

Critical Issues in Transportation 2002

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The Transportation Research Board is a division of the National Research Council, which serves as an independent adviser to the federal government on scientific and technical questions of national importance. The National Research Council, jointly administered by the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine, brings the resources of the entire scientific and technical community to bear on national problems through its volunteer advisory committees.

Critical Issues in Transportation 2002

Because transportation is important to the U.S. economy and to individual well-being, the Executive Committee of the Transportation Research Board (TRB) periodically identifies and assesses critical issues in transportation to

- Direct attention to the issues,
- Facilitate debate on how to address the issues, and
- Encourage research to resolve the issues.

The terrorist attacks of September 11, 2001, have disrupted a benefit that Americans have taken for granted—the ability to travel conveniently, safely, and at reasonable cost. Much of the success and efficiency of the U.S. transportation system is attributable to easy and convenient access by travelers and shippers—yet these attributes also make the system vulnerable to terrorist attack. Greater attention must focus on improving transportation system security; research must play an important role.

However, we must not neglect other issues—also outlined here—that are critical to maintaining and increasing the levels of transportation service on which Americans depend.



John M. Samuels
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Historically, the U.S. transportation system has been among the best in the world, providing a remarkable level of mobility and access to goods and services. Moreover, the system's quality and pervasiveness have been influential in shaping development patterns both locally and nationally.

In many respects, however, the system has become the victim of its own success. The affluence that the system has helped to create has resulted in a demand for travel and access that is increasingly difficult to meet, as witnessed by the growing congestion and delays that characterize all transportation modes. Although this congestion may abate in the short term, the problems will return.

In addition, the system's expanding infrastructure has intruded increasingly on neighborhoods and the environment. Society's responses—or failure to respond—to the complex challenges will have fundamental consequences for the nation's prosperity and quality of life, as well as for the environment.

Transportation System's Importance

In a country as vast as the United States, it is easy to lose sight of the tremendous size of the transportation infrastructure and the magnitude of its effects:

- The scale and use of the system are extraordinary (see Table 1). All modes of transportation combined account for more than 4.6 trillion passenger-miles of travel annually. The value of the goods shipped each year totals nearly \$8 trillion, and transportation's contribution to the global nature of the U.S. economy is

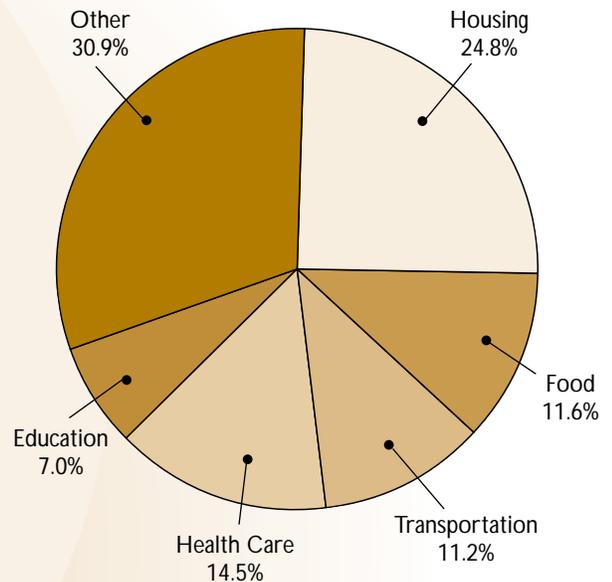


FIGURE 1 U.S. gross domestic product by major societal function, 1998. (SOURCE: Bureau of Transportation Statistics, U.S. Department of Transportation.)

reflected in the \$1.5 trillion in international cargo moving through U.S. ports by various modes annually.

- Transportation is a major component (11 percent) of the gross domestic product (GDP)—roughly equivalent to the shares of health care and food (see Figure 1). It also is a major component of family expenditures (19 percent), second only to expenditures for housing.
- Individuals spend an average of one hour each day traveling for work, shopping, medical appoint-

TABLE 1 Scale and Use of the U.S. Transportation System

Mode	Components	Annual Output (1997)
Highway	3,921,000 road miles	4,130,200,000,000 passenger-miles 1,051,000,000,000 ton-miles
Air	5,352 public airports	463,000,000,000 passenger-miles
Urban Transit	Bus: 156,000 route miles Rail: 6,600 route miles	20,400,000,000 passenger-miles 21,300,000,000 passenger-miles
Rail	120,000 freight rail miles	1,348,900,000,000 ton-miles
Water	20,000 port terminals	707,410,000,000 ton-miles
Oil Pipeline	200,500 pipeline miles	617,000,000,000 ton-miles

SOURCE: Table 1-38. National Transportation Statistics, Bureau of Transportation Statistics, U.S. Department of Transportation, 1999.

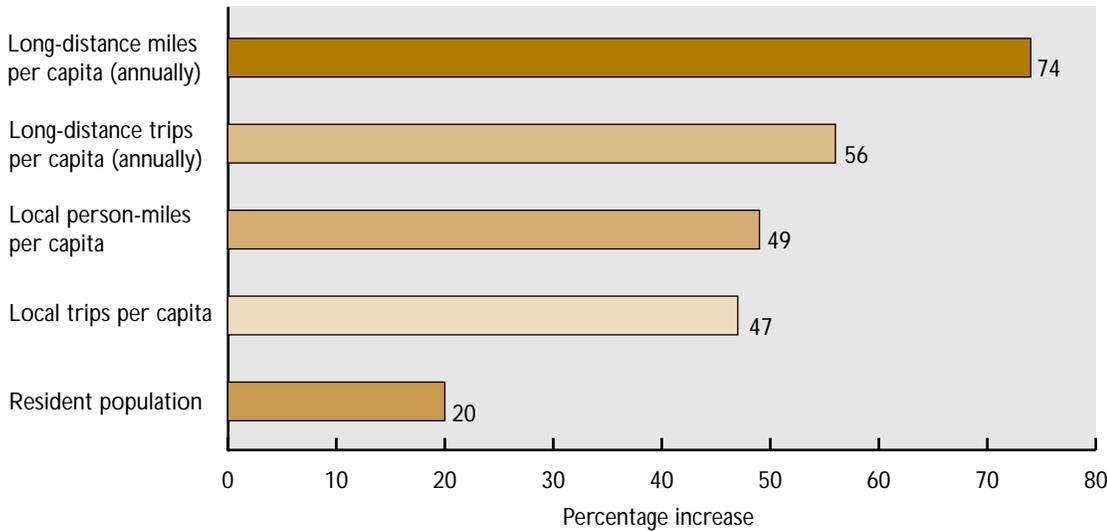


FIGURE 2 Percentage increase in population and travel in the United States, 1977–1995. (SOURCE: Table 5-1 in *Changing Face of Transportation*, U.S. Department of Transportation, 2000.)

ments, socializing, and recreation. Although the population has grown only by 20 percent in 18 years, trip making per capita has grown by 50 percent, as has the distance traveled (see Figure 2).

- The nation's inventories, which once resided in warehouses, are now almost constantly in motion in trucks, rail cars, and seagoing containers. Any significant disruption in the flow of this inventory would have dramatic negative consequences for the U.S. economy. The system moves more than 15,000 ton-miles of freight per capita each year.

As the globalization of the economy continues, U.S. national and international competitiveness will depend on the ability to move people, goods, services, and information quickly, cheaply, and safely.

Critical Issues

Important challenges face users and providers of transportation services; the TRB Executive Committee has identified 14 issues as most critical (see box on this page). Many of these issues are interrelated, but each is described separately as follows.

The transportation system is vulnerable to attacks by terrorists and saboteurs.

The U.S. transportation system was designed to serve an open society and a market economy. The emphasis is on efficiency, speed, and reliability. The features that tie transportation to the way of life in the United States, however, also make the system vulnerable to attack. Redundancies in the system make it unlikely that the physical infrastructure could be rendered inoperable for any length of time.

Terrorists, however, act to cause mayhem and suffering. Transportation becomes a target by concentrating people in aircraft and terminals and on vehicles that travel through tunnels and over bridges. The tragedies of September 11, 2001, demand that security must become a central goal of transportation. Achieving that goal will be difficult and costly, but necessary. New technologies, operations, and strategies for deterrence are needed.



PHOTO: JAMES R. TOURELLOTTE

Security must become a central goal of transportation.

Critical Issues 2002

- Security
- Safety
- Congestion
- Institutional Constraints
- Environment
- Energy
- Aging Infrastructure
- Finance
- Human Resources
- Industry Consolidation
- Aging Population
- Equity
- Impact of Telecommunications
- Barriers to Innovation

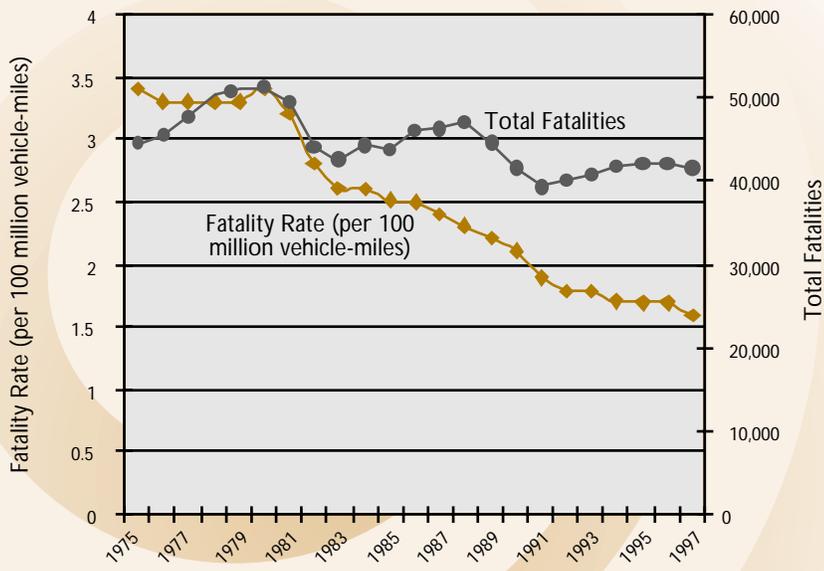


FIGURE 3 Fatalities and fatality rate on U.S. highways. (SOURCES: National Highway Safety Administration, U.S. Department of Transportation, Traffic Safety Facts 1998; Bureau of Transportation Statistics, Annual Report 1999.)

Fatalities and injuries from transportation crashes are a major public health problem.

Fatality and serious injury rates associated with transportation have declined steadily. Yet more than 40,000 people die each year in transportation crashes; 95 percent of these crashes occur on the nation’s highways (see Figure 3); additionally, more than 3 million people are seriously injured. About 85 percent of highway deaths claim motor vehicle occupants and the remaining 15 percent comprise pedes-

trians and cyclists, who are the most vulnerable to injury from collisions.

Although vehicle manufacturers and infrastructure owners continue to introduce safety-enhancing features for vehicle occupants, most of the obvious, politically feasible improvements with major benefit have been made. Even so, thousands of deaths could be averted each year at low cost if the use of safety belts increased beyond 70 percent of motorists. Strategies for reaching higher-risk drivers involve stronger state laws or other interventions that lack political support. Nevertheless, behavioral change may be key to continued reductions in traffic fatalities and injuries; further improvements will require ingenuity and political will.

The demand for passenger travel and freight movement is straining the capacity of the U.S. transportation system.

Congestion in the transportation system is worsening as demand outstrips the ability to add capacity. Increased travel is a product of population growth, but the number of trips per capita is also increasing. Midrange projections by the Bureau of the Census indicate that in less than 25 years, the U.S. population will increase by 60 million—roughly equivalent to adding twice the population of California. Immigration will account for a substantial share of this growth, but is difficult to predict.

The greatest challenge will be accommodating the housing and transportation demands in metropolitan areas in which people are likely to settle. During the last decade of economic prosperity, pas-

More integrated technologies and improved approaches to demand management and system operations—as well as additional infrastructure—will increase the capacity of the U.S. transportation system.



senger and freight trips by air, transit, highway, and rail grew at a much greater rate than capacity. The result is increased congestion and frustration. Delays due to air and roadway congestion cost an estimated \$75 billion annually in lost time and wasted fuel.

The physical capacity of the system is growing more slowly than before for various reasons, including cost, community resistance, and environmental concerns. Operators of all modes are attempting to increase throughput with new intelligent technologies and system management procedures for aviation, rail, road, transit, and maritime operations. More integrated technologies and improved approaches to demand management and system operations—as well as additional infrastructure—are needed.

Current institutional arrangements constrain the orderly development, operation, and coordination of the U.S. transportation system, including facilities, modes, and services.

Whether capacity-enhancing technologies and new management procedures can be developed and whether techniques can be introduced to keep pace with escalating demand are open questions. New approaches not only must be developed, but must be applied by institutions created to build systems, not to manage operations.

The transportation system is a patchwork of loosely connected modes encompassing 35,000 government owners of roads; tens of thousands of private carriers; and thousands of independent authorities responsible for ports, transit systems, and airports. The funding mechanisms for these entities remain unconnected and uncoordinated, despite reforms incorporated into federal legislation.

Furthermore, in keeping with values of local, democratic decision making, much of transportation planning, programming, and implementation is conducted at the metropolitan and state levels. These processes are deliberate and time consuming. The result is a series of disconnects: on one hand, slow public planning and implementation, and on the other, ever-changing demands of private firms and individuals for transportation services.

On a regional basis, the major challenge for transportation agencies is changing the focus from building and maintaining infrastructure to operating and managing capital assets for maximum public benefit.

Worthy environmental goals and values pose serious challenges to the operation and expansion of transportation facilities to meet growing demand.

Public opinion data reveal that Americans place a high value on clean air and water and are increas-



ingly concerned about transportation's adverse effects on the environment. Individuals and communities oppose noise from operations, and debates about the long-term effects of transportation facilities on sprawling development are contentious.

Transportation officials are being asked to balance the public's conflicting demands. Yet the available tools for predicting the consequences of new or expanded facilities or alternative strategies for meeting transportation demand are inadequate. Neither the data nor the methods for deriving reliable estimates of costs and benefits are sufficiently developed. Regulations intended to achieve environmental and transportation objectives can cause lengthy and expensive delays in decision making and produce results that are less than satisfying for the parties involved.

Government and industry have invested heavily in producing cleaner-burning technologies and have made progress. However, introducing new technologies that will have higher initial costs requires incentives, which are lacking. Moreover, the level of public investment in research aimed at exploiting these opportunities—though substantial—pales against the importance of protecting and improving the environment. New ways must be found to satisfy public demand for travel and for meeting environmental goals.

Cleaner-burning technologies are progressing; however, new ways must be found to satisfy public demand for travel and for meeting environmental goals.

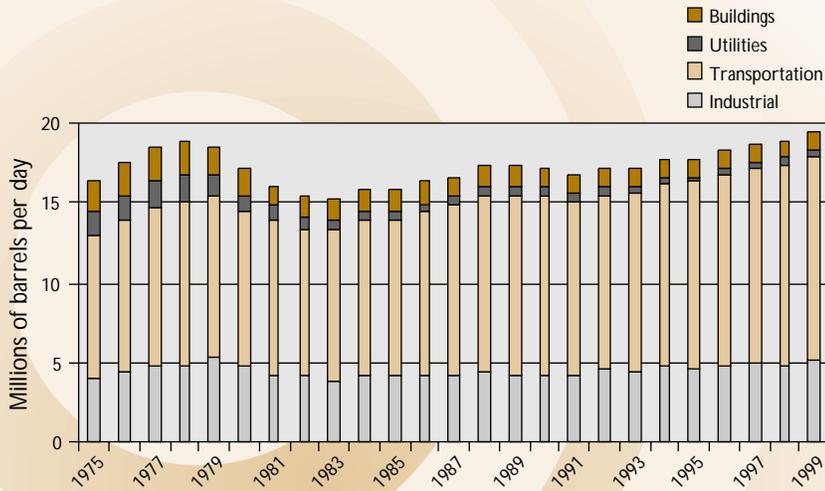


FIGURE 4 Annual total petroleum use in the U.S. economy, 1975–1999. (SOURCE: Figure 5-22 in *Changing Face of Transportation*, U.S. Department of Transportation, 2000.)

The U.S. transportation system, which depends on fossil fuels, faces an uncertain future with respect to the availability and cost of energy.

Transportation relies heavily on fossil fuels—primarily petroleum—and demand is increasing (see Figure 4). The consumption of fossil fuels produces emissions harmful to health and ecosystems, contributing to climate change. Sources of petroleum—including petroleum reserves, tar sands, and shale—appear to be plentiful, but the economic and environmental consequences of their use are worrisome.

Investment in technology and distribution systems is needed to make alternative fuels and propulsion systems competitive with petroleum-based fuels.



Recent dramatic price fluctuations have hurt the balance sheets of private carriers—fuel represents more than 10 percent of their expenses—and have caused budget problems for transit systems. Alternative fuels and propulsion systems appear promising, but considerable investment in technology and distribution systems will be needed to make these energy sources competitive with petroleum-based fuels.



Public agencies invest more than \$30 billion annually to maintain the highway and transit infrastructure.

The aging transportation infrastructure must be rebuilt, but the costs involved exceed revenues.

Major highway and transit assets built in the post-World War II era—including the entire Interstate system and most airports and transit systems—demand constant renewal and upkeep, necessitating large reinvestments to maintain capacity. Public agencies invest more than \$30 billion annually to maintain the highway and transit infrastructure. The U.S. Department of Transportation has estimated that the substantial funding increases incorporated in recent federal legislation for highway and transit infrastructure fall short of meeting the needs for maintenance and upkeep.

Railroads, which provide private financing for capacity enhancements, face the same imbalance of costs and revenues. The costs of maintaining waterways, airports, and air traffic control systems also are substantial. However, the price of not keeping up with transportation system demand is decreased productivity, products that are less competitive, and a lower standard of living.

The financing of publicly provided transportation infrastructure is not adequately matched to use or need.

Taxes on fuel have financed most of the nation's major highway and transit facilities. However, in the longer term, fuel-tax revenues are threatened by the growth in tax-exempt additives (such as ethanol), increased fuel efficiency, and the development of propulsion technologies not based on gasoline. Moreover, the trend toward increased reliance on sales taxes and general taxes in some jurisdictions is eroding the long-established principle of paying for transportation through user fees.

These alternative revenue sources also are more sensitive to changes in the economy and political priorities. Despite an almost unparalleled era of prosperity, the public sector is being forced to do more with less on many fronts and is becoming increasingly reliant on less-predictable revenue streams.



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Transportation organizations are having difficulty attracting and retaining the technically diverse personnel needed in the 21st century.

Changing technology in transportation has created a need for personnel with expanded skills. Transportation agencies, asked to adopt sophisticated technologies for operating systems and vehicles, are having difficulty attracting skilled personnel because of higher salaries available in private industry; however, even private firms that contract with transportation agencies are having difficulty finding workers with the needed skills.



Enrollments in engineering and other technical programs are declining, although the demand for individuals with advanced technical training has never been greater. Many questions face the transportation industry, including how to train, recruit, and retain sufficient numbers of persons with the requisite technological skills.

Changing technology has created a need for personnel with expanded skills.

Consumer benefits from deregulation are threatened by industry consolidation.

Reduced economic regulation of transportation industries has brought great benefits to consumers as firms have cut costs and expanded services. The marketplace has been tumultuous, but industry has become more productive and service oriented.

But even as industry continues to innovate and cut costs to meet customer demands, concern arises that further reducing the number of major airlines and railroads could result in insufficient competition. Government resistance to mergers is constrained by the potential failure of venerable firms, the resulting widespread impacts on shippers and travelers, and the cost savings that carriers derive from mergers.

Reduced economic regulation of transportation industries has brought great benefits to consumers, but competition may suffer.



Because driving skills decline with age and vulnerability to injury increases, alternative modes of transportation are needed for older drivers.



An aging population poses special safety and mobility challenges.

More than 19 percent of Americans will be age 65 or older by 2025, compared with 13 percent today. The mobility needs of older people change, but the majority of trips are made by automobile. However, driving skills decline with age, even as vulnerability to injury from collisions grows. Most people retire in the neighborhoods in which they have resided; these mainly suburban settings were designed around the automobile and are difficult and costly to serve with alternative modes. Nonetheless, alternative modes are needed.

The burden of owning and operating vehicles is increasing for the lowest-income families.

Transportation was the third-highest household expense in the 1970s; today it is the second highest. For affluent households, this change reflects personal preferences. For families with lower incomes, however, particularly those living in automobile-dominated metropolitan areas, costs for transportation compete in magnitude with those for housing. In many lower-income households in low-density suburbs, 25 percent of household income is spent on transportation.

Telecommunications and information technologies are likely to have significant but uncertain consequences.

The merging of telecommunications and information technologies with transportation offers the greatest potential for innovation in transportation. Like the sweeping changes effected by the Internet, the outcomes from merging the three domains cannot be predicted with certainty.

Possible outcomes include smoother traffic flows; greater ease in telecommuting, such as wireless Internet access for drivers and other travelers; and crash-avoidance technologies for all types of vehicles. At the same time, complex questions arise about system reliability, privacy, and liability; effects on dispersed development; and the risk that additional vehicle services and driver warning systems will detract from—not enhance—driving performance.

Transportation faces formidable barriers to innovation, which are compounded by growing constraints on research investments.

Although innovation offers promise in almost all disciplines of transportation, the challenges to developing and introducing innovations are daunting. Private manufacturers of new vehicles, for example, work in an environment that rewards innovation and can respond accordingly; the public sector, however, must address multiple social goals, which often slow the pace of decision making. Moreover, public agencies are reluctant to try new things in the face of uncertainty, conflicting objectives, and low public tolerance for failure.

Research programs are decentralized because operations are decentralized, and needs vary across the country. Decentralization, however, leads to pro-



Despite challenges, innovation offers promise in almost all disciplines of transportation.

grams of modest scale addressing only near-term problems. Longer-term, higher-risk research efforts are difficult to sustain.

The ability of federal mission agencies to invest in such programs is also increasingly constrained by congressional designations of research and development (R&D) funds. The earmarking of research funding—a practice that has grown with each budget cycle—bypasses the quality-control mechanisms of competition, merit review, and peer review. These mechanisms have been central to the remarkable contributions of science and engineering to society in recent decades, and earmarking threatens to undermine even modest programs of transportation research.

Transportation Research Opportunities

The opportunities offered by transportation research hold great promise. The following are examples of the benefits that research may provide:

- New intelligent technologies in all modes can improve safety and service quality as transportation, information, and telecommunications infrastructures merge. New traffic operations centers could help operate traffic more efficiently and also provide a more focused response during emergencies.
- Improved materials can extend the service life of assets and can lower maintenance costs.
- New construction techniques can permit replacement and upgrading of congested facilities with less disruption and delay.
- Innovative approaches to purchasing services from the private sector promise a better return for the public sector in terms of quality and life-cycle cost.
- Enhanced understanding of public preferences and behavior with regard to safety and trip making can guide better investment decisions.
- Better tools for predicting, managing, and avoiding environmental impacts can improve environmental stewardship.
- Better understanding of complex and long-term side effects—such as sprawl—can improve decisions about development.
- Deeper understanding of the causes of crashes can lead to more cost-effective countermeasures.
- More efficient, less-polluting vehicles and fuels that are less environmentally disruptive are within reach in terms of availability and cost.
- Analysis of newly emerging institutional experiments within states and regions can indicate new and better ways to make decisions and to manage and operate facilities.

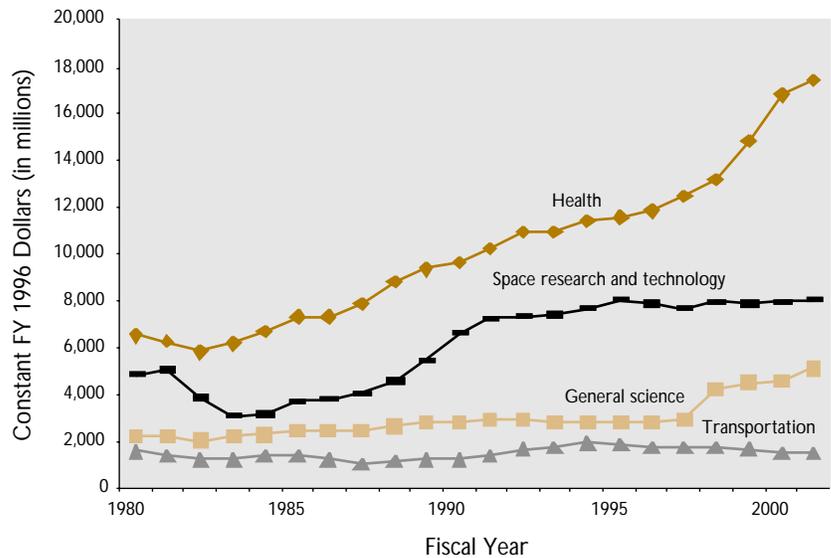


FIGURE 5 Total federal R&D by selected budget function, fiscal years 1980–2001. (SOURCES: Federal R&D Funding by Budget Function, Fiscal Years 1999–2001; Historical Tables, National Science Foundation, 2000.)

But despite this promise, transportation R&D is out of balance with national needs and with the sector’s importance. Although transportation’s share of the GDP is nearly equal to that of health care, the federal R&D investment in health care is 10 times that in transportation (see Figure 5).

Moreover, the national investment in science, engineering, and health has increased sharply in recent years, but the investment in transportation has remained low and unchanged. This underinvestment makes it difficult to attract the best minds to work on solving transportation problems and leads to insufficient development of intellectual capital in agencies and universities. Federal investment in highway research as a share of expenditures, for example, is a mere 0.5 percent—a share substantially lower than that for low-tech industries.

Necessary Investment

Transportation is vitally important to individuals, communities, and the nation. The challenges facing the system are changing and have never been greater. Research and innovation hold great promise for addressing these challenges, but face formidable barriers.

Moreover, transportation research programs are not being funded or organized optimally. The nation must invest wisely to realize the potential benefits of transportation research. At the national level, the investment in transportation research—a primary source of innovation in the sector—is entirely out of balance with the importance of transportation to society.



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