people and freight) globally in peacetime and in wartime. The Department of Transportation and the transportation sector should leverage this significant investment to improve the safety, efficiency, and security of the Nation's civil and commercial transportation systems. The Department should also ensure that there is sufficient resources and technical expertise to maintain and operate the Nation's growing information infrastructure for transportation.

*Recommendation 7c.* The Secretary of Energy and Secretary of Transportation should assess the infrastructure requirements for an economy based on non-carbon fuels (e.g., hydrogen) and related transition issues. Moving to non-carbon based fuels would allow the United States to eliminate its dependence on unreliable foreign sources, while improving local air quality and reducing the emissions of greenhouse gases. This shift might not have a major impact for at least 20 years, but we need to start making these adjustments now if we are to avoid potential environmental catastrophe.

*Partnership Matters.* The need for partnerships and alliances in transportation is imperative, if we are to achieve the vision laid out in this document. But partnering is not easy. The National Science and Technology Council studied the challenges faced by the private and public sectors in creating partnerships, especially in areas where motives, resources, and legal and institutional constraints differ.[11] For example, government and academia are often interested in partnering to advance a broad-based research agenda, whereas the private sector's interest in partnering usually has a narrower basis, due to a stronger financial and near-term market focus. We need to minimize these differences, so

we can optimize our collective energies and resources for a common good. A key area for improved partnering revolves around a heightened commitment to improve system operations on a performance-driven, customer-responsive basis.

*Recommendation 8.* The Secretary of Transportation should continue to foster partnership arrangements throughout the transportation community, providing the incentives to partner and helping to eliminate the social, institutional, and cultural barriers that hinder success. The Secretary should provide particular attention to multimodal and information technology partnerships, those areas most critical to the development of an integrated national transportation system.

*Legal and Regulatory Framework Matters.* Cost and time-to-market decisions are critical components for being competitive in the global economy. The regulatory and legal systems have a profound impact on both, and they need to be streamlined in order to get ideas to market more quickly and affordably. In transportation, many regulations have not kept pace with rapidly changing technologies or global industries. In other areas, government regulations at the federal, state, and local levels are cumbersome and often conflicting, especially in the environmental area.

*Recommendation 9.* The Secretary of Transportation should create a government-university-industry task force to identify ways of eliminating the regulatory and legal barriers to innovation in transportation.

*Capital Matters.* Although recent surface transportation and aviation authorization bills made available record levels of funding for capital improvements in the states, they provided limited research and development that would move the transportation toward a truly integrated multimodal system within the United States and across North America. Unlike the European Union, which taxes its member nations and its imports to provide such a venture capital fund for research and development, the United States has little capital to fund research and technology demonstrations that could lead to significant improvements in transportation system-level performance.

*Recommendation 10.* The President and the Congress should create a transportation investment fund with the transportation sector, to provide the research and development necessary to spur innovative and system-level solutions in transportation.

*The nation has not had a bold vision for transportation in 45 years, since President Eisenhower signed into law the Federal-Aid Highway Act on June 29, 1956. That law created the interstate highway system and transformed America into a mobile society. We believe that the nation needs a new transportation vision now for the next 50 years. The nation's economic strength and the quality of life of all American depend on it. We call upon the President to lead this effor t and to take the bold steps necessary to achieve the vision laid out in this document.*

## Footnotes

1. U.S. Department of Transportation, Bureau of Transportation Statistics, *National Transportation Statistics 1999*, pp. 129, 157–158.

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