TRANSPORTATION RESEARCH BOARD

Informing Transportation Policy Choices

Celebrating the 20th Anniversary of Conducting Policy Studies

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OF THE NATIONAL ACADEMIES

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Washington, D.C.
2003
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Printed in the United States of America.

This publication was sponsored by XXX and the Transportation Research Board.

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INTRODUCTION

At the beginning of the 21st century, transportation in the United States, though extensive, is as controversial as ever. Debates over the siting of new highways, airline safety, fuel economy standards, speed limits, the health effects of vehicle emissions, and similar topics are as complex and contentious as any that rage in the national and state capitals. The debates are intensified by the vital importance of transportation to the U.S. economy as well as to the lifestyles and expectations of Americans. Thus, any major policy change affecting transportation can have extraordinary economic, social, and political ramifications. This should come as no surprise. National expenditures on transportation represent the equivalent of 11 percent of gross domestic product, and transportation accounts for 19 percent of total household spending (Figure 1). About 11 million people, or 8 percent of the U.S. labor force, work in transportation industries or provide transportation services.

Also driving the debates over transportation policy is the fact that more than 40,000 lives are lost and 3 million serious injuries inflicted every year on the nation's highways. Moreover, transportation is the major driver of the nation's increasing reliance on imported petroleum and is a significant source of air and water pollution.

continued on page 3

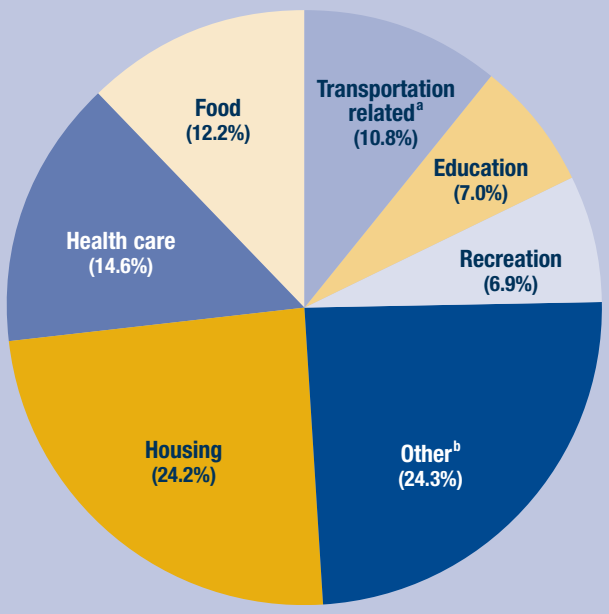
POLICY STUDIES AND THE COMMITTEES OF THE TRANSPORTATION RESEARCH BOARD

- The Transportation Research Board (TRB) of The National Academies has been providing technical guidance on transportation to the states and the federal government for more than 80 years. The National Academies—encompassing the National Academy of Sciences, the National Academy of Engineering, the Institute of Medicine, and the National Research Council—is an independent, nonprofit organization that operates under the congressional charter granted to the National Academy of Sciences in 1863.
- Since 1982, TRB has also conducted an influential program of policy studies on issues of national importance in transportation. Each study is carried out by a specially appointed independent committee. Committee members are selected to represent appropriate areas of expertise and a balance of perspectives on the issues involved; members serve without compensation. The committee process is open to public scrutiny and comment, in accordance with the Federal Advisory Committee Act Amendments of 1997. Each final report undergoes a rigorous institutional review, in which outside experts examine the report in accordance with guidelines developed by The National Academies to ensure that the committee has provided a balanced and fair assessment of the topic addressed.
- Since 1982, TRB has conducted more than 70 policy studies in response to requests by Congress, agencies of the executive branch, and the states on a wide array of complex, often controversial, transportation topics. Examples include counterterrorism, speed limits, highway design, truck size and weight regulations, airport capacity, transit use, high-speed rail, airline deregulation, dredging, environmental policy, school transportation safety, and automotive safety. To conduct these studies, TRB draws on the nation's leading experts in transportation and related fields to assess the technical bases for policy and regulatory decisions across all transportation modes; analyze the potential effects of transportation policy alternatives on mobility, safety, the economy, and the environment; and review specific research and development programs. Funding is typically provided for each study by a designated federal agency, the state departments of transportation, or foundations. A bibliography of the policy studies produced by TRB committees appears at the end of this volume, along with a listing of the respective committee members and supporting TRB staff.[1]

[1] The focus of this volume is on the work of committees convened by TRB's Policy Studies group. Information about numerous other policy-relevant reports resulting from the papers, conferences, and workshops of TRB's standing technical committees and research commissioned by TRB's cooperative research programs is available at TRB's website, www.TRB.org.

Figure 1

U.S. Gross Domestic Product by Major Societal Function: 2000



[a] Includes all consumer and government purchases of goods (e.g., vehicles and fuel) and services (e.g., auto insurance) and exports related to transportation.

[b] Includes all other categories, such as entertainment, personal care products and services, and payments to pension plans.

Source: U.S. Department of Transportation, Bureau of Transportation Statistics, calculated from data in U.S. Department of Commenrce, Bureau of Economic Analysis, *Survey of Current Business,* October 2001.

Committees of the Transportation Research Board (TRB) have played a major role in the transportation policy arena. Their work has generated findings and recommendations that have helped frame the issues, shape the debate, and inform the policy-making process. The following sections present highlights of the reports produced by the committees to address eight overarching objectives of transportation policy: improving passenger travel, delivering goods to market, managing risk, providing for security against terrorism, protecting the environment, achieving energy conservation, managing human resources, and conducting public-sector research and development (R&D). Interested readers will find much greater detail in the reports themselves. Many are posted on the TRB website, www.TRB.org or national-academies.org/trb. For information on ordering see page ii of this publication

IMPROVING PASSENGER TRAVEL KEY COMMITTEE FINDINGS AND RECOMMENDATIONS

- Transportation policy choices at the metropolitan level are inextricably linked with decisions about other social goals, such as limiting sprawl and enhancing environmental quality, and involve a complex mix of government authority at different levels.
- Decisions about new transportation facilities involve analysis of social benefits and costs that exceeds the capabilities of current models and procedures, suggesting the need for new approaches.
- Although public demand for transit in U.S. cities is unlikely to match that in the cities of Europe and Canada, transit use could be increased in many areas of the United States. A number of practices and policies in effect in Europe and Canada—from channeling of development to locations well served by transit to creative marketing and fare policies—are especially relevant to these areas.
- In growing metropolitan areas with heavily used highways and transit systems, reducing the congestion associated with transportation will require both market-based (pricing) approaches and the provision of new facilities. However, pricing strategies lack broad public understanding and acceptance. Thus experimentation with and evaluation of incremental steps toward user fees that vary with demand will be necessary.
- Advanced technological solutions to urban congestion, although proven technically, are quite difficult to introduce unless they can be blended into the complex interplay of market demand and existing institutional arrangements. Nonetheless, continued technological innovation is vital to providing the capacity needed to meet increasing demand.
- Although full automation of highways is problematic both technically and socially, society would benefit from the increased development of technologies designed to facilitate communication between roadsides and automobiles.
- Deregulation has had clear benefits in terms of consumer savings and efficient utilization of assets (both carrier use of aircraft and demand for airports). The outcomes of this policy are still evolving, however, and the benefits could be eroded by industry concentration. Thus continual monitoring, assessment, and appropriate policy intervention are needed to ensure adequate competition.
- The future effectiveness of airline competition could be enhanced by federal policies designed to ease the entry of new carriers at airports and to facilitate shifts to secondary, underutilized airports.
- Environmental concerns, particularly with regard to noise, are major constraints on additional airport development and expansion.
- Demand for air travel is likely to increase with growth in the economy and the population. Strategies to meet this demand include continued improvements in air traffic control, additional runways and airports, shifting of aircraft sizes to optimize traffic flows, market instruments designed to allocate demand, and support for other high-speed modes in appropriate markets.
- The potential role of high-speed rail in intercity markets is limited by the lack of institutional arrangements—federal or state—for assessing this potential, estimating the benefits that might justify the necessary subsidies, and facilitating such funding.
- If highly innovative transportation technologies, such as the Small Aircraft Transportation System concept, are to succeed, they must meet the tests of market demand, public safety, and environmental protection and be capable of adapting to the existing complex market and institutional arrangements.

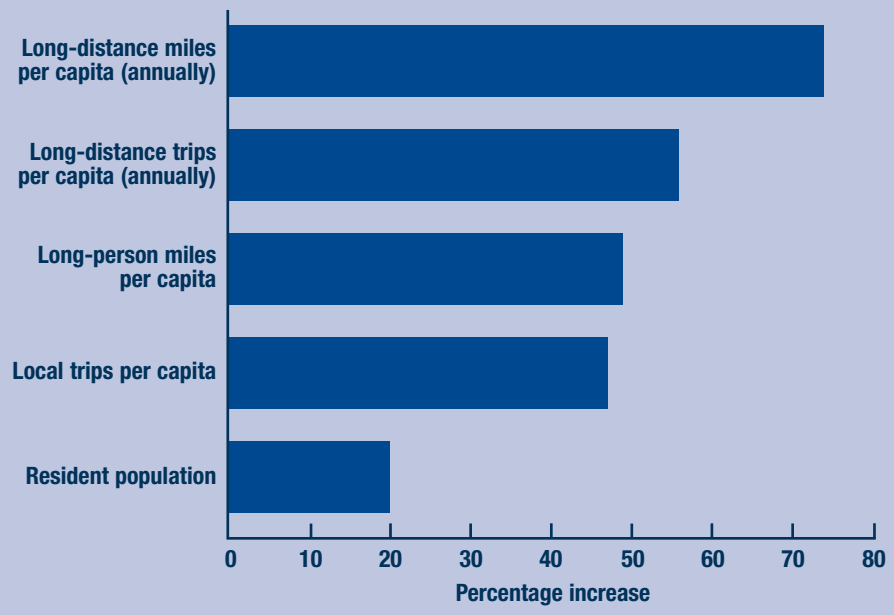
IMPROVING Passenger Travel

The 20th century was a period of unparalleled public investment in transportation facilities, one that also saw major transportation policy innovations at the federal level. As a result, the average person in the United States has the highest level of personal mobility ever enjoyed. The landmark national policies designed to facilitate passenger travel include the design and primary funding of the Interstate highway system beginning in the 1950s; the reinvestment in public transportation initiated in the 1960s; funding for airport construction starting in the 1970s; the deregulation of airlines, railroads, and motor carriers during the 1970s and 1980s; and the creation of Amtrak.

Roughly 85 percent of the total miles traveled by passengers (or passenger miles) occurs in private vehicles—primarily cars and light trucks—operated on the nation's roads and highways. Commercial aviation accounts for about 10 percent of passenger miles, while transit, intercity bus, and intercity rail represent the balance. Whereas transportation policy in the post–World War II era resulted in the construction of extensive transportation facilities, the economy and population of the United States continue to grow. In an increasingly affluent society, moreover, the demand for transportation has risen even more rapidly than the number of people (Figure 2). Two key issues involved in meeting this demand have been addressed by TRB committees: reducing metropolitan area congestion and improving intercity travel.

Figure 2

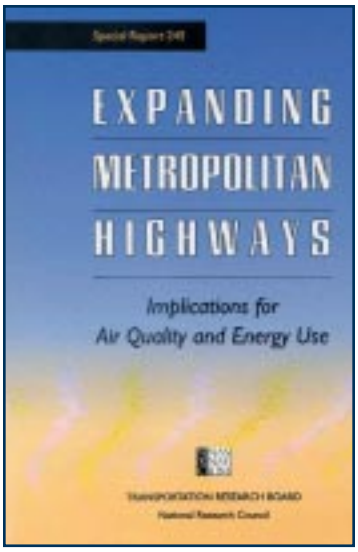
Percentage increase in population and travel in the United States, 1977–1995.



Source: Table 5-1 in *Changing Face of Transportation,* U.S. Department of Transportation, 2000.

Reducing Metropolitan Area Congestion

Although billions of dollars has been spent on transportation infrastructure during the last several decades, the most common public lament about transportation concerns congestion. Congestion occurs where people concentrate, and during this same period, most people have elected to live in metropolitan areas. Between 1980 and 2000, population in these areas grew much more rapidly (27.3 percent) than in other areas (13.1 percent). By 2000, residents of metropolitan areas represented more than 80 percent of the population. The fastest growth is occurring in the peripheral counties of existing metropolitan areas that are often least prepared with adequate infrastructure. Moreover, the Census Bureau predicts that nearly 60 million more people will need to be housed in the next 25 years, and if past trends are indicative, they are likely to choose metropolitan areas in which to live. For these and other reasons, metropolitan areas will remain the flashpoints for policy debates about transportation.



Special Report 245:
Expanding Metropolitan Highways: Implications for Air Quality and Energy Use **(TRB 1995)**

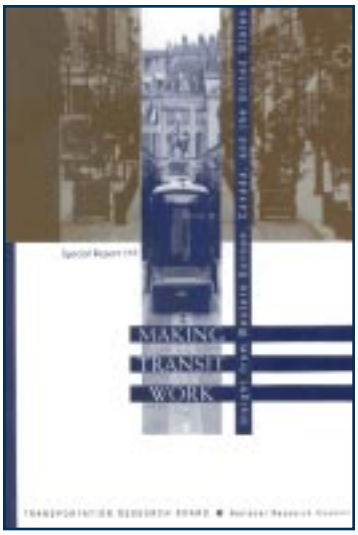
Adding Metropolitan Highway Capacity

There are few more difficult or vexing local issues than the siting of a new highway or the expansion of an existing one. Local debates revolve around the trade-offs between easing congestion and increasing air pollution, noise, and sprawl.

For many years, officials have attempted to respond to traffic congestion by adding highway capacity. Beyond meeting the public's demand for roads, local and state officials view highway improvements as an integral part of their economic development strategies. Moreover, because vehicles in highly congested traffic operate inefficiently, it is believed that improving traffic flow would reduce emissions. On the other hand, opponents of new capacity contend that it induces more trips; that traffic in free-flow conditions also generates high emissions of some pollutants, particularly ozone precursors; and that the long-term effect of adding capacity is to support sprawling development. Examining these claims and counterclaims with technical evidence requires computer modeling of travel preferences, the resulting vehicle emissions, regional air quality, and the effects of new highway capacity on long-term land development.

For decades, federal funding assistance created an incentive to build new highways. The Clean Air Act Amendments of 1990 represented an attempt to balance this incentive. Once these amendments became effective, metropolitan areas risked losing a share of their federal transportation funding if adding highway capacity would contribute to their failing to meet national air quality standards.

Even though the regulations implementing the Clean Air Act Amendments require metropolitan areas to model the consequences of new capacity, the committee that conducted this study concluded that the existing analytical tools are inadequate for the task specified in the regulations. Whether new capacity is better or worse for air quality depends on local conditions. Relatively modest expansions probably have little effect, positive or negative, on air quality or land development in the urban periphery, whereas significant new capacity can, over a period of many years, contribute to increased travel, emissions, and low-density development patterns. Attempting to meet air quality goals through constraints on travel is an indirect policy measure. More direct benefits would accrue from improvements in vehicle technology, effective pricing or taxation of vehicle use, and more effective land development controls, although such measures are not without controversy and involve trade-offs of their own.



Special Report 257:
Making Transit Work: Insight from Western Europe, Canada, and the United States **(TRB 2001)**

Expanding Transit

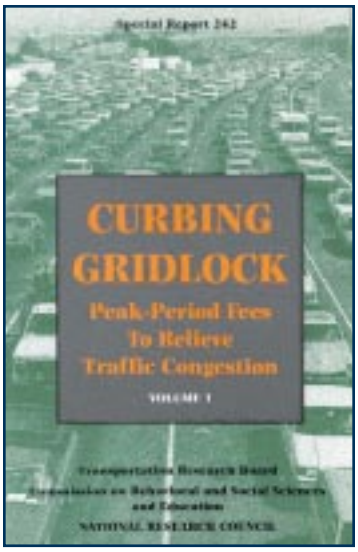
Travelers often return from major European cities marveling at the ubiquity and efficiency of urban transit services and wondering why U.S. cities fare so poorly by comparison in this regard. With few exceptions, such as its central role in serving New York City, public transit has a far more prominent role in Canada and Western Europe than in the United States. This is true not only in major cities, but also in smaller communities and throughout entire metropolitan areas. Transit is used for about 10 percent of passenger trips in urban areas of Western Europe, compared with 2 percent in the United States.

A number of factors have contributed to this differential, including higher taxes on motor vehicles, steep fuel taxes, and concerted efforts to control urban development and preserve the form and function of historic cities in both Canada and Western Europe. Moreover, both regions have devoted considerably more attention and resources to ensuring that transit services are convenient, comfortable, and reliable.

At the outset of the 20th century, American cities were leaders in introducing and using transit. Today, however, much of metropolitan America is largely suburban in character. The preponderance of suburban development is due to an abundance of inexpensive land available outside of cities, burgeoning metropolitan populations and economies, and perceptions of inner-city economic and social strife, combined with the ubiquity of the automobile. Transit works best in areas with high concentrations of workers, businesses, and households, whereas suburbs are characterized by low-density development.

The committee that studied the issue of making transit work better in the United States concluded that dramatic changes in transportation investments, land use controls, and public attitudes—including much denser settlement patterns, together with Western European–style fuel taxes and other disincentives to driving—would be required to reshape the American urban landscape in ways that would fundamentally favor transit use.

Nonetheless, there is ample opportunity for transit to play a more prominent role in meeting passenger transportation demand in many U.S. cities. Although it is not reasonable to expect the modal share of transit in most U.S. metropolitan areas to equal that of European cities, there are many areas in which transit is appropriate and its use can be increased. American cities that have retained high levels of central-city employment and dense residential development and have a history of transit service can learn from and apply the policies and practices used abroad.



Special Report 242:
Curbing Gridlock: Peak-Periods Fees to Relieve Traffic Congestion
(TRB/CBASSE, 1993)

Managing Demand with Prices

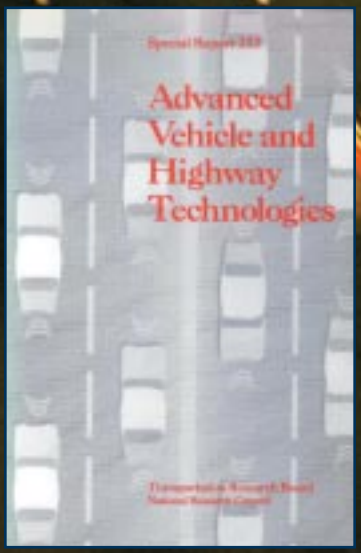
Traffic congestion frustrates millions of motorists daily and imposes economic costs in the 50 largest urban areas in excess of $70 billion annually. As discussed above, however, adding highway capacity to allow free-flow traffic is problematic for environmental and other reasons. Economists have long argued that some direct pricing mechanism for highway use would help allocate demand on existing facilities more efficiently by shifting some road users to off-peak hours, when plenty of capacity is usually available. As everyone who drives in peak periods knows, too many people are trying to travel within too limited a space at these times.

In the private sector, such peak demand is managed through pricing. At least until recently, however, proposals for peak-period pricing of road use have been dismissed as impractical because of the difficulty of charging users efficiently. Today, electronic toll collection has made it possible to charge users varying prices with considerable efficiency without invading privacy. Now that variable pricing of road use has become technically feasible, the debate has shifted to questions of effectiveness and political acceptability.

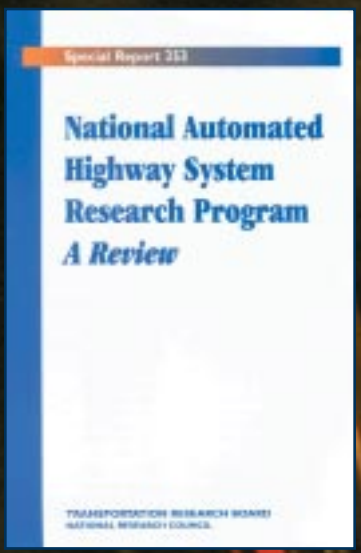
Economic theory and analytical modeling predict that variable pricing would reduce congestion. The effect can be illustrated by the example of a freeway on which motorists encounter stop-and-go travel. In such a situation, a reduction of only a few percentage points in the number of motorists in the traffic stream can return traffic to free flow. Of course, most motorists would be reluctant or unable to shift their travel times, but those who would adjust their work schedules or be flexible in other ways could shift to off-peak periods, and the result would be net economic and environmental benefits to society. Those traveling in peak periods would have to pay considerable fees, but these revenues could be used to provide more capacity or to compensate those groups hurt economically by such a policy.

The committee charged with investigating this issue considered whether the public would find congestion pricing acceptable. Although road users pay fuel taxes to support the costs of building and maintaining roads, most people view roads as free. Pricing may also be viewed as unfair to the poor, though compensation mechanisms are feasible. Since passage of the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA), federal policy has reflected appropriate caution with regard to advancing alternative pricing concepts by encouraging and funding experimentation at the local level, an approach the committee supported and recommended. Many jurisdictions are considering or engaging in experiments such

as pricing underused high-occupancy vehicle lanes, offering discounts on toll facilities for off-peak travel, and increasing parking fees. Preliminary results of these efforts are encouraging and may help gain public acceptance for wider application of such approaches. Although still far from being realized in the mainstream of transportation programs, road pricing may yet become a tool for managing an ever-growing demand with a limited supply.



Special Report 232:
Advanced Vehicle and Highway Technologies **(TRB 1991)**



Special Report 253:
National Automated Highway System Research Program: A Review **(TRB 1998)**

Facilitating Demand with Technology

Another approach to providing for growing demand is to use computer and communications technologies to increase the efficiency of the existing network. Under ISTEA, Congress began providing roughly $200 million annually in R&D funding to consolidate the efficiency gains offered by such technologies under the rubric of intelligent transportation systems (ITS). Similar funding levels were sustained under the Transportation Equity Act for the 21st Century, enacted in 1998.

ITS has spawned a variety of new services and operational capabilities, such as real-time traveler information, regional traffic operations services, and improved emergency response. Such technologies hold considerable promise. At the same time, however, they raise questions about how a national program can be integrated with existing institutional responsibilities, and how public agencies and vehicle and component manufacturers can collaborate to allow vehicle and infrastructure systems to operate together effectively. Resolving these questions is an ongoing challenge for the U.S. Department of Transportation (USDOT) as it encourages greater orientation toward operating systems supported by ITS technologies among the thousands of state and local agencies responsible for building, maintaining, and operating transportation infrastructure.

Perhaps the most ambitious ITS concept advanced in ISTEA was the proposed development of automated highways. Automated highways were envisioned as increasing throughput dramatically while simultaneously reducing crashes. In ISTEA, Congress challenged USDOT to create, test, and select a prototype automated highway system within 7 years. To this end, a public–private consortium was formed to develop and test automation concepts. Those concepts were demonstrated in San Diego, California, in 1997.

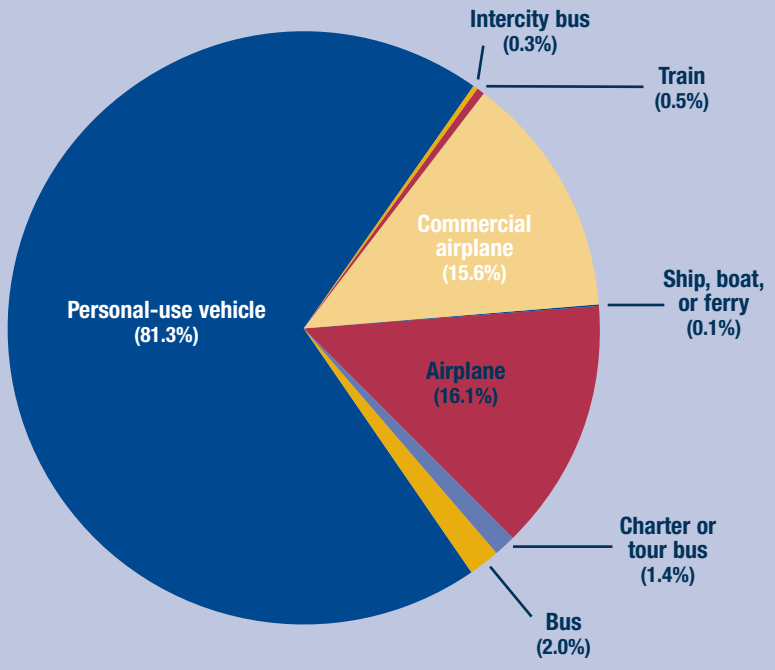
Although the demonstration showcased some exciting technologies, the committee that reviewed the national automated highway research program found that daunting technical, social, and institutional issues would have to be addressed before such a system could become a reality in any metropolitan area. For example, although the demonstrated technologies would enable remarkably high throughput on high-volume urban Interstates feeding into the heart of a congested urban area, they could not resolve the complex problem of allocating these increased traffic volumes safely and efficiently into the traffic streams of already congested local streets. Even so, the committee urged USDOT to continue to explore the potential for using automation in specific circumstances, as well as the possibilities for developing vehicle-based safety-enhancing technologies for cars, trucks, and transit vehicles (discussed later in the section “Managing Risk”).

Improving Intercity Travel

Although it is often assumed that long-distance trips in the United States are made by air, aviation has a majority share only for round-trip distances of more than 1,000 miles. Among all round trips of 100 miles or more, 81 percent are by automobile and about 16 percent by air; charter buses account for about 2 percent and intercity passenger rail for about 0.5 percent (Figure 3). Despite the dominance of the highway mode for intercity travel, aviation plays a large role. In 2000, for example, U.S. passengers traveled more than 515 billion miles by air (Bureau of Transportation Statistics 2002, Pocket Guide to Transportation, Table 10). Thus the importance of policies affecting this mode is clear.

Figure 3

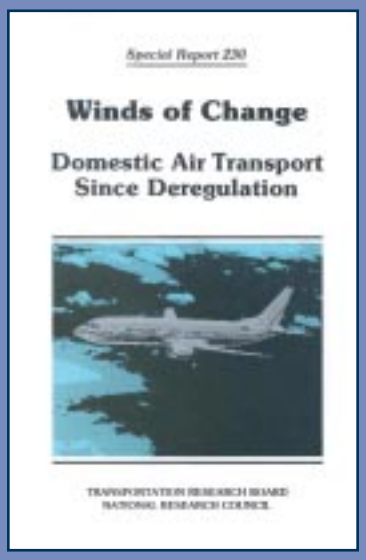
Long-Distance Travel in the United States by Principal Means of Transportation 1995*



*Roundtrips of 100 miles or more, one way, U.S. destinations only.

Notes: Numbers and percentages may not add to totals due to rounding.

Source: U.S. Department of Transportation, Bureau of Transportation Statistics, 199 american Travel Survey Profile, BTS/ATS95-US (Washington, DC: October 1997).



Special Report 230:
Winds of Change: Domestic Air Transport Since Deregulation
(TRB 1991)

Ensuring Competitive Pricing of Commercial Aviation

Perhaps the most significant federal policy change regarding aviation occurred in 1975 when the Civil Aeronautics Board (CAB) began giving air carriers greater freedom in discounting prices and serving new markets.[1] These administrative actions were followed by the Airline Deregulation Act of 1978, which removed restrictions on market entry, pricing, and route service and began the phase-out of the CAB itself. Whereas this legislation did not affect federal safety regulations, it greatly reduced federal economic controls on air carriers. Deregulation resulted in a substantial upheaval among carriers and sharply increased competition. Passengers have generally benefited from the resulting reduced fares and increased air service throughout the country, with little or no indication of increased risk.

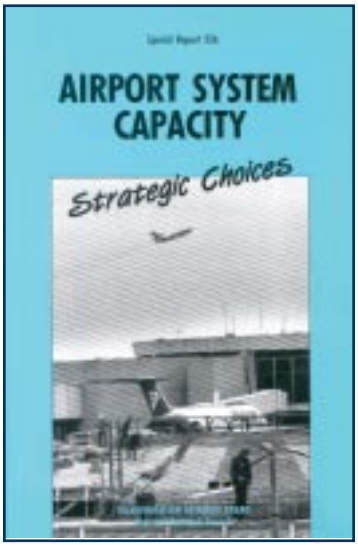
Deregulation was expected to lead to the emergence of new, service-oriented carriers that would compete with the existing heavily regulated, inefficient carriers. Although many new carriers have tried to enter aviation markets, few have survived. The TRB committee that reviewed developments in domestic air transport service following deregulation concluded that preexisting carriers were able to exploit inherited advantages such as the ability to exercise considerable control over the use of airports they served. This advantage became pronounced as carriers shifted from point-to-point to hub-and-spoke service, which has many operational advantages for both carriers and passengers. The ability to limit competition at major hub airports, however, greatly reduces opportunities for the entry of new carriers. Such inherited advantages were compounded by a period in which many mergers between old-line carriers, including several mergers between rivals, were permitted.

[1] The reports referred to in this section were written before policy toward enhanced aviation security, accompanied with a downturn in the economy, is having a profound effect on commercial aviation.

Special Report 255:
Entry and Competition in the U.S. Airline Industry: Issues and Opportunities **(TRB 1999)**

Yet even with barriers to entry and anticompetitive mergers, the airline industry is intensively competitive. Some carriers, such as Southwest, have been able to grow and prosper with low-fare, point-to-point service between secondary airports. The committee concluded that, although the first decade of deregulation had proved largely beneficial for consumers, the question whether the number of major carriers would continue to decline, resulting in too few competitors to discipline pricing, remained.

During the mid-1990s, new-entrant carriers filed formal complaints with USDOT, contending that large established airlines were engaging in predatory pricing (pricing below cost). Such strategies were alleged to include matching low fares and providing far more service than could a new entrant, but then raising fares and cutting service as soon as the new entrant failed or withdrew. USDOT contemplated writing regulations against such alleged practices, but the committee that studied entry and competition in the U.S. airline industry advised against doing so. Given the difficulties involved in defining fair and unfair competition, the proposed regulations could have proved as harmful as helpful. The committee noted that USDOT has other policy instruments that could be used to promote the entry of new carriers, such as supporting the development of additional gates and airports, eliminating service restrictions at some key airports, and ensuring that federal rules promote rather than hinder more open access to major airport facilities.



Special Report 226:
Airport System Capacity: Strategic Choices **(TRB 1990)**

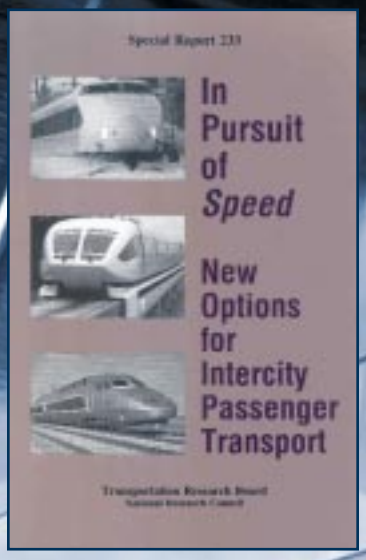
Expanding Airport Capacity

The long-term trend in aviation travel closely mirrors growth in gross domestic product. As the U.S. economy and population grow and the globalization of the economy continues, air travel can be expected to increase as well. Airport expansion, however, is very difficult because of community opposition to traffic and noise.

The construction of major new airports ended with the opening of the new Denver airport in 1995. Attempts are being made to expand most major airports by adding runways. However, only

seven new runways were added in the last decade, largely as the result of a lack of land and neighborhood opposition to aircraft noise. Despite these problems, many formerly secondary airports on the edge of major metropolitan areas have grown sharply and become desired destination airports in their own right. Even so, air passengers have been keenly aware of congestion and delay. Many delays in the air traffic system that are not attributable to weather can be traced to a shortage of places for planes to land during peak periods.

As with other infrastructure assets, the federal government provides substantial funding for airports, but decisions about siting, expanding, building, and operating the facilities are made at the state and local levels. There is no simple, universal, permanent solution to congestion and delay with regard to stimulating and ensuring adequate capacity. The committee that addressed this issue concluded that a combination of remedies is required, including financing of incremental expansions at crowded airports, improvments in techniques and technologies for managing air traffic control, support for advanced aircraft designs better optimized for passenger flows and the physical constraints of airports, incorporation of noise mitigation in aircraft designs and flight patterns, and support for alternative high-speed modes in appropriate markets.



Special Report 233:
In Pursuit of Speed: New Options for Intercity Passenger Transport
(TRB 1991)

Introducing High-Speed Rail

In certain corridors, high-speed rail could offer a means of reducing congestion at airports and on major intercity highways while serving the travel needs of a substantial number of intercity passengers. Technologies in use in Europe and Japan have already resulted in highly successful systems operating at average speeds of 125-185 mph with enviable safety records. In 2000, Amtrak introduced tilt-train technology with a maximum speed of 150 mph in the Northeast Corridor (Washington, D.C., to Boston)—the most heavily traveled corridor in the country. Congress has provided limited funding for research and planning toward the deployment of magnetic levitation (maglev) technology in both the Intermodal Surface Transportation Efficiency Act and the Transportation Equity Act for the 21st Century. Though still in an experimental phase, maglev trains have demonstrated speeds of 300 mph.

The committee that examined new options for high-speed rail noted a striking and important contrast between intercity train travel in Europe and Japan and the United States. Both Europe and Japan had substantial intercity rail markets before evolving to high-speed technologies; comparable service offered by Amtrak occurs in few corridors. Trains in Europe and Japan also connect directly to extensive networks of intracity transit service, whereas Amtrak passengers enjoy such interconnections in only a few cities. The committee found that high-speed train service competes most effectively with automobile and air travel in major city-pair markets of roughly 150 to 300 miles. Many such city pairs exist in Europe and Japan, which are more densely populated and cover smaller geographic areas than is the case with the United States. Rail can connect the major cities of France relatively easily,

for example, but could scarcely compete with air transport between New York and Atlanta or Chicago and Los Angeles. Moreover, whereas the French and the Japanese have long histories of strong institutional commitment to and government support for passenger rail development, U.S. support for such service has been modest and wavering.

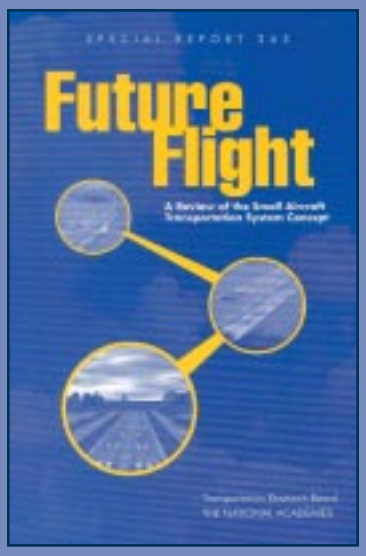
The committee concluded that high-speed rail service is costly and that passenger revenues would be unlikely to cover its capital and operating costs in the United States. Public subsidies might be justified in some corridors because rail could divert enough passengers from crowded airports and highways, resulting in less adverse environmental impact and lower energy consumption per passenger mile. High-speed rail is relatively noisy, however, and requires long, straight alignments to achieve its high speeds; such corridors could traverse residential areas and sensitive wetlands and lead to fragmented habitats. Moreover, whether high-speed rail corridors would be any easier to build than other major transportation infrastructure is an open question.

The committee recommended that USDOT develop the capacity to analyze investments in intercity travel modes and help fund the most cost-effective strategies (accounting for environmental and other "external" costs), regardless of mode. Aside from the special provisions made by Congress for Amtrak, however, the United States lacks an institutional mechanism to subsidize high-speed rail. Highway and aviation users are taxed to form trust funds for infrastructure improvements for these modes, but the trust funds cannot be used to subsidize rail service, even in situations where such funding may be warranted. The committee also found that conventional high-speed technologies pose much less technical risk and would cost less than proposed maglev systems, which require additional research and experimentation.

Creating a Small Aircraft Transportation System

Given the above-noted capacity limitations of most hub airports, as well as the striking potential reductions in the cost of reliable, small jet engines, small aircraft may offer business travelers and others willing to pay a premium an opportunity to bypass hubs and fly directly to their destinations. Over time, such an option might expand to take greater advantage of the nation's 5,000 general aviation airports, many of which are used only lightly, and make such travel appealing to a broader segment of the traveling public.

After partnering with general aviation manufacturers in the 1990s to advance small jet engines, avionics, and fly-by-wire technologies, the National Aeronautics and Space Administration (NASA) proposed such an option in 2000. The Small Aircraft Transportation System (SATS) is envisioned as relying on increasingly



Special Report 263:
Future Flight: A Review of the Small Aircraft Transportation System
(TRB 2002)

sophisticated and affordable small aircraft flying between small airports in lightly used airspace. The system was proposed to provide a growing share of the nation's intercity personal and business travel. The development of such a system was considered to be justified by the potential to ease congestion in the existing aviation system and on highways serving densely traveled intercity markets.

Without attempting to prejudge how advances in general aviation technology might evolve and affect travel markets, the committee that examined the SATS concept concluded that the concept is problematic in several ways as a vision to guide NASA's technology development. Although the cost of small jet engines developed in partnership with NASA could drop dramatically, small jets would still be well beyond the means of all but the wealthiest members of society. The aircraft might be adopted by firms offering air taxi service, but the cost of such service would likely remain steep; therefore, sufficient market penetration to relieve congestion at hub airports would be unlikely. Moreover, the origins and destinations of most business travelers are major population centers, making travel to and from remote general aviation airports unappealing. The cost to upgrade such airports would be substantial as well, even assuming that SATS aircraft would have onboard technologies that would reduce the need for airport radars, precision landing guides, and air traffic control. The environmental consequences could also be substantial—particularly an increase in aircraft noise in rural areas unaccustomed to such intrusions. Perhaps the most difficult issues to address would be public concerns about safety. Finally, the use of SATS aircraft in and around major metropolitan areas would complicate an already overstressed air traffic control system, and the human factors issues of increased automation for relatively inexperienced pilots are far from being resolved.

For all of the above reasons, the committee did not endorse the SATS concept as a guide for NASA R&D. The committee noted, however, that NASA's support for ongoing technology development in general aviation is welcome and needed. General aviation has a much worse safety record than commercial aviation. The committee recommended that NASA work with other federal agencies, such as USDOT, the Federal Aviation Administration, and the National Transportation Safety Board in defining and pursuing opportunities to advance and improve general aviation.

DELIVERING GOODS TO MARKET
KEY COMMITTEE FINDINGS AND RECOMMENDATIONS

- The federal presence in freight transportation includes a broad and complex set of funding mechanisms, regulations, and market-based policies encouraging competition, and varies widely across modes.
- Because highways serve to connect all modes of transportation, federal policies related to highways have profound effects on freight transportation. These policies include the taxation of motor carriers, safety regulation, incentives for new investment, and determination of funding levels to ensure efficient system operation.
- Establishment of a level playing field for competition across modes is a major policy objective that has yet to be fully realized.
- The congressional role in establishing maximum truck dimensions has substantial consequences for trucking productivity, but is an indirect means of influencing safety.
- Federal and state policy with regard to trucking should permit recovery of the costs heavy trucks impose on infrastructure and should incorporate externalities.
- Because estimates of externalities within and across modes, both positive and negative, are critical for balancing competition across modes, USDOT should fund a study using the methodology developed by the committee that produced Special Report 246 to improve the available estimates of externalities across all modes.

DELIVERING
Goods to Market

Other than perhaps being bothered by large trucks on the highway or delayed by freight trains at railway crossings, most Americans probably pay little attention to the freight transportation sector. Yet just-in-time delivery for manufacturing, retail and food distribution, and doorstep delivery of goods ordered over the Internet would not be possible without this remarkable and efficient system.

The scale of annual freight movement is extraordinary. Several million trucks, three-quarters of a million rail cars, thousands of barges and ships, and thousands of miles of pipeline move more than 14,000 ton-miles of freight every year for every person in the country. The value of goods exported and imported by freight carriers equaled nearly $2 trillion annually in 2000 (Bureau of Transportation Statistics 2002, Pocket Guide to Transportation, Table 16).

Among the first major federal agencies spawned by the Industrial Revolution was the Interstate Commerce Commission (ICC), which for more than 90 years regulated routes, carriers, and commodities moved, initially by rail, and beginning in the 1930s for other modes. The federal deregulation of motor carriers and railroads in the 1980s, which phased out ICC, led to increased competition and greater efficiency of surface freight movement.

Over the last two decades, the introduction of supply chain logistics has revolutionized freight transportation. Goods that were formerly shipped from factory to warehouse to final destination are now by passing intermediate transshipment points; the result is lower handling and transportation costs.

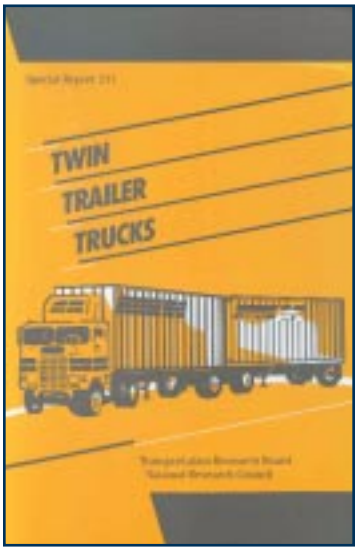
Although the federal government has relinquished some of its control over surface freight movement, federal and state agencies still have substantial influence through their roles in such areas as providing and maintaining infrastructure, regulating vehicle dimensions and weights, inspecting vehicles, and setting standards for operators. The federal and state governments are extensively involved in maritime freight as well—for example, through financing ports, dredging harbors and channels, and providing vessel traffic management and safety services. The work of TRB committees has informed government policies related to two key aspects of delivering goods to market: enhancing freight productivity and expanding freight capacity.

Enhancing Freight Productivity

Trucking accounts for the largest modal share of domestic and export-bound freight movement: trucks move 62 percent of the value of freight in the United States and 29 percent of freight ton-miles. Among the major controls that the federal government continues to exercise over motor carriers are the limitations placed on truck and bus dimensions and on axle and gross vehicle weights for operations on Interstate highways. These limits originated from policies designed to ensure that pavements and bridges would not be overstressed and that vehicles could operate within design constraints, such as lane width and ramp curvature.

Initially, these limits were imposed only by the states, the first being introduced as early as 1913. Much later, Congress imposed a series of limitations, beginning in 1956 with maximum axle and gross vehicle weights for vehicles operating on Interstates. Recognizing that inconsistencies in state regulations regarding other vehicle dimensions were impeding interstate commerce, Congress subsequently placed uniform maximum limits on such dimensions for vehicles operating on Interstates, which are still in place today. Over the years, the intent of

these regulations has expanded from protecting infrastructure to limiting competition for bulk freight between large truck operators and railroads and responding to concerns about the risks of mixing increasingly large trucks with passenger vehicle traffic.



Special Report 211:
Twin Trailer Trucks: Effects on Highways and Highway Safety
(TRB 1986)

Longer Trucks

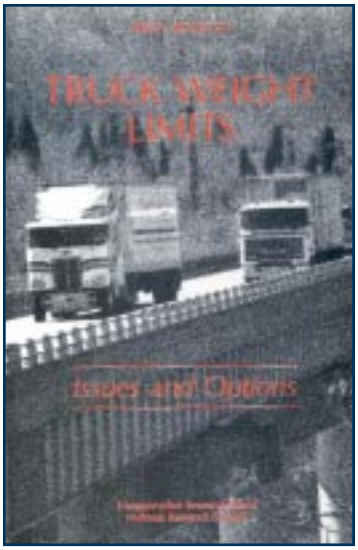
In the Surface Transportation Assistance Act of 1982, Congress permitted nationwide use of trucks pulling dual 28-foot trailers on Interstate highways. At the same time, Congress established more uniform limits on maximum truck dimensions, which effectively raised the maximums in a few states that had opposed such increases. Twin trailer trucks (twins) operating with 28-foot trailers raised a number of operational and safety concerns, particularly on the more densely trafficked Interstates on the East Coast, where these vehicles had not previously been permitted. Because such trailers offer more cubic space, they might be expected to see widespread use. In the 1982 legislation allowing twin trailers, therefore, Congress called for a TRB study to evaluate the effects of their use.

The committee formed to conduct this study concluded that twins would see fairly limited application in the trucking industry. Although twins provide more storage capacity, the general freight carriers most likely to use them accounted for only about 15 percent of intercity combination truck travel in the early 1980s. The committee found further that the greater carrying capacity of twins would probably cause about 2 percent more pavement damage than that due to the trucks they replaced, but would result in no additional effects on bridges. Moreover, twins would probably not replace other trucks on a one-to-one basis; instead, slightly fewer twins would be required to move the same amount of cargo, resulting in a modest reduction in total truck miles traveled.

Truck safety is a serious issue. Large trucks are involved in roughly 5,000 fatal crashes each year. Prior experience with twins and computer modeling of their handling implied that they may have a somewhat higher crash rate. Because they would allow more cargo to be moved per shipment, however, the committee concluded that the reduction in truck travel would offset this somewhat higher risk.

This TRB study highlighted one of the key policy debates surrounding the use of larger trucks. Because the incremental (marginal) cost of adding longer trailers is relatively small, the productivity potential of larger trailers is quite substantial. The

intensely competitive private market drives shippers to seek such gains. The safety consequences, however, are not so obvious. Thus policy makers are faced with making choices that involve nearly certain benefits but uncertain costs. Better data on truck safety and truck travel would help reduce this uncertainty. (Safety issues associated with trucking are discussed in the section "Managing Risk.")



Special Report 225:
Truck Weight Limits: Issues and Options **(TRB 1990)**

Heavier Trucks

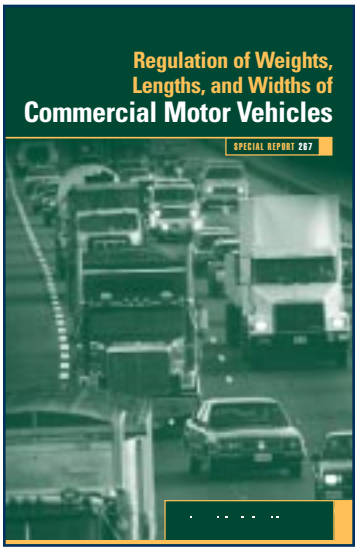
Truck weight limits have always been controversial. They involve trade-offs between the cost to build and maintain highways and the cost to transport goods by truck, and they have implications for highway safety, traffic flow, and highway finance. In 1987, Congress requested a study of various proposals for changes in truck weight regulations.

Improvements in highway design and vehicle performance have allowed truck weight limits to be revised periodically and generally adjusted upward, and proposals for further revisions appear inevitable. Because of the competitiveness of freight transportation and the ever-increasing demands of shippers, carriers have strong incentives to enhance productivity. Increasing weight is one means to this end. Moreover, there are many specialized trucking configurations that would be within maximum gross weight and axle weight limits, but would not be permitted under the federal bridge formula, which is designed to prevent overstressing of bridges on the Interstates. Heavy, short-wheel-base vehicles, such as dump trucks, can be limited in this way.

The committee that conducted this study concluded that, within limits, the savings in goods movement that would result from allowing heavier trucks would exceed the increased costs for pavements and bridges. A major impediment to making incremental changes in the weight limits, however, is the difficulty highway agencies experience in recouping fees from trucking firms to compensate for the damages they cause. The inability to charge users directly makes most states reluctant to support higher weight limits, even though society as a whole might benefit from the resulting productivity gains. Heavier trucks can also constrict traffic flow and increase risk, but their net effect depends on the extent to which allowing heavier weights might reduce total truck traffic.

The committee found that incremental changes to policies limiting vehicle weights, with attendant net benefits to society, could be achieved with relatively minor adjustments to the federal bridge formula (to allow heavier dump trucks to operate) and with a special permit program. The latter would allow states to permit the

operation of heavier trucks provided the carrier followed new safety criteria and the fees collected compensated for the potential infrastructure damage. Moreover, a portion of the fees could be used to enhance enforcement against illegal overloads, which are a serious problem. At the same time, a complicating feature of policies designed to rationalize trucking regulations is that certain types of trucking operations compete head-to-head with railroads, and unless the fees charged are appropriate, such operators can have an unfair advantage that would compromise the viability of rail (as discussed further below).



Special Report 267: ***Regulation of Weights, Lengths, and Widths of Commerical Motor Vehicles*** **(TRB 2002)**

Productivity-Enhancing Regulation

In 1991, Congress placed a freeze on maximum truck weights and dimensions. Some safety groups were protesting against the safety implications of increased truck size and weight, and the railroads were objecting to the introduction of vehicles they deemed to have an unfair advantage. Railroads, unlike trucking firms, must pay for the capital costs of their infrastructure. The railroads contend that large trucks do not pay sufficient taxes to compensate for the highway damage they cause and the environmental costs they generate.

Although Congress apparently hoped it had placed a cap on maximum truck dimensions in 1991, such has not proven to be the case. Carriers operating under specific conditions have been able to seek and obtain special exceptions from the federal freeze by appealing directly to Congress (without any formal review of the possible consequences), thereby encouraging additional firms to seek similar exceptions. In the Transportation Equity Act for the 21st Century, Congress requested a TRB study to review federal policies on commercial vehicle dimensions.

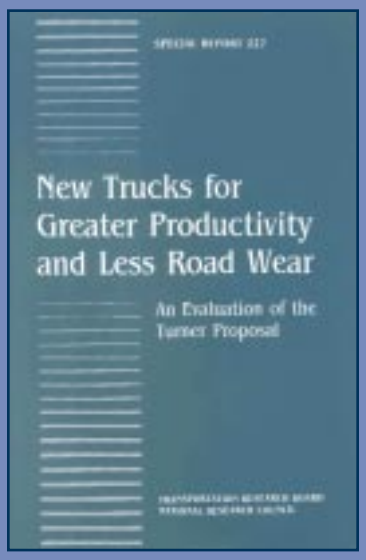
The committee that undertook this study found that regulatory analyses of the benefits and costs of changes in truck dimensions are hampered by a lack of information. Regulatory decisions on such matters will always entail a degree of risk and uncertainty, but the degree of uncertainty surrounding truck issues is both unusually high and unnecessary. The committee concluded that the uncertainty could be alleviated if procedures were established for carrying out a program of basic and applied research, and if evaluation and monitoring were permanent components of the administration of trucking regulations.

The committee recommended immediate changes in federal regulations that would allow for a federally supervised permit program. The program would permit the

operation of vehicles heavier than would normally be allowed, provided that the changes applied only to vehicles with a maximum weight of 90,000 pounds, double trailer configurations with each trailer up to 33 feet, and an overall weight limit governed by the federal bridge formula. Moreover, enforcement of trucks operating under such a program should be strengthened, and the permits should require that users pay the costs they occasion. States should be free to choose whether to participate in the permit program. Those that elected to do so would be required to have in place a program of bridge management, safety monitoring, enforcement, and cost recovery, overseen by the federal government. (The specific safety issues addressed by the committee are discussed in the section "Managing Risk.")

Related Studies

TRB has conducted other major studies dealing with trucking issues. In response to a congressional request in 1982, a TRB committee addressed the issue of what constitutes "reasonable access" of large trucks permitted under the Surface Transportation Assistance Act of 1982 to a designated national network of major trunk roads for heavy-truck travel (Special Report 223, *Providing Access for Large Trucks,* 1989). A second study was conducted as the result of a proposal selected and partially funded by the TRB Executive Committee because of its importance (Special Report 227, *New Trucks for Greater Productivity and Less Road Wear: An Evaluation of the Turner Proposal,* 1990). The committee that carried out this study identified two truck configurations outside the weight and length limits established by federal law that would offer greater productivity without increasing infrastructure or safety costs. These vehicles formed the basis for the configurations recommended in a later (2002) TRB report, Special Report 267: *Regulation of Weights, Lengths, and Widths of Commercial Motor Vehicles.*

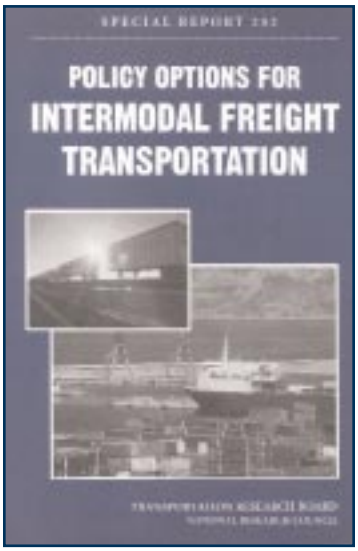


Special Report 227:
New Trucks for Greater Productivity and Less Road Wear: An Evaluation of the Turner Proposal **(TRB 1990)**

Expanding Freight Capacity

The role of government in the provision of freight capacity is complicated by differences in the evolution of the various modes by which freight is moved and by the shifts in the federal role that have occurred over time. Most modes—including inland waterway, maritime, highway, rail, and aviation—are important components of the freight system, but each has a different history, regulatory regime, and governmental presence. Government is perhaps least involved in railroads, which move about one-quarter of total freight ton-miles. Private firms own their own track and equipment, and government policy over railroads is exercised mainly through merger policy, safety regulation, and labor protection provisions, some of which date to the 19th century. For trucking, by contrast, the federal and state governments provide the highways; attempt to recoup taxes from carriers to cover the pavement

and bridge damages they cause; and regulate safety, emissions, and mergers. Water commerce is perhaps the most complex case because of the long and rich history of maritime trade as a cornerstone of the U.S. economy, the significant role of federal agencies in maintaining and regulating use of the nation's waterways, the varied roles of state and local governments and private firms in the pro-vision of ports, and the numerous and complex federal and state provisions for environmental protection that apply to port and maritime operations.



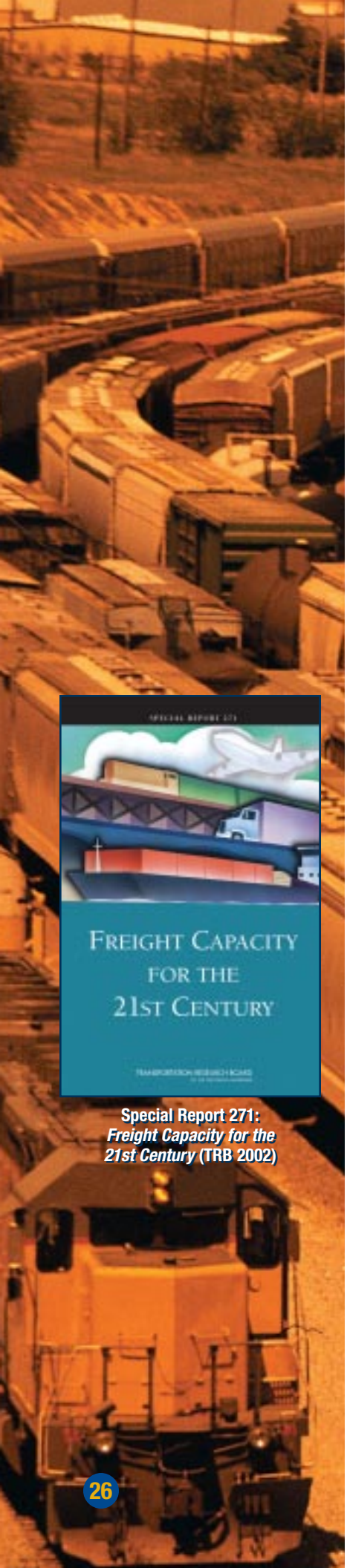
Special Report 252:
Policy Options for Intermodal Freight Transportation **(TRB 1998)**

Increased Public Investment in Freight Transfer Points

During the last two decades, the importance of freight efficiency to the nation's economy has become more apparent to federal policy makers and has emerged as an increasingly important element of laws and regulations related to surface transportation. In the Intermodal Transportation Efficiency Act of 1991 (ISTEA), Congress stated: "It is the Policy of the United States to develop a National Intermodal Transportation System that is economically efficient and environmentally sound, provides the foundation for the Nation to compete in the global economy, and will move people and goods in an energy efficient manner." The term "intermodal" is usually interpreted as referring to places where the various modes connect for the purpose of transferring passengers or freight or to operations designed to move on more than one mode. ISTEA introduced provisions, carried over and extended in the Transportation Equity Act for the 21st Century, that allowed taxes collected for the highway trust fund to be used for intermodal investments designed to facilitate more efficient connections between the modes. Highways and trucking are central to intermodalism because virtually all freight moves by truck at some point in its trip.

Intermodal transfer points include any terminals where freight is transferred from one mode to another. Intermodal connections are critically important to freight movement. Massive seagoing vessels deliver containerized cargo to ports, where the containers are either trucked to rail yards for placement on trains or off-loaded directly onto rail cars at the port terminal. Containerization has introduced extraordinary efficiencies into freight movement, but the connection points remain sources of friction and lost efficiency.

The TRB committee that examined policy options for intermodal freight transportation concluded that public investment in freight facilities is complex. These types of



Special Report 271: ***Freight Capacity for the 21st Century*** **(TRB 2002)**

facilities (railyards, port terminals, and truck terminals) have usually been financed exclusively by the private sector. The committee concluded that introducing public funds into this mix could undermine the "user pays" principle that has been fundamental to highway finance, fuel interstate rivalries, and come to be demanded by private-sector firms as a substitute for formerly private investment.

Appropriate federal and state roles in such projects are not yet well established in practice; hence there are uncertainties about how to proceed and a risk of wasted resources. Before federal and state funds are invested in such facilities, the investments should be clearly justified. Such justification might include, for example, that the investment would reduce negative externalities and increase positive externalities, or that it is necessary for national defense. In defining an appropriate public role, government agencies should apply standard analysis tools to estimate costs and benefits and winners and losers. The public role in financing major facilities should also receive close scrutiny to ensure that public benefits justify the expenditure of public funds and that users pay to the extent that they benefit. The location of benefits also matters: when benefits are primarily local rather than national, local or state governments are the appropriate sources of funding.

Will Future Freight Capacity Be Adequate?

During the late 19th and most of the 20th century, the nation collectively made massive investments in transportation facilities, including railroads, ports, highways, and pipelines. The nation is now well interconnected, [see table, page 27] but many bottlenecks remain. During the last decades of the 20th century, overall investment in new capacity slowed even as the use of facilities continued to grow apace. The reasons for the slower expansion of capital facilities are complex. They include the completion of the Interstate highway system, the introduction of federal and state provisions for environmental protection that make it more difficult to add new capacity, and the evolution of the national economy from a production to a service orientation.

Yet the economy and population continue to grow. By the middle of this century, the U.S. economy's output of goods, the volume of international trade, and vehicle miles of travel will have more or less doubled, and the population will have increased by half. The addition of major new facilities is a daunting task, often requiring one or more decades from approval of a concept to its realization. Hence, government officials must plan over a long time horizon—often longer than that of the private sector—to avoid potential capacity shortfalls and lost economic growth.

The committee that addressed the issue of freight capacity for the 21st century took note of some worrisome trends. Highway capacity expansion is falling behind traffic growth. Railroads have been downsizing, and recent mergers have caused substantial service disruptions. Many border crossings and freight terminals are experiencing increased congestion. And conflicts between passengers and freight for shared facilities are growing.

Table ?

Scale and Use of the U.S. Transportation System (1999–2000)

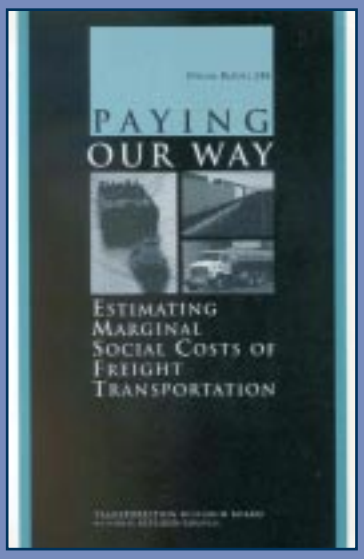
Mode	Components	Annual Output
Highway	3,951,115 road miles	4,994,703,000,000 passenger-miles 1,093,000,000,000 ton-miles
Air	5,317 public airports	515,367,000,000 passenger-miles
Urban Transit	Bus: 160,500 route miles Rail: 6,600 route miles	21,4000,000,000 passenger-miles 22,874,000,000 passenger-miles
Rail	120,000 freight rail lines	1,465,960,000,000 ton-miles
Water	26,000 navigable waterways	645,799,000,000 ton-miles
Oil Pipeline	177,000 pipeline miles	617,000,000,000 ton-miles

Source: Pocket Guide to Transportation, Tables 1, 10, and 15, Bureau of Transportation Statistics, USDOT, 2002; National Transportation statistics 2001, Bureau of Transportation Statistics, USDOT, 2002.

Despite these trends, the committee observed that the private freight industry can be quite dynamic and innovative in responding to inevitable bottlenecks in capacity as they arise. Moreover, workplaces and residences tend to move away from congestion within metropolitan areas and from more-congested to less-congested regions. Such adjustments have been a characteristic way of accommodating growth throughout the nation's history. Yet this resolution, while tolerable, is certainly far from the economic optimum. Moreover, regions unable to address capacity needs face the loss of jobs and growth.

At the national level, the federal government can and should take a variety of actions to maximize the efficiency of public investment and freight movement. Virtually no federal measure affecting freight is as consequential as the level of investment in and the tax structure of the federal-aid highway system. As suggested earlier, highway services are essential to the functioning of the rail, air freight, port, and waterway systems. Federal policy can encourage economic efficiency by maintaining and reinforcing the principles of user financing and by more closely aligning user fee payments with the costs users occasion.

Other measures are also important, such as maximizing the efficiency of federal planning for and investment in improvements to waterways and port harbors and channels. Moreover, financing of these investments should be based on user fees rather than general fund subsidies, and more concerted efforts should be made to expedite the conduct of environmental regulatory reviews. Overall, the public role would be significantly enhanced by improved and better-informed analyses across all modes of the benefits, costs, beneficiaries, and appropriate means of financing new and managing existing capacity.



Special Report 246:
***Paying Our Way: Estimating Marginal Social Costs of Freight Transportation* (TRB 1996)**

Pricing Full Social Costs

Another way to approach capacity is through demand management. In freight transportation, the major debate in this regard is about whether the freight modes are charged appropriately for the full costs they impose on society. Railroads and pipelines are funded almost entirely by private funds, but highway and water transportation are funded in part through user fees and taxes. These fees and taxes, however, are designed to recover infrastructure costs, not to compensate society for other social costs, such as pollution, congestion, and crashes. And when shippers and consumers are not charged the full cost of the services they use, they tend to overconsume them. Moreover, to the extent that one mode is subsidized more than another, the competition between them is not on a level playing field.

The TRB committee that addressed these issues produced a preliminary examination of whether shippers of domestic surface transportation freight pay the full social costs of the services they use. Their report was intended not to provide definitive answers, but to assess the feasibility of making such estimates. In the report, the concept of marginal social costs is used to determine whether freight users are subsidized. The marginal social cost of a good being transported is defined as the increase in total social costs that results from producing one additional unit of output above the level currently being produced.

The committee conducted a small number of case studies to examine whether data were available or could be constructed for estimating the marginal social costs of bulk and general cargo shipments by truck, rail, and barge. The case studies revealed that it would be possible to develop reliable estimates. The committee recommended that USDOT fund a much larger number of case studies to develop a sufficiently large sample so that generalizations can be drawn about subsidies in U.S. surface freight transportation.

Waterborne Transportation

TRB committees have conducted other important studies on freight-related topics. One committee reviewed a broad range of federal policies that influence the efficiency of marine transportation of containers (Special Report 236, *Intermodal Marine Container Transportation: Impediments and Opportunities,* 1992). Another examined problems with road and rail access to ports and made recommendations for changes in federal, state, and local policy to facilitate improved access (Special Report 238, *Landside Access to U.S. Ports,* 1993). Most recently, TRB collaborated with The National Academies' Water Science and Technology Board on a peer review of the adequacy of the U.S. Army Corps of Engineers' studies of environmental impacts and of the demand for barge traffic that would result from improving locks on the Upper Mississippi–Illinois waterway (*Inland Navigation System Planning: The Upper Mississippi River—Illinois Waterway,* NRC 2001).

MANAGING RISK
KEY COMMITTEE FINDINGS AND RECOMMENDATIONS

- Many of the obvious requirements to improve the safety of transportation have been put in place, but the toll in deaths and injuries, particularly on highways, remains steep.
- Federal fuel economy regulations should be designed to minimize incentives to reduce the size and mass of vehicles.
- Motorists' compliance with speed limits enhances safety but requires a level of enforcement that cannot usually be sustained in the United States because of the extent of the road network and human resources required. Experimentation with automated forms of enforcement should be conducted to determine the practicality and political feasibility of such approaches.
- Good estimates of the benefits of vehicle safety features are hindered by inadequate data and funding for research. The federal government, in partnership with the automobile industry, should develop a program of research to develop, test, and improve such estimates.
- Reliable estimates of the benefits and cost-effectiveness of safety measures are needed to inform policy choices.
- Congress should establish a new, independent organization to rigorously evaluate the risks of larger and heavier trucks.
- Alcohol impairment by the operators of commercial vehicles is not an acceptable risk. The penalties for violation of federal and state standards should be commensurate with the degree of impairment.
- Federal efforts to provide consumers with safety-relevant information about vehicles appear promising. However, the estimation of risks and means of conveying risk information should be improved through research, systematic testing, and evaluation of consumer understanding of the information provided.

MANAGING Risk

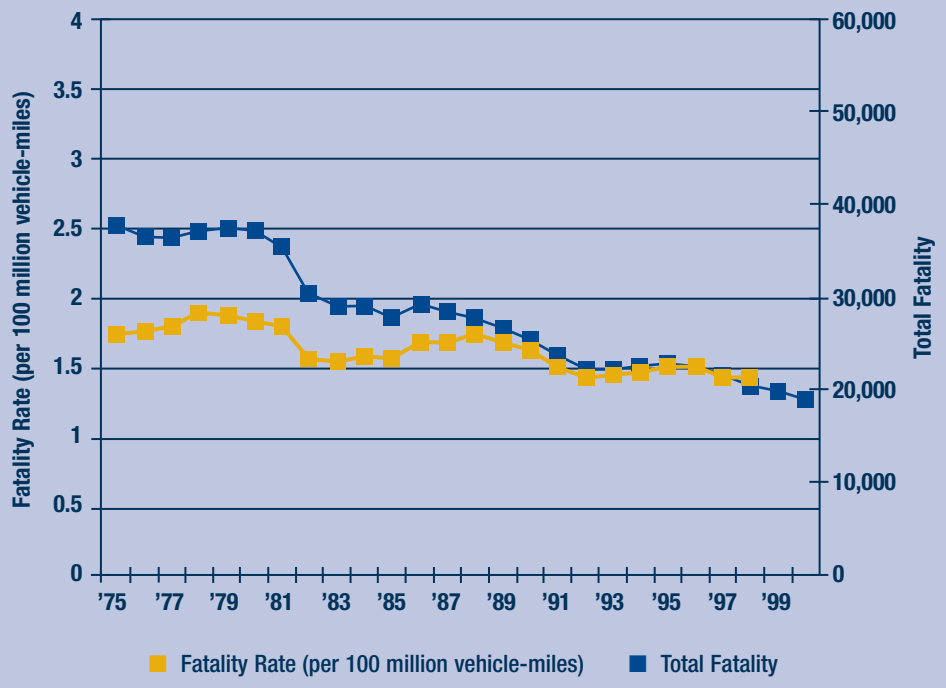
More than 40,000 people are killed each year and millions more injured while traveling within the nation's transportation system. About 95 percent of fatalities and an even larger share of injuries associated with transportation occur on roads and highways. Even as deaths and injuries per passenger mile of highway travel have generally decreased over time (Figure 4), the human toll remains high.

Safety thus continues to be a major emphasis of federal and state policy. Many safety features and regulations have been instituted for all transportation modes, covering vehicles, operators, and infrastructure. Each such innovation necessitates complex and often contentious analysis of the associated safety benefits and costs. Given the significant safety impacts involved, it is essential that careful analysis be done to support such policy choices.

The importance of managing risk and achieving a safer transportation system has made this an area of focus for a number of TRB committees. Specific topics addressed include safer vehicles, infrastructure safety, regulation of drivers, means of informing consumer choices with regard to automotive safety and fuel efficiency, monitoring of shipments of hazardous materials, and safer travel to school.

Figure 4

Fatalities and fatality rate of passenger car occupants on U.S. highways.



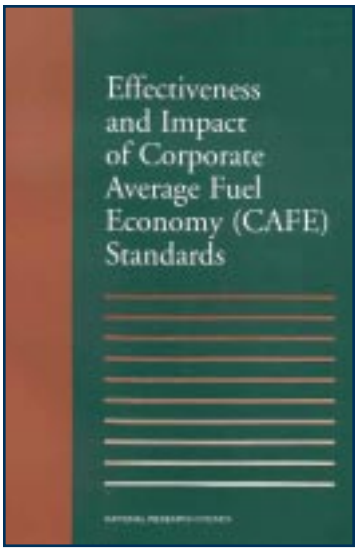
Source: U.S. Department of Transportation, Bureau of Transportation Statistics, National Transportation Statistics 2001.

Safer Vehicles

Passenger Vehicle Standards

Fuel economy standards were instituted following the energy crisis of 1973 without consideration of how they might affect safety. These Corporate Average Fuel Economy (CAFE) standards require motor vehicle manufacturers to increase the sales-weighted average fuel economy of passenger cars and light-duty trucks.

The CAFE standards have always been controversial. Manufacturers complain that the standards run counter to market demand and impose extra costs on consumers and industry. Safety advocates complain that the standards increase risk by encouraging sales of smaller vehicles to save fuel. On the other hand, those concerned about environmental protection and the costs of imported fuel have supported the standards as necessary.

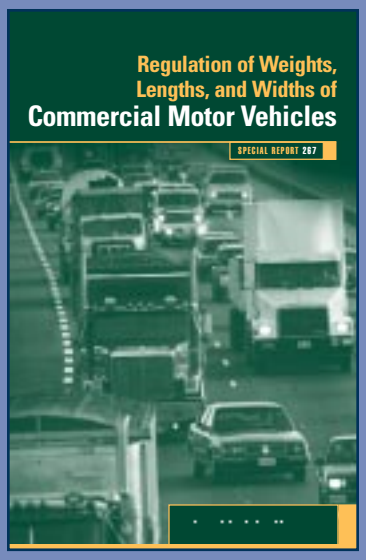


Effectiveness and Impact of Corporate Average Fuel Economy (CAFE) Standards **(NRC 2002)**

Throughout the entire 30-year period during which the standards have been applied, their actual effects on costs, sales, fuel economy, emissions, and safety have been disputed. Accordingly, in fall 2001, Congress asked The National Academies to conduct a study evaluating the effectiveness and impacts of the CAFE standards. The Academies had conducted a similar study in 1991. In both cases, TRB provided assistance on the safety issues (the focus here), while the Board on Energy and Environmental Systems focused on energy-saving technology opportunities and costs.

In the past, manufacturers reduced the size and weight of vehicles to make them more fuel-efficient. A key debate concerns whether the ability of a vehicle to absorb energy (its "crush space") can be retained if the vehicle is made lighter through design changes and the use of lighter-weight materials. Even within the committee, the safety issues involved were controversial. The majority of the committee members concluded that the downsizing (and downweighting) of vehicles that occurred in the late 1970s and early 1980s probably resulted in 1,300 to 2,600 crash fatalities and 13,000 to 26,000 serious injuries in 1993 (the most recent year for which a comprehensive estimate has been developed). The proportion of these casualties attributable to fuel economy standards is uncertain, however, because some consumers shifted from larger to smaller vehicles to save on fuel costs. Two of the committee members, however, dissented from these conclusions. They noted that the relationships between vehicle weight and safety are complex and difficult to measure with any degree of certainty, and the models used to estimate the safety consequences of downweighting are subject to considerable criticism.

For the future, it is not clear whether significant weight reduction can be achieved without some additional downsizing, which could be expected to result in additional deaths and injuries. The committee unanimously recommended that the National Highway Traffic Safety Administration consider a regulatory system that would not provide incentives for downsizing to meet fuel economy standards, and strongly encouraged the agency to conduct additional research to resolve the debate over CAFE's safety effects.

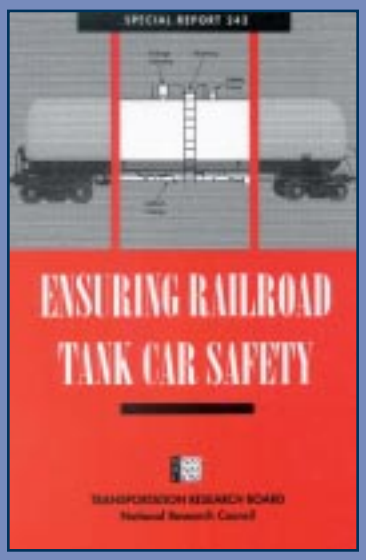


Special Report 267:
Regulation of Weights, Lengths, and Widths of Commerical Motor Vehicles **(TRB 2002)**

Truck Safety

The fundamental problem involved in evaluating proposals for changes in truck dimensions is that their effects can often only be estimated or modeled. The data available for estimating safety consequences in particular are inadequate, and probably always will be. Thus, the committee that conducted this study (whose findings with regard to productivity were discussed earlier in the section "Productivity-Enhancing Regulation") concluded that the resulting analyses usually involve a high degree of uncertainty. What is needed is some way to evaluate potential changes through limited and carefully controlled trials, much as proposed new drugs are tested before being allowed in widespread use.

The committee recommended that a new independent entity be created to work with private industry in evaluating new concepts and recommending changes to regulatory agencies. Limited pilot tests would be required, which would need to be carefully designed to avoid undue risks and ensure proper evaluation. Special vehicles could be allowed to operate under carefully controlled circumstances, just as oversize and overweight vehicles are allowed to operate under special permits in many states. Changes in federal laws and regulations would be required to allow states to issue such permits on an expanded network of highways, under the condition that a rigorous program of monitoring and evaluation be instituted.



Special Report 243:
Ensuring Railroad Tank Car Safety
(TRB 2002)

Railroad Tank Cars

Tank cars are common, representing about one out of every seven rail cars. Over the years, industry and government have worked together to enhance both the physical tank car and the environment in which it operates. Following several incidents involving tank cars, however, the National Transportation Safety Board raised concerns about the adequacy of this process for protecting public safety.

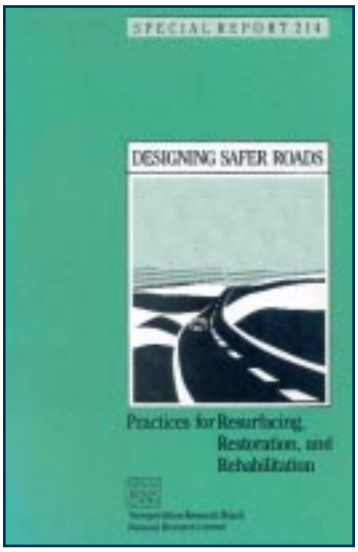
About half of the nation's roughly 200,000 railroad tank cars carry materials regulated by USDOT because they are flammable, corrosive, poisonous, or otherwise hazardous. In 1990, Congress directed USDOT to arrange for a study of the railroad tank car design process, including initial design, subsequent performance evaluation, and the means by which government and industry oversee and improve tank car design.

Design standards for tank cars are established by the Tank Car Committee of the Association of American Railroads, which consists of technical representatives from railroads, shippers, and tank car builders. Many of these design standards were adopted as requirements by federal regulations. In cases in which the standards are general in nature, USDOT relies on the Tank Car Committee to establish detailed design standards and review individual design drawings to ensure that they meet the underlying USDOT criteria.

The TRB committee that studied tank car safety found that the safety record of tank cars carrying hazardous materials is good and that severe incidents are

rare and likely to remain so in the future. The committee also concluded that the government–industry design process is fundamentally sound. However, the committee recommended several modifications aimed primarily at ensuring that safety decisions are well supported and guided by long-range safety goals and strategies.

Infrastructure Safety



Special Report 214:
Designing Safer Roads: Practices for Resurfacing, Restoration, and Rehabilitation **(TRB 2002)**

Cost-Effective Safety Design for Rural Highways

Safety is a central design consideration for modern highways. For roads receiving federal aid, safety is incorporated through the design policies established by the American Association of State Highway and Transportation Officials (AASHTO), adherence to which is required by the Federal Highway Administration for roads funded with federal aid. Many older and rural roads, however, were built before AASHTO's modern guidelines had been established. When federal aid is used to improve these roads—when they are resurfaced, for example—safety advocates have urged that they be upgraded to incorporate modern design standards, which might include wider lanes, improved provision for driver sight distance, and other enhancements. State and local officials, by contrast, often contend that raising these roads to the current standards would greatly reduce the number of miles of road that could be resurfaced or upgraded, which would itself be detrimental to safety.

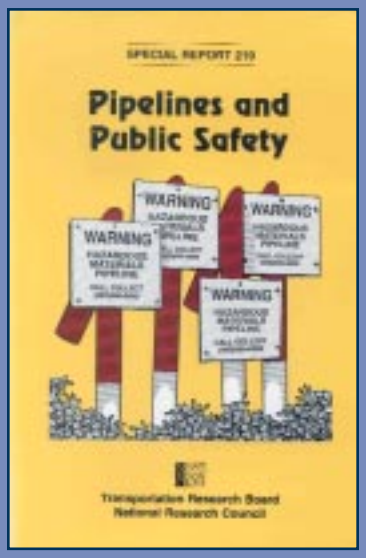
At the request of Congress, a TRB committee examined the cost-effectiveness of safety-related geometric design elements such as lane and shoulder widths, crest vertical curves, stopping sight distances, and intersections. Unfortunately, the safety benefits of such design features have not been well established. Moreover, the variability in local conditions, the amount of daily traffic, and other considerations undermine the usefulness of specific standards. Nonetheless, the committee recommended a number of safety-conscious design practices and improvements, including minimum lane and shoulder widths for two-lane roads and bridge widths. The committee also recommended analytical approaches that could be used by state and local officials to determine when safety improvements should be considered, and outlined an approach for assessing the safety cost-effectiveness of doing so. The report produced by the committee has become a standard reference for engineers designing improvements to rural roads.

Pipelines

Pipelines provide a vital transportation service. Approximately half of the nation's supplies of crude oil and petroleum products and virtually all of its natural gas supplies are transported through a network of 1.7 million miles of pipelines.

The materials carried by pipelines are flammable, explosive, or toxic, which means that pipelines pose a danger to people and property should their failure result in release of these materials to the environment. The development of residences, workplaces, and shopping areas near once-isolated transmission pipelines, which carry gas and liquids at high pressure from producing areas to refineries or distribution networks, threatens to increase the risk of pipeline failure due to inadvertent excavation damage. Historically, such excavations have been a major cause of pipeline accidents. Accidents in the future could also be more severe because new development has exposed more people and property to risk in the event of a failure.

Pipeline safety was addressed by a TRB committee, many of whose recommendations were adopted by government and industry after release of the committee's report. The recommended measures include collaboration on damage prevention and public awareness programs, land use measures, and emergency preparedness programs. The committee stopped short of recommending specific development setbacks that would provide more uniform land use control across the nation. Instead, it pointed out a number of procedural changes in land development review and regulation that would reduce the risk of inadvertent damage. Although more uniform public policies on land use near pipelines might be desirable, differences in local conditions argue against establishing definitive standards or limits on specific land uses near pipeline rights-of-way.



Special Report 219:
Pipelines and Public Safety: Damage Prevention, Land Use, and Emergency Preparedness
(TRB 1988)

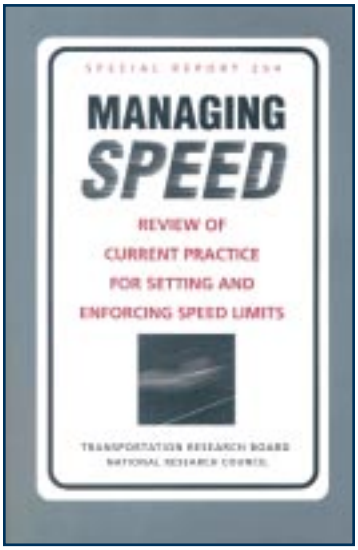
Regulation of Drivers

Alcohol-Impaired Driving

About 35 to 40 percent of traffic fatalities involve alcohol. As part of a broad strategy to improve the performance of commercial drivers, Congress established requirements for a national commercial driver's license in the Commercial Motor Vehicle Act of 1986. That legislation also proposed reducing the then-prevailing standard for such licenses that defined the offense of driving a commercial vehicle while under the influence of alcohol in terms of blood alcohol concentration (BAC). In most states, the defined limit for alcohol impairment was 0.10 percent BAC at the time the 1986 legislation was enacted; most states have since reduced their limits to 0.08 percent. The Commercial Motor Vehicle Act set a standard of 0.04 percent BAC for commercial drivers and requested a study of alternative standards by the National Academy of Sciences.

Roughly 15 percent of commercial operators involved in fatal crashes had been drinking, according to the best available information in the early 1980s. While commercial operators fare better in this regard than the average motorist involved in alcohol-related crashes, there is considerably less tolerance for any alcohol impairment among drivers while working. The victims of crashes involving heavy trucks, regardless of which driver is at fault, are most often the operators of the smaller vehicles.

Performance on driving-related tasks decreases at any BAC above zero, and crash risk increases sharply as BAC rises. Enforcement at low BAC levels is problematic, however, because assessing driver impairment, even with the assistance of breath analysis devices, is more difficult than at higher BAC levels. The majority of the members of the TRB committee addressing this issue recommended that a zero tolerance policy be adopted, with penalties ranging from 30 days' suspension below 0.04 percent BAC to license revocation for BAC above 0.04. USDOT subsequently adopted a 0.04 percent BAC standard, with a 1-year revocation for offenses at or above that level on the first offense.



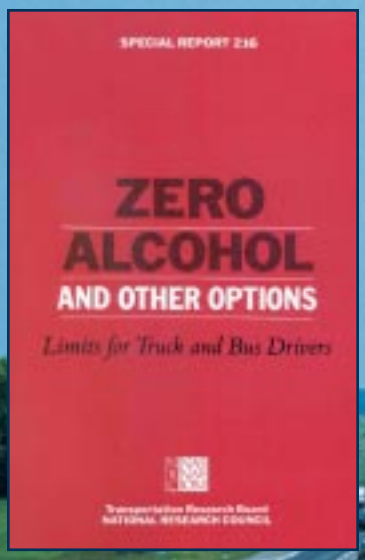
Special Report 254: ***Managing Speed: Review of Current Practice for Setting and Enforcing Speed LImits*** **(TRB 1998)**

Managing Speed

Speed limits for regulating driving behavior date to 1901, but they remain controversial. The imposition of a nationwide 55-mph speed limit following the oil embargo of 1973, the allowance for states to raise limits to 65 mph on rural Interstate highways in 1987, and the allowance for states to increase limits on other major highways in 1995 were all hotly debated and the subject of numerous special studies.

A 1984 TRB study, requested by Congress, evaluated all the available research on the effects of the 55-mph national maximum speed limit. The committee concluded that 10 years after the reduction in maximum limits, 2,000 to 4,000 lives were being saved each year as a result of slower travel speeds relative to the period before the 55-mph national limit was imposed. These savings were apparently due to the reduction in average speeds and the reduced variability of speed on the highways. Reduced average motorist speed should reduce the risk of injury when a crash occurs because it typically results in a lower impact speed, whereas reduced variability in speeds among motorists should reduce the frequency of accidents.

With each passing year, however, motorists' compliance with the 55-mph limit was eroding. Even by 1984, the majority of motorists were exceeding the limit. Congress



Special Report 216: ***Zero Alcohol and Other Options: Limits for Truck and Bus Drivers*** **(TRB 1987)**

Special Report 204:
55: A Decade of Experience
(TRB 1984)

responded by allowing the national maximum limit to increase to 65 mph and subsequently abolished the national limit altogether.

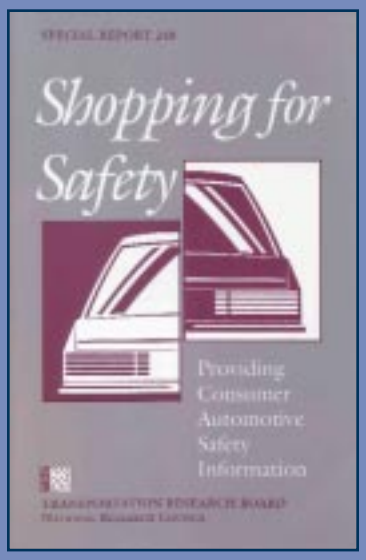
In 1998, a TRB committee revisited this issue. Its report provides a retrospective on the experience with national maximum limits and suggestions for future policy. The committee's analysis of the studies of speed limits supports the general finding that higher speed limits increase risk, but the committee also took note of the wide variety of local conditions and the statistical problems involved in isolating speed from other factors. Both this and the 1984 committee agreed that motorists' compliance is critical and that enforcement is difficult.

In general, state and local officials are probably in the best position to judge appropriate maximum limits for highway systems in their locales, but they should also allow for speed zones where limits would be established to take account of both design issues and motorist behavior. Legislated system limits should be based on the design speed, vehicle operating speeds, safety experience on the route, and enforcement experience. The established approach of basing speed limits in speed zones solely on the 85th percentile of free-flowing speed is not always appropriate; an expert-system approach would take into account a range of important factors.

Enforcement of speed limits has always been a challenge and is made more so when most motorists believe a limit to be unreasonable. Even when the majority comply, it is difficult to deter the highest-speed motorists, who put others at risk. Deployment of enough officers to catch or deter high-speed drivers can impose more expense than many jurisdictions are willing or able to bear. Automated technologies, such as photo-radar or intelligent systems, should be tested for both efficacy and public acceptability.

Means of Informing Consumer Choices

Since passage of the National Traffic and Motor Vehicle Safety Act of 1966, which created the agency known today as the National Highway Traffic Safety Administration (NHTSA), establishment of motor vehicle safety standards has been a primary emphasis of federal policy. Numerous such standards have been introduced, including those mandating collapsible steering columns, nonlacerating windshields, safety belts, and air bags. Although the role played by these measures cannot be determined, the rate of motor vehicle fatalities has declined by 70 percent since 1966. Yet an annual toll in excess of 40,000 highway deaths suggests that more can be done in the area of vehicle safety.



Special Report 248:
Shopping for Safety Providing Consumer Automotive Safety Information **(TRB 1996)**

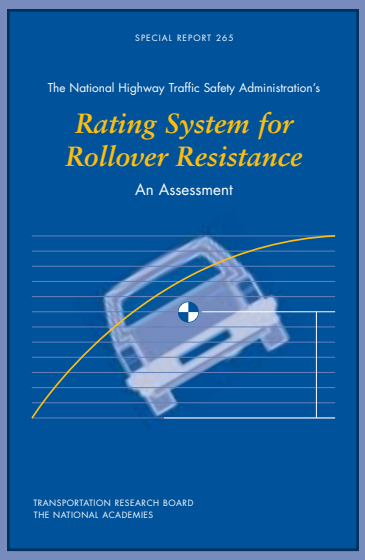
Mindful of the growing interest in motor vehicle safety features and the federal role in automotive safety, Congress requested a study of related consumer information needs in 1994. Consumers have increasingly been demanding and paying for more vehicle safety features, such as antilock braking systems and air bags. Consumer magazines, such as *Consumer Reports,* provide safety information about vehicles, and a

prominent television program even features the crash test results of the Insurance Institute for Highway Safety. The strong and growing consumer interest in safety indicates that the government could influence which vehicles and vehicle features consumers seek out to provide for their own safety.

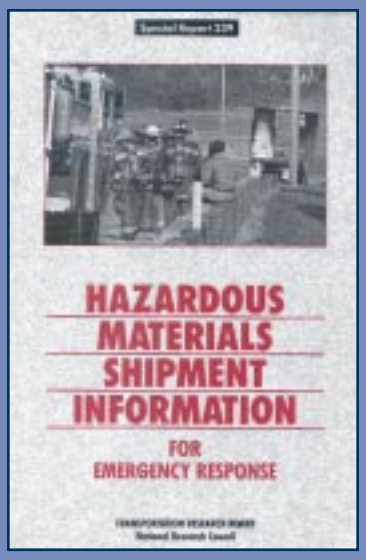
Perhaps the most common question consumers ask is which car is safest. Unfortunately, there is no good answer to this question. Many vehicle, driver, and roadside features influence crash outcomes in ways that are difficult to predict. A 1996 TRB committee concluded that the federal government could facilitate progress toward an overall measure of vehicle safety by investing in research and by working with experts in academia and industry. Because of the complexities involved and the current lack of adequate data on many salient variables, however, achievement of such a goal would take many years. In the nearer term, NHTSA could do much to improve the quality of existing information and convey it to consumers more clearly and efficiently. For example, the agency could give consumers a better understanding of the importance of vehicle dimensions for safety outcomes, the benefits of proper use of vehicle safety features, the frequency of crash types for which tests exist, and the uncertainties associated with crash tests themselves.

Following NHTSA's issuance of vehicle ratings to inform consumers about rollover risk, Congress requested a TRB study to evaluate the appropriateness of the rating system. Motor vehicle rollovers involving passenger cars, vans, pickup trucks, and sport utility vehicles result in approximately 10,000 deaths and 27,000 serious injuries each year in the United States. NHTSA developed a five-star rating system to inform consumers about the rollover resistance of passenger cars and light-duty passenger vehicle trucks.

After thoroughly evaluating NHTSA's development of the rating system, the committee that conducted this study concurred with the agency's reliance on a static measure of vehicle stability but pointed out some inadequacies of the statistical model used to relate this static measure to rollover risk. Alternative statistical approaches would provide a better approximation of risk. The rating system itself was found wanting. The procedures used to develop and test the ratings with consumers through focus groups did not provide credible evidence that consumers understood the message about the actual risk associated with a given vehicle. By being limited to only five levels, the system also discarded valuable information. The data developed by NHTSA could be refined to enable consumers to discriminate better among vehicle models with regard to their rollover experience.



Special Report 265: *The National Highway Traffic Safety Administration's Rating System for Rollover Performance: An Assessment* (TRB 2002)



Special Report 239:
Hazardous Materials Shipment Information for Emergency Response **(TRB 1993)**

Monitoring of Hazardous Materials Shipments

Federal law defines a hazardous material as any substance or material in a quantity and form that may pose an unreasonable risk to health, safety, or property when transported in commerce. Thousands of materials are classified as hazardous, and tens of thousands of firms are involved in their movement. The number of daily movements of these materials is not known with precision but is estimated to exceed 500,000. The risks posed by such commodities vary widely depending on the material itself, its packaging, and the mode and route selected for its movement.

In 1990, Congress called for a study of "the feasibility and necessity of … a central reporting system and computerized telecommunications data center that is capable of receiving, storing, and retrieving data concerning all daily shipments of hazardous materials … and that can provide information to facilitate responses to accidents and incidents involving the transportation of hazardous materials." Firefighters and police regularly respond to incidents involving the release or threat of release of hazardous materials in transport. Minimizing the danger of injury and other costs of such events requires knowledge of the materials so that appropriate firefighting and other mitigation measures can be taken and decisions made regarding evacuation or traffic diversion. In some cases, emergency responders are unable to determine the appropriate response because information about the hazardous material in question is not complete or has been obscured or lost as the result of a crash.

In 1993, a TRB committee reviewed the existing system that involved providing placards on vehicles and using then-current information sources. The committee found the system to be wanting, but stopped short of recommending the centralized reporting and monitoring system it was asked to consider. Review of a sample of crashes indicated that most of the information problems faced by emergency responders would probably not be resolved by the envisioned system until many other issues had been addressed. Moreover, many daunting institutional and technical impediments would have to be overcome before a nationwide information system would be operational and cost-effective.

The committee therefore recommended incremental improvements to the existing system, involving more rigorous monitoring and enforcement, changes in regulations, improved training, and advanced technologies. USDOT was encouraged to begin deploying and evaluating prototype reporting systems to determine their efficacy, with the expectation that more automated information systems would become increasingly feasible and cost-effective over time.

Safer Travel to School

In response to a congressional request, a TRB committee prepared national estimates of the relative risks of travel to and from school by various modes. The committee found it difficult to prepare comparable risk estimates on a consistent, reliable basis. Using plausible assumptions, however, it was able to combine national datasets to estimate the comparative risks (Table 1).

During normal school travel times, school buses and transit buses are by far the safest modes for school travel, followed by private passenger vehicles driven by adults. On a per-trip or per–passenger mile basis, walking, cycling, and being driven by a teenager are the riskiest modes. About 800 children die each year in crashes during the normal hours of school travel; only about 3 percent of these deaths occur in school buses or transit buses. By contrast, about 50 percent of injuries and fatalities occur to children in vehicles driven by teenagers.

Local jurisdictions can use the estimates developed by the committee to manage school travel risk more comprehensively. USDOT can assist states and local jurisdictions in managing their risks by providing guidance on the effectiveness of such safety measures as graduated licensing programs, bicycle helmet requirements, laws mandating safety belt use, improved pedestrian and cyclist access, and other such safety measures.

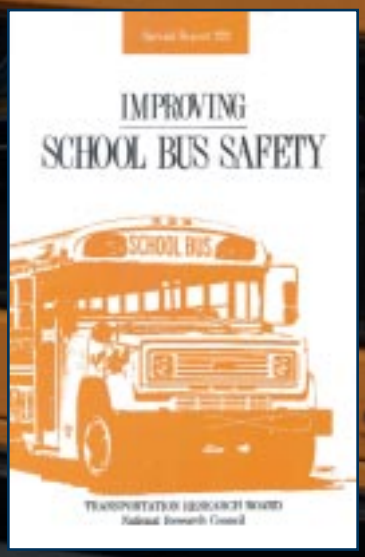
Table 1

Estimated Student Injury and Fatality Rates by Mode During Normal School Travel Hours

	Injuries		Fatalities	
Mode	Per 100 Million Student Trips	Per 100 Million Student-Miles	Per 100 Million Student Trips	Per 100 Million Student-Miles
School bus	100	20	0.3	0.1
Other bus	120	20	0.1	<0.1
Passenger vehicle, adult driver	490	90	1.6	0.3
Passenger vehicle, teen driver	2,300	430	13.2	2.4
Bicycle	1,610	2,050	9.6	12.2
Walking	310	590	4.6	8.7
Overall rate	650	130	3.5	0.7

Sources: 1991–1999 Fatality Analysis Reporting System and National Automotive Sampling System General Estimates System and 1995 Nationwide Personal Transportation Survey

Special Report 269:
The Relative Risks of School Travel: A National Perspective and Guidance for Local Community Risk Assessment **(TRB 2002)**



Special Report 222:
Improving School Bus Safety
(TRB 1989)

PROVIDING FOR SECURITY AGAINST TERRORISM
KEY COMMITTEE FINDINGS AND RECOMMENDATIONS

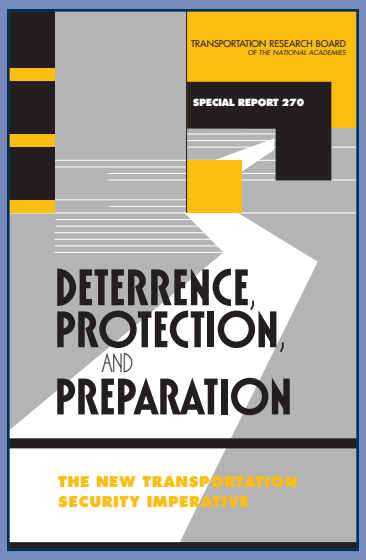
- Security against terrorism has been elevated to a major policy goal for transportation, on an equal footing with goals of mobility, safety, and environmental protection.
- The ubiquity and openness of transportation systems in the United States represent at the same time transportation's strongest virtues and greatest vulnerabilities.
- Traditional security measures based on perimeter defenses will probably not be successful in eliminating breaches and could impose large economic and social costs.
- A multilayered approach that builds on opportunities to improve efficiency in passenger and goods movement appears promising.
- It is essential to couple a strategy for deterring, protecting against, and responding to threats with a research agenda designed to help accomplish these goals.

PROVIDING for Security Against Terrorism

The attacks of September 11, 2001, galvanized the nation to strengthen its counterterrorism defenses. The nation's vast air, land, and maritime transportation systems are marvels of innovation and productivity, but they are designed to be accessible, and their very function is to concentrate passenger and freight flows in ways that can create many vulnerabilities for terrorists to exploit. Improving the security of the system while maintaining its efficiency and effectiveness is a daunting challenge. Terrorists worldwide have regularly victimized patrons of transportation facilities. Two studies related to providing security against terrorism have been conducted—one addressing security strategies and the other R&D for transportation security.

Security Strategies

The committee that addressed security strategies concluded that the prospects for defending against each of the vulnerabilities of the transportation system through traditional means, or "guards, guns, and gates," are dim. The transportation sector is simply too large and the threats faced too diverse and inconstant for such blanket approaches to work. Moreover, if applied in the large and diffuse transportation sector, these approaches run the risk of creating a diluted and patchwork collection of poorly connected defenses that disperse security resources while leaving many vulnerabilities unprotected against a terrorist attack.



Special Report 270:
Deterrence, Protection, and Preparation: the New Transportation Security Imperative **(TRB 2002)**

Transportation security can best be achieved, concluded the committee, through coherent security systems that are well integrated with transportation operations and deliberately designed for deterrence even as they selectively guard against and prepare for terrorist attacks. In particular, layered security systems, characterized by an interleaved and concentric set of security features, have the greatest potential to deter and protect. Layered systems cannot be breached by the defeat of a single security feature—such as a gate or guard—because each layer provides backup for the others so that impermeability of individual layers is not required. Moreover, the interleaved layers can confound the would-be terrorist. Calculating the odds of breaching a multitiered system of defense is far more difficult than calculating the odds of defeating a single, perimeter protection.

The committee found that when integrated well with transportation services and functions that confer other benefits, such as enhanced safety and service quality, layered systems are even more likely to be deployed and sustained over time. Multiuse systems—for instance, systems that benefit transportation operators and users by monitoring the condition of infrastructure and location of vehicles, baggage, and cargoes—are apt to be maintained and continually adapted to the changing transportation environment. A combination of public leadership and private incentives is therefore essential to the deployment of such dynamic, built-in security systems.

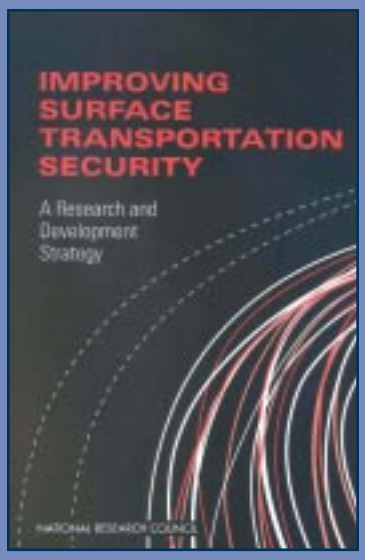
R&D for Security

The chemical attack on the Tokyo subway system in 1995 and suspected sabotage causing the derailment of an Amtrak train that same year made the nation aware of the vulnerability of the surface transportation system to terrorism. In response, Congress requested an assessment of this vulnerability and the development of an R&D strategy for improving security.

The committee that took up this task encouraged USDOT to develop an R&D strategy before establishing a detailed research agenda. This strategy should be founded on a systematic process of five steps: clear definition of the problem and objectives, identification of a wide array of possible solutions, rigorous evaluation of those alternatives, careful

decision making, and effective implementation. This process should be implemented across rather than within modes.

Moreover, USDOT should understand and be sensitive to its role. The federal government itself is responsible for the operation of but a small fraction of the nation's infrastructure, which is generally owned and managed by other units of government. Thus the federal purview is far smaller than it is often understood to be by the public. It is most important to involve the owners and operators of the transportation system in the development and implementation of any security strategy, as well as in the R&D that informs it. In addition, much of the potentially relevant R&D for security is being conducted by and through other federal agencies, and a good part of USDOT's role should be surveying promising technologies, adapting them to transportation applications, and sharing the resulting knowledge with other system operators. The committee concluded further that a dual-use approach, in which security objectives are furthered along with other transportation goals, has the most potential for successful application.



Improving Surface Transportation Security: A Research and Development Strategy **(NRC 1999)**

PROTECTING THE ENVIRONMENT KEY COMMITTEE FINDINGS AND RECOMMENDATIONS

- Since passage of the Clean Air Act and creation of the Environmental Protection Agency, as well as state-level environmental protection agencies, U.S. society has struggled both nationally and locally with balancing goals for transporting people and goods on the one hand and protecting the environment on the other.
- "Technology-forcing" policies aimed at cleaning up fuels, reducing emissions, and preventing oil spills have resulted in dramatic reductions in environmental damage. By comparison, policies aimed at changing behavior have had modest effects.
- The environmental regulatory process for considering new investments in infrastructure and establishing regulations for dredging involve multiple agencies with different missions and often take considerable time. Society would benefit from allocating resources to expedite these reviews in ways that would not sacrifice the quality of the analysis.
- Environmental strategies that depend on managing land use involve multiple levels of government with differing goals and responsibilities, and their consequences require many years to unfold. Yet land use strategies can have highly significant effects over the long term.
- The regulatory process for determining compliance with national air quality standards places a great deal of emphasis on a technical modeling process that has many weaknesses. Reconsideration of the appropriateness of this approach is needed.
- Transportation, particularly highway transportation, is a major contributor to emissions of greenhouse gases. Substantially curbing these emissions will require measures, such as fuel taxes, that would necessitate broad public understanding of the risks of global warming and support for considerably heavier taxes.
- Additional evaluation of transportation-related environmental programs could help make them more effective and less costly. Congressional reauthorization of the Congestion Mitigation and Air Quality Improvement program should incorporate support for project evaluation.
- Double-hull tankers have been effective in reducing oil spills. Models of tanker collisions and groundings can help the U.S. Coast Guard compare less expensive tanker designs that are claimed to be equally effective.

PROTECTING the Environment

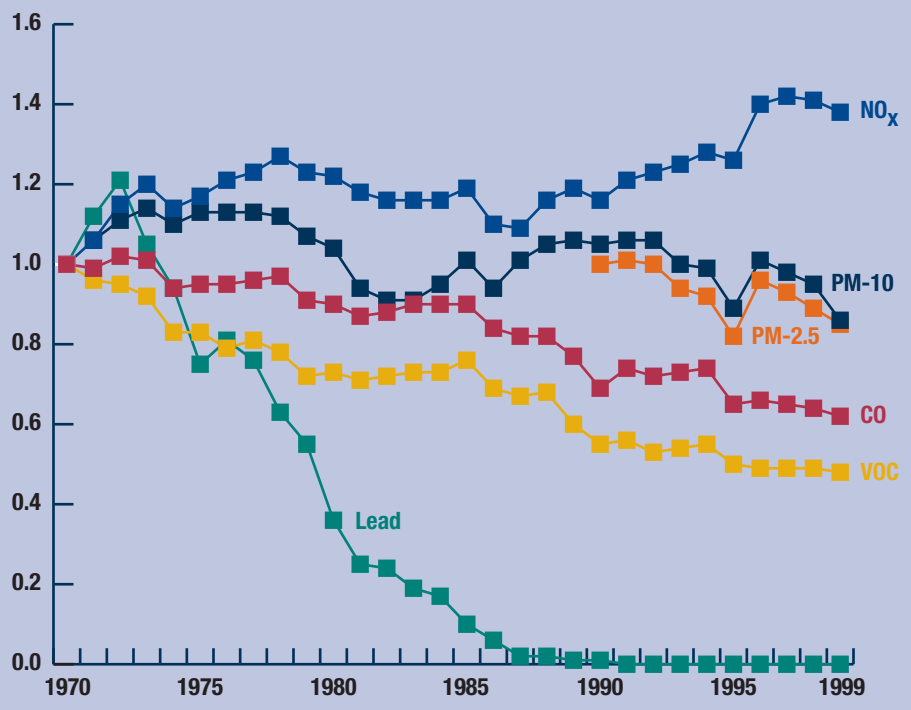
At least since the passage of the Clean Air Act in 1969, the transportation sector has struggled to include environmental protection as one of its primary objectives. Federal policy has placed considerable emphasis on vehicle- and fuel-based solutions, and the success achieved has been notable (Figure 5). With the exception of emissions of nitrogen oxides, vehicle emissions regulated under the Clean Air Act Amendments are all lower than they were in 1970 despite more than a doubling of total vehicle miles of travel. Many regions, however, are not yet in attainment of clean air standards, and others will lose this classification when Environmental Protection Agency regulations for fine particulates take effect later in this decade. Thus, transportation will continue to be a focus of federal, state, and local environmental measures for years to come.

Moreover, given worldwide concern about the role of carbon dioxide emissions in climate change, vehicle emissions are likely to continue to be a major concern. In contrast to regulated emissions, transportation emissions of carbon dioxide have been growing steadily along with total travel, and transportation is responsible for about one-quarter of total carbon dioxide emissions.

Clean air is but one of the environmental challenges facing the transportation sector. Clean water is also a major concern. Dredging of waterways to serve maritime transportation

Figure 5

Index of Key Air Pollutant Emissions for U.S. Transportation, 1970–1999.



Index: 1970=1.0, 1990=1.0 for PM-2.5.

Key: NOx=oxides of nitrogen; PM-10 and PM-2.5=airborne particulates of less than 10 microns or 2.5 microns, respectively; CO=carbon monoxide; VOC volatile organic compounds.

Note: Transportation emissions include all onroad mobile sources and the following nonroad mobile sources: recreational vehicles and boats, airport service equipment, aircraft, commercial maine vessels, and railroads. Other nonroad sources, such as lawnmowers and farming equipment, are not included. Lead estimates include onroad mobile sources only.

Source: US EPA, Office of Air Quality Planning and Standards, *National Air Pollutant Trends.*

continues to be controversial. And prevention, control, and cleanup of oil spills is a subject of increasing attention and importance. TRB committees have conducted studies on a range of topics related to these and other environmental challenges, including achieving sustainable development, reducing motor vehicle emissions, evaluating transportation environmental programs, affecting land use through transportation policy, dredging waterways, and preventing oil spills.

Achieving Sustainable Development

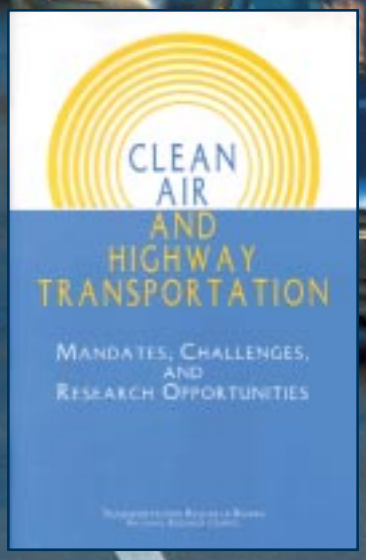
Recognition that humans may be influencing environmental systems and processes on a global and lasting basis has encouraged interest in the concept of sustainable development. The basic premise of this concept is that each generation should seek to provide for its own needs in ways that do not compromise the ability of later generations to meet their needs. International concern over the effects of current development patterns has spawned far-ranging debate about alternative policies and practices that can foster more sustainable forms of development and reduce the risk of detrimental long-term environmental changes.

Policies, technologies, and practices within the U.S. transportation sector have become part of this debate. A study conducted by a TRB committee examined a number of environmental disturbances due to motor vehicle transportation. The committee decided to focus on those disturbances having lasting and adverse environmental consequences that may not become fully manifest for decades and would be difficult, if not impossible, to rectify if left untreated. The premise of the committee's report is that a significant risk of an adverse outcome is undesirable and, at a minimum, warrants taking early steps to better understand and reduce that risk.

The report considers two long-term environmental risks in particular: that of global climate change caused by the buildup of greenhouse gases in the atmosphere, including carbon dioxide; and that of losses in biological diversity and ecosystem functioning due to changes in air, water, and soil chemistry caused by the chemicals emitted into the atmosphere by motor vehicles, as well as the gradual changes in habitats and natural processes caused by pervasive road and other transportation infrastructure.

A broad range of strategies could curb the growth in carbon emissions from transportation. Substantially higher fuel taxes would both curb demand and provide incentives to own and operate more fuel-efficient vehicles, but the level of taxation required lacks public support. Major breakthroughs in fuel-efficiency technologies could also substantially reduce carbon emissions from transportation over the long term. Without incentives or market demand for such technologies, however, they may not materialize. Reducing the ecological consequences of motor vehicle transportation will require developing a much better

Special Report 251:
Toward a Sustainable Future: addressing the Long-Term Effects of Motor Vehicle Transportation on Climate and Ecology **(TRB 1997)**



Clean Air and Highway Transportation: Mandates, Challenges, and Research Opportunities **(TRB 1997)**

understanding of how emissions and infrastructure contribute to changes in soil and water chemistry and disrupt habitats. The committee recommended major research initiatives on the determinants of travel demand and on the long-term ecological damage from transportation, as well as long-range technology R&D.

Reducing Motor Vehicle Emissions

As discussed previously in the section "Reducing Metropolitan Area Congestion," regulations governing conformity with the Clean Air Act Amendments (CAAA) are at the heart of major policy debates about highway improvements. The Environmental Protection Agency (EPA) mandates that metropolitan planning organizations (MPOs) project future travel demand and its effects on air quality as an essential element of the development of transportation improvement plans. These plans must be linked to the implementation plans the states file with EPA indicating how they will meet clean air goals. If transportation improvements, such as adding highway capacity, are shown to contribute to a failure to attain compliance with CAAA standards, regions face the loss of significant amounts of federal transportation funding.

MPOs use a variety of transportation models—sometimes linked with land use models—to estimate future travel that might result from capacity additions. They then calculate the air quality consequences using a model prescribed by EPA. The linkage of these projections with the states' transportation improvement plans and with the limits established in the implementation plans filed with EPA constitutes the conformity process.

A TRB committee that examined this process concluded that the databases and models used to determine compliance with the CAAA lack credibility among government highway and transportation officials and are inadequate for or not suited to the tasks for which they are applied in the conformity process. The critical inadequacies are in capabilities for predicting and monitoring how government policies affect travel and how changes in travel affect emissions one to two decades in the future. The committee that prepared Special Report 245 (discussed earlier in the section "Reducing Metropolitan Area Congestion") reached the same conclusion. Both near- and long-term research is needed on actual behavior, vehicle emissions under different operating conditions, the effectiveness of transportation control measures, and

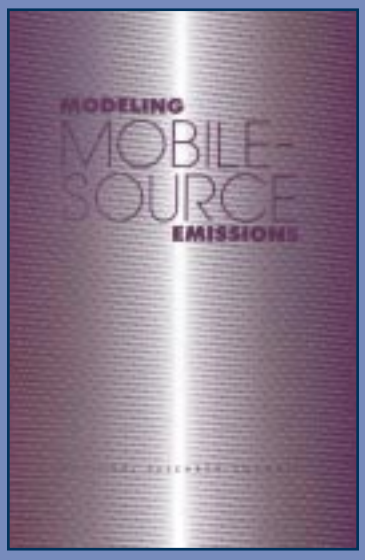
improvements to models used to estimate the air quality consequences of emissions.

Motor vehicles are major sources of air pollutant emissions in U.S. cities. The constituents of those emissions can be harmful to human health and the environment, and they are responsible for the formation of other harmful compounds, such as ozone and particulate matter. Effective management of air pollution problems depends on having accurate estimates of automotive emissions. In the United States (outside of California), the Mobile Source Emissions Factor (MOBILE) Model has been at the heart of this process.

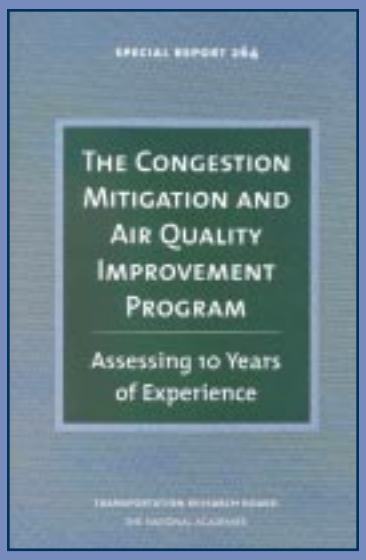
MOBILE is used to develop emissions factors that, along with information on vehicle activity, are used to estimate emissions inventories for on-road mobile sources. Further, MOBILE is used to adjust those emissions factors to account for the impact of control measures and to forecast how emissions will change in the future and how effective control programs will be.

A committee charged with evaluating the MOBILE model concluded that its accuracy in assessing the effectiveness of various very expensive programs, such as those for oxygenated fuels and inspection and maintenance, is poor. This study, conducted under the auspices of the Board on Environmental Studies and Toxicology and TRB, reviewed EPA plans for the latest version of the model (MOBILE6). The committee noted uncertainties regarding the data used to develop the model's algorithms, the statistical analysis of test data, and the model input parameters, which together result in large uncertainties in model outputs.

The committee made a number of recommendations to EPA, including the development of a toolkit of models designed for particular purposes. One of the disadvantages of being required to use MOBILE for conformity analysis is that the model was not designed for this application. The committee recommended that EPA conduct sensitivity analyses and test and validate MOBILE6 and other toolkit models to determine their accuracy for particular applications.



Modeling Mobile Source Emissions
(NRC 2000)



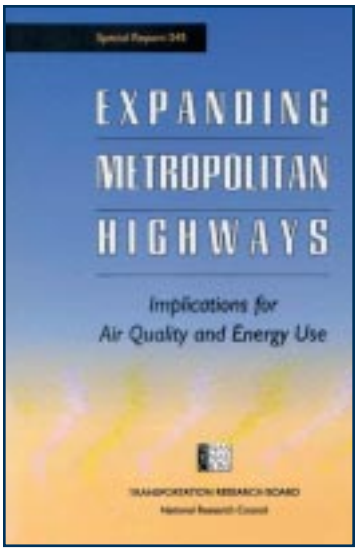
Special Report 264:
The Congestion Mitigation and Air Quality Improvement Program: Assessing 10 Years of Experience
(TRB 2002)

Evaluating Transportation Environmental Programs

The Congestion Mitigation and Air Quality Improvement (CMAQ) program was enacted as part of the surface transportation legislation authorized in 1991 to provide support for projects that would aid local efforts to meet the strict new federal deadlines imposed by the Clean Air Act Amendments (CAAA) of 1990. CMAQ was included in the reauthorization of surface transportation legislation in 1998 for another 6 years, and funding for this period was set at $8.1 billion. In the 1998 legislation, Congress also requested an evaluation of the effectiveness of the program and the cost-effectiveness of the projects funded by the program.

CMAQ funds are focused primarily on the transportation control measures (TCMs) contained in the 1990 CAAA (with the exception of vehicle scrappage programs, which have not been permitted). TCMs are strategies whose primary purpose is to lessen the pollutants emitted by motor vehicles by decreasing highway travel (for example, bicycle, pedestrian, and some transit projects) and to encourage more efficient facility use (for example, projects focused on ridesharing and on traffic flow improvements, such as signal timing). In addition, CMAQ funds may be used for projects that reduce vehicle emissions directly, such as through vehicle inspection and maintenance programs and purchase of alternative-fueled transit vehicles. In the spirit of the legislation that originally authorized the program, decisions about project selection are made at the local level, usually by or through the local metropolitan planning organization.

After reviewing the limited information available about these types of projects, the committee that evaluated the CMAQ program concluded that, when compared on the sole criterion of tons of emissions reduced per dollar spent, strategies aimed directly at emissions reductions—such as emissions and fuel standards for new vehicles, well-structured inspection and maintenance programs, and vehicle scrappage programs—are more cost-effective than the typical CMAQ TCMs, which tend to depend on changes in behavior. A few behaviorally based TCMs, however, such as pricing and regional ridesharing, compare favorably with vehicle- and fuel-based strategies. The committee recommended that the CMAQ program be continued, in part because it is a "funded" rather than an "unfunded" mandate. The committee also called for a focus of future projects on reductions in emissions with the largest public health consequences and for improved evaluation of project effectiveness.



Special Report 245:
Expanding Metropolitan Highways: Implications for Air Quality and Energy Use **(TRB 1995)**

Affecting Land Use Through Transportation Policy

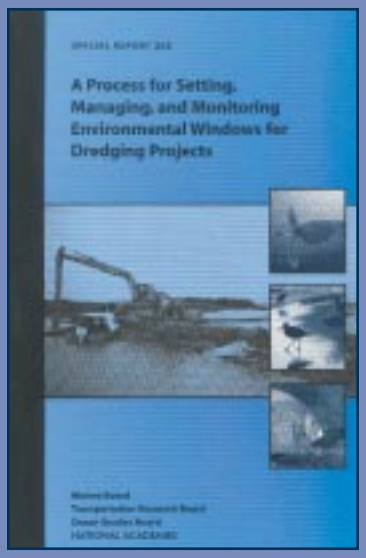
Even as population growth has slowed over the last two decades, land development around metropolitan areas has grown sharply. Such development—often referred to as sprawl—depends on transportation and is frequently blamed on highway development. Many advocates of environmental protection therefore look to changes in transportation policy as an instrument for achieving their goals.

Clearly, highways are an enabling factor for suburban development, much as were trolleys, streetcars, and ferries in the 19th century. The decentralization of urban population that began during the Industrial Revolution, made possible by transportation, was much lauded at the time because central cities were congested, unsanitary, and unsafe. The dispersal of population that has occurred over the last few decades is due to a more complex set of causes, including fear of crime; racial strife; public preferences for low-density, single-family development; and lax land control in outlying counties.

That transportation facilitates population dispersal is unquestioned; whether transportation policies can reverse this strong trend is uncertain. Land development occurs over decades. Hence even if development on the urban fringe can be slowed, the results will take many years to become manifest. Effecting such change is made more difficult by the complex mix of jurisdictions and institutions that control land development. Most metropolitan areas are surrounded by dozens, if not hundreds, of jurisdictions that establish land development policy, and the strategies of such local governments are often inconsistent with the desires of central cities. Moreover, the institutions that make decisions about and fund transportation facilities are connected only loosely with those that control land development.

A TRB committee that examined the implications of expanding metropolitan highways concluded that transportation facilities clearly influence development patterns, and major new highways in metropolitan areas that serve the urban fringe enable sprawling development.

Metropolitan areas are already intensively built up, however, often including millions of citizens and hundreds of square miles. Hence the committee concluded that relatively modest highway expansion or transit-oriented development can have only marginal impacts on regional pollutant emissions.



Special Report 262:
A Process for Setting, Managing, and Monitoring Environmental Windows for Dredging Projects
(TRB/OSB 2001)

Dredging Waterways

Environmental windows are periods in which regulators have determined that the adverse impacts associated with dredging of waterways and disposal of the dredged materials can be reduced below critical thresholds, and dredging is therefore permitted. Conversely, seasonal restrictions are applied—dredging and disposal activities are prohibited—when the perceived increase in potential harm to aquatic resources is above critical thresholds. Since passage of the National Environmental Policy Act of 1969, resource agencies have requested environmental restrictions on dredging with increasing frequency. Today, more than 80 percent of federal contract dredging is subject to some type of restriction. At the request of the U.S. Army Corps of Engineers, TRB and The National Academies' Ocean Studies Board convened a committee to address concerns about the decision-making process for setting environmental windows.

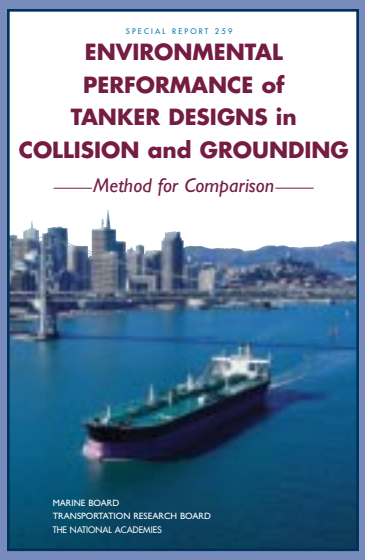
Windows are intuitively simple means of reducing risk to biological resources from stressors generated during dredging and disposal activities, including entrainment of fish eggs and larvae, resuspension of contaminated sediments, habitat loss, and collisions with marine animals. The use of windows as a management tool, however, can have significant cost implications for both the U.S. Army Corps of Engineers and the local sponsors of dredging projects, delay project deadlines, and increase risk to dredging personnel by shifting projects to periods of potentially inclement weather and sea states.

The committee that reviewed the windows-setting process concluded that scientific information about risks to resources and technical options for reducing those risks was not being systematically incorporated into the process. The process itself is complex and time-consuming because of the numerous federal and state agencies and interest groups involved. The committee recommended use of a broad-based decision-making process designed to engage stakeholders more effectively and to improve the scientific and technical basis for the decisions made.

Preventing Oil Spills

Spills from the transportation of petroleum are a major environmental concern. Since passage of the Oil Pollution Act (OPA) of 1990 and subsequent decisions of the International Maritime Organization, the world tanker fleet has been evolving to double-hulled designs to reduce the risk of accidental spills. A previous study by the Marine Board, now part of TRB, concluded that the double-hull design had been effective in reducing oil spills (*Double-Hull Tanker Legislation: An Assessment of the Oil Pollution Act of 1990,* NRC 1998) .

OPA 1990 was passed because of the 1989 *Exxon Valdez* oil spill in Prince William Sound. Although the world's tanker owners have been shifting to double-hull designs, a variety of other hull designs have been proposed that might be as effective and less costly. The U.S. Coast Guard has not been willing to consider such alternatives, in part because of the wording of OPA 1990 and in part because of the difficulty of comparing complex designs. In response to a congressional request, a TRB committee developed a modeling process for evaluating alternative designs. The process encompasses consideration of the structural deformations from collisions and grounding and the environmental consequences of spills of different sizes, and uses a risk-based approach for comparing designs.



Special Report 259:
Environmental Performance of Tanker Designs in Collisions and Groundling: Method for Comparison
(Marine Board/TRB 2001)

ACHIEVING ENERGY CONSERVATION KEY COMMITTEE FINDINGS AND RECOMMENDATIONS

- The transportation sector is almost completely reliant on petroleum-based fuels and consumes more of these fuels each year than the United States produces, contributing to the nation's growing dependence on imports.
- Corporate Average Fuel Economy (CAFE) standards would be more effective if government tax policy on fuels reflected the true social costs of reliance on petroleum and if manufacturers were allowed to trade fuel economy credits.
- A weight-based CAFE standard could ameliorate safety concerns and is worthy of investigation.
- The government–industry collaboration on the Partnership for a New Generation of Vehicles program has been successful in accelerating the introduction of fuel-conserving technologies, even though the program is unlikely to meet the goals for 2004 prototype vehicles established in 1993.
- Because of the comparatively low cost and high energy density of gasoline, alternative liquid transportation fuels face steep barriers to market acceptance. However, promising research opportunities can narrow the gap.

ACHIEVING Energy Conservation

More than 50 percent of the petroleum consumed annually in the United States is imported from other nations. The transportation sector relies almost exclusively on petroleum and by itself consumes more than is produced domestically (Figure 6). Contributing to the demand for imported petroleum has been a long-term decline in the real cost of gasoline and the growing popularity of sport utility vehicles and light trucks. The increasing dependence on foreign sources of petroleum and ever-stricter controls on emissions from transportation vehicles keep energy conservation at the top of the list of major transportation policy concerns.

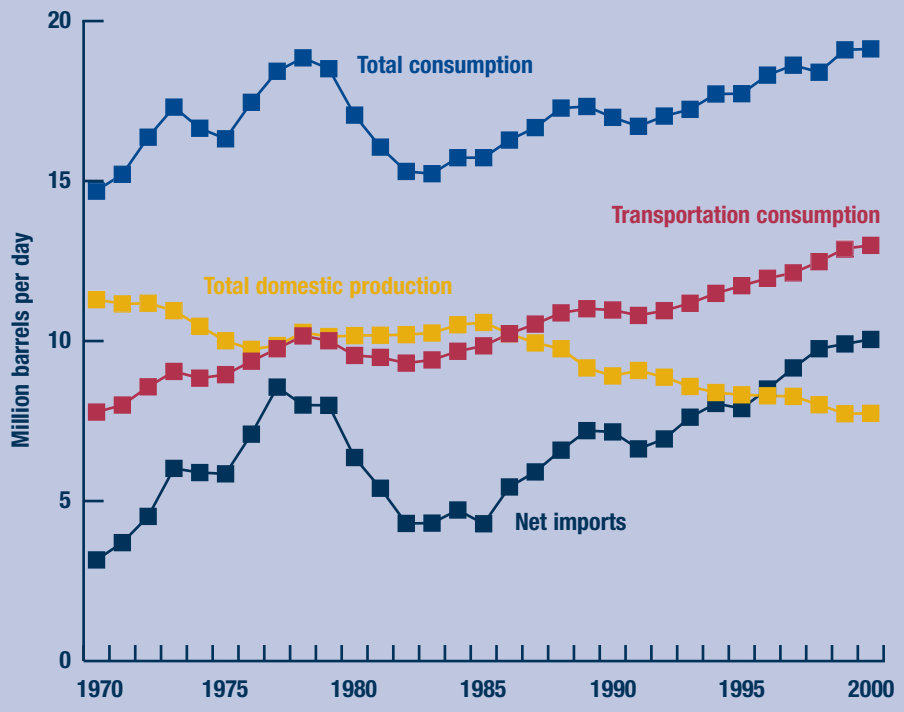
Within The National Academies, the majority of studies focusing on energy issues are conducted by the Board on Energy and Environmental Systems. TRB has collaborated with that board on major policy studies involving transportation in such areas as conserving the energy consumed by automobiles and developing more fuel-efficient vehicles.

Conserving the Energy Consumed by Automobiles

In the aftermath of the 1973 oil crisis, the U.S. Congress passed legislation designed to reduce the nation's dependence on foreign oil. As part of that legislation, Congress established the

Figure 6

U.S. Petroleum Production and Consumption

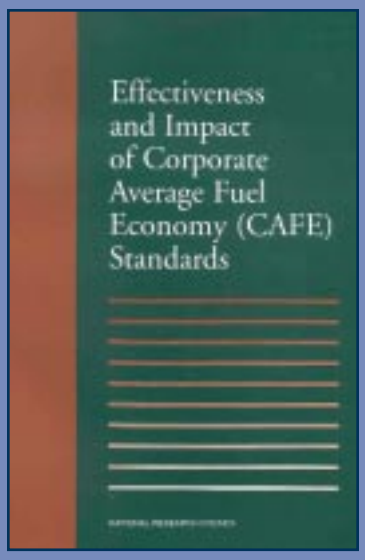


Source: U.S. Department of Energy, Energy Information Administration, *Annual Energy Review 2000* (Washington, DC: August 2001), table 5.1.

Corporate Average Fuel Economy (CAFE) program, which required automobile manufacturers to increase the sales-weighted average fuel economy of the passenger car and light-duty truck fleets sold in the United States (see also the earlier section on safer vehicles). Today the light-duty truck fleet, which includes minivans, pickups, and sport utility vehicles, represents about half of all new passenger vehicle sales. In the 1973 legislation, Congress itself set the fuel economy standard for passenger cars, which rose from 18 miles per gallon (mpg) in automobile model year 1978 to 27.5 mpg in model year 1985. Congress authorized USDOT to set standards for light trucks, which were far from being the popular choice of consumers that they are today. Current standards are 27.5 mpg for passenger cars and 20.7 mpg for light trucks.

The CAFE program has been controversial since its inception. Since 1996, provisions in USDOT's annual appropriations have prohibited the agency from changing, or even studying, the CAFE standards. Sharp disagreements exist regarding the effects of the program on the fuel economy of the U.S. fleet, the current mix of vehicles in the fleet, the overall safety of passenger vehicles, the consequences of the standards for the health of the domestic automobile industry and its workforce, and the preferences of consumers.

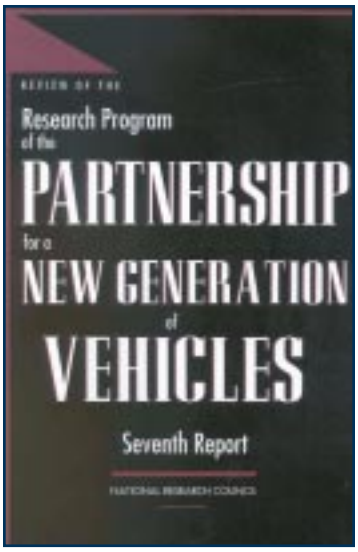
Following a 6-month review of the technical literature, the committee convened to review the CAFE standards concluded that these standards had contributed to energy conservation. (As discussed in the section "Safer Vehicles," these fuel savings have been detrimental to safety.) The committee estimated that considerable further gains in fuel economy can be made during the next 15 years, but achieving those gains will depend on the price of fuel (including the level of taxation), consumer valuation of energy conservation, policies to mitigate adverse effects on safety, and policies designed to reduce the production of greenhouse gases. The committee also recommended some modifi-cations to the CAFE program, including allowing tradeable fuel economy credits among manufacturers and considering a weight-based regulatory regime that would not give manufacturers an incentive to downsize vehicles to meet CAFE goals.



Effectiveness and Impact of Corporate Average Fuel Economy (CAFE) Standards **(NRC 2002)**

Developing More Fuel-Efficient Vehicles

Throughout the Clinton administration, the Partnership for a New Generation of Vehicles (PNGV) was a cooperative R&D program between the federal government and the United States Council for Automotive Research, which comprises DaimlerChrysler Corporation, Ford Motor Company, and General Motors Corporation. PNGV was initiated in September 1993 with the express purpose of enhancing the productivity and competitiveness of the U.S. domestic automobile industry. The aims of the PNGV program were to improve automobiles over a roughly 10-year time frame and to develop technologies for a new generation of vehicles that would enable prototype vehicles of 2004 to achieve fuel economics up to three times those of 1993 vehicles without increasing cost (inflation-adjusted) or sacrificing consumer amenities. Such vehicles would also have to meet or exceed federal emissions and safety regulations. [The PNGV program ended under the



Review of the Research Program of the Partnership for a New Generation of Vehicles, **Reports 1–7 (NRC 1994–2001)**

Bush administration, and was replaced by the "Freedom Car" initiative, which emphasizes hydrogen fueled vehicles.]

The Board on Energy and Environmental Systems, with assistance from TRB, convened a committee that annually reviewed the program plans and progress made on PNGV. The seventh report in the series provides a summary judgment on the progress made toward the program's goals: that the program had made significant progress by 2002 despite the complexity of managing an interdisciplinary program involving three competing companies, several government agencies, and significant government budget constraints. The participating companies had produced concept cars in 2000 that showed evidence of genuine achievement.

Throughout the program's existence, government funding wavered. While the industry was reporting a combined private investment of about $980 million annually, government support in 2002 was less than half that amount, and uncertain. Even so, the program was able to demonstrate improvements in the use of lightweight structural materials, four-stroke direct-injection diesel engines and fuels, fuel cells, power electronics, and electrical systems.

The committee concluded, however, that major barriers remained that would put the achievement of program goals with 2004 prototype vehicles beyond reach. Achieving 80 mpg while maintaining the cost of 1993 vehicles appears unlikely. The Environmental Protection Agency's tier 2 emissions requirements would require radically better emissions controls for the fuel-efficient diesel engines under development, and the overall cost of all the new technologies under development appears to prevent attainment of the goal of keeping the cost comparable with that of 1993 vehicles. Nonetheless, because of the notable technical achievements of the program and growing concerns about automotive fuel economy, the committee recommended extending the program with more achievable goals.

Related Reports

The Board on Energy and Environmental Systems has provided assessments of the Department of Energy's research initiatives related to transportation, particularly with regard to fossil fuels and alternatives to gasoline. Two reports produced by the board provide guidance on the technical and policy options for increasing the domestic production of transportation fuels from petroleum, methanol, biomass, and other alternatives (*Fuels to Drive Our Future,* NRC 1990; and *Review of the Research Strategy for Biomass-Derived Transportation Fuels,* NRC 1999). Although many options are available domestically, none can yet compete with the cost and power density of gasoline. These reports point to the most promising technical options worthy of government investment to help close the gap.

MANAGING HUMAN RESOURCES
KEY COMMITTEE FINDINGS AND RECOMMENDATIONS

- The transportation workforce, which includes many highly skilled workers, such as air traffic controllers, is highly unionized. Thus many issues that affect public policy are dependent on the outcomes of labor–management negotiations.
- State and local transportation agencies are finding it difficult to attract and retain skilled employees, in part because salaries for these public-sector jobs are not competitive with those for similar jobs in the private marketplace.
- Shortfalls in the future transportation workforce can be averted by prudent actions on the part of employers. However, those actions must be taken long before the workers are needed to ensure an adequate flow through the education and training pipeline.
- The university, college, and community college programs that prepare the future transportation workforce should be developing people with a diverse set of skills beyond the traditional emphasis on civil engineering.

MANAGING Human Resources

The workforces of transportation organizations, both public and private, are characterized by considerable size and diversity. The most expansive definition of transportation, which includes carriers, government, and vehicle manufacturing and retailing, encompasses firms and agencies that employ about 11 million people, or about 8 percent of the total U.S. labor force. Even if the definition of transportation is restricted to private carriers in all modes and government agencies involved in transportation infrastructure and services, the total transportation workforce numbers in excess of 5 million employees. Moreover, because transportation is a field of activity, rather than a discipline, the labor force includes individuals with diverse expertise and training. Engineering, management, economics, planning, finance, and law are among the most important disciplines at the professional level. The largest segment of the workforce, however, comprises vehicle and system operators, maintenance workers, and clerical and other staff.

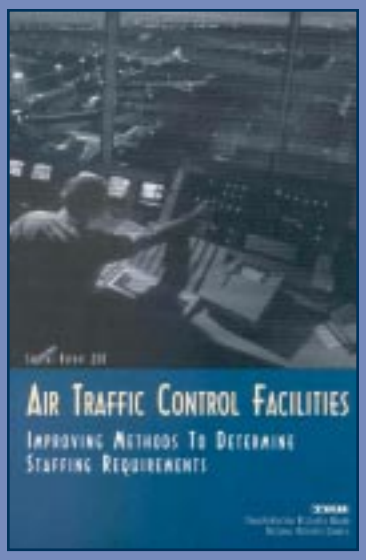
As in any enterprise, transportation systems depend first and foremost on the expertise and skills of the people who make the system work. Studies produced by TRB committees have addressed several human resource issues, including preparation of the surface transportation workforce, the adequacy of air traffic control personnel, and compensation for injured railroad workers.

Special Report 207:
Transportation Professionals: Future Needs and Opportunities **(TRB 1985)**

Preparing the Future Surface Transportation Workforce

In the post–World War II era, highway and transit agencies were required to expand their staffing considerably in response to the national commitment to build an Interstate highway system and revive transit systems in urban areas. By the 1980s it was apparent that the public sector would face a wave of retirements of senior engineers and managers.

A TRB committee was convened to examine the future needs of the transportation workforce. The committee acknowledged the many challenges that will be faced by public agencies, but also noted that the forthcoming generational shift in the workforce could result in strong, dynamic, future-oriented organizations if handled with foresight. Obtaining the needed professional skills should be feasible if employers follow a number of prudent measures. For example, employers need to institute training programs, substitute consultants where appropriate, and rely more heavily on technicians. Employers should also expect and actively recruit a more diverse workforce that includes a greater proportion of women and minorities. Moreover, universities and colleges should be actively revising their curricula in response to employers' demands for a workforce with a broad range of skills.



Special Report 250:
Air Traffic Control Facilities: Improving Methods to Determine Staffing Requirements **(TRB 1997)**

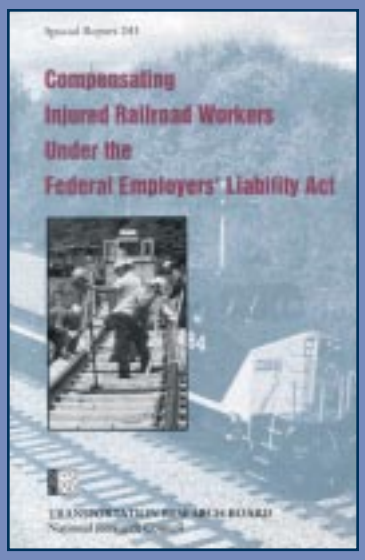
Evaluating the Adequacy of Air Traffic Control Personnel

The appropriate level of staffing for air traffic control (ATC) has long been controversial. As a service of the Federal Aviation Administration (FAA), ATC is almost exclusively staffed by federal employees. Following the controller strike of 1981, which resulted in the firing of two-thirds of controllers, congressional concerns about staffing were focused primarily on the overall size and rebuilding of the workforce. During the 1990s, however, congressional concerns shifted to questions about whether staffing levels are appropriate at the agency's highest-traffic locations.

FAA has long had difficulty staffing its ATC centers, terminal radar approach control facilities, and other terminal facilities in metropolitan areas such as New York, Chicago, and Los Angeles. In addition to being the most demanding locations because of the volume and types of traffic that must be handled, they are among the areas with the highest cost of living. Concerns about stressful working conditions and the

amount of overtime required of workers at these locations have been raised regularly by the controllers' union and sometimes by members of Congress.

In the aftermath of the controllers' strike, FAA developed analytical models for estimating the number of specialists required to control traffic safely. The application of these models to particular locations became a source of controversy between FAA and the controllers' union. The committee formed to examine whether these models were sufficiently accurate for estimating staffing levels at specific locations determined that they could not be relied upon for this purpose. The models provide a useful starting point, but the staffing estimates they produce need to be adjusted on the basis of both local conditions and the norms that exist across FAA's workplaces. The committee recommended a process that FAA could follow to make these adjustments.



Special Report 241:
Compensating Injured Railroad Workers Under the Federal Employers' Liability Act
(TRB 1994)

Compensating Injured Railroad Workers

Railroad workers who are injured on the job seek compensation for their injuries under the provisions of the Federal Employers' Liability Act of 1908 (FELA). This act prescribes a tort-based approach to on-the-job injury as opposed to the no-fault approach of workers' compensation applicable to most U.S. workers. For many years, railroad management has argued that the FELA process imposes higher costs on the rail industry than those imposed by the workers' compensation system that applies to its competitors—primarily the trucking industry—which places railroads at a competitive disadvantage. Rail union leaders contend that FELA is a necessary system to provide fair compensation and to offer incentives to industry to offer a safe working environment.

At the request of Congress, a TRB committee compared FELA with other workers' compensation systems. Although the data for making such comparisons are imperfect, the committee concluded that the FELA process generally provides higher benefits but can result in delays in payments, involve higher transaction costs, and result in greater costs to railroads. The differences in the two injury compensation systems, however, are not as great as they were at one time. Moreover, because of the high degree of unionization in the railroad industry, any reductions in injury compensation benefits are likely to be resisted strongly by labor. The committee recommended that industry and labor make constructive changes in the FELA process that would reduce transaction costs. One means of doing so would be to rely on alternative dispute-resolution mechanisms to reduce the extent of litigation.

FORMULATING PUBLIC-SECTOR R&D POLICY
KEY COMMITTEE FINDINGS AND RECOMMENDATIONS

- In reauthorization legislation for surface transportation, Congress should:
  - Support a reorientation of the Federal Highway Administration's research and technology program so that at least one-quarter of its budget is allocated to advanced, long-term research; stakeholder involvement is enhanced; and competitively solicited, merit-reviewed proposals are emphasized.
  - Fund the Future Strategic Highway Research Program through a takedown of 0.25 percent of apportioned federal-aid highway funds.
  - Continue to support the 40-year partnership of the federal government and the states through the allocation of highway funds to State Planning and Research.
  - Fund the Surface Transportation Environmental Cooperative Research Program originally authorized, but not funded, in the Transportation Equity Act for the 21st Century.
  - Continue to fund the Transit Cooperative Research Program.
  - Continue to fund the Long-Term Pavement Performance Program.
  - Continue to support the collection, improvement, and dissemination of vital transportation statistics.
- The Federal Motor Carrier Safety Administration should refine the analysis plan for its Large Truck Crash Causation Study to ensure that appropriate data are collected for the study.
- The Intelligent Transportation Systems Joint Program Office should continue to focus on human factors research as part of the Intelligent Vehicle Initiative, and to include in its study not only crash avoidance technologies, but also other new technologies being introduced into automobiles that might be overly distracting to drivers.
- The Federal Railroad Administration should further focus its R&D program on projects that promise the largest safety benefits, work with industry to improve the quality of safety data, fund research into the development of performance-based safety regulations, and give priority in the incremental high-speed rail development program to development and testing of positive train control technologies.
- The Bureau of Transportation Statistics should shift its emphasis from reliance on a small number of periodically collected general-purpose surveys to a family of surveys that could be addressed more specifically to user needs and collected on an ongoing basis.
- USDOT should more closely align the research and technology activities of the modal administrations with its strategic goals.

FORMULATING Public-Sector R&D Policy

Innovation in the public sector is a particular challenge. Public agencies are understandably risk-averse in matters involving safety, which, as noted earlier, is a paramount concern of transportation policy makers. Moreover, public procurement practices, which often depend on producing detailed specifications and awarding contracts to the lowest bidder, inhibit the introduction of new concepts, technologies, and practices. For these reasons, the classic federal model of investing in basic research and assuming that the private sector will draw on the fruits of these efforts to innovate does not work well in the largely public-sector environment of transportation systems. Entrepreneurs have little incentive to take risks when they face high barriers to market entry and relatively low assurance that they can derive profit from the introduction of new products.

In transportation infrastructure in particular, which has such a large public presence, government must therefore be more involved in the funding of applied research to ensure that the public will reap the benefits of improved products, services, and technologies being developed throughout the private economy. Likewise, in the emerging field of intelligent transportation systems, in which numerous firms are offering new products and services, federal applied research, demonstrations, and support for open standards are needed to facilitate the procurement of those products and services by public agencies.

Applied transportation research programs have historically been modally oriented. There is some logic to this approach because each mode is characterized by a different blend of public and private involvement, as well as a different degree of federal responsibility and focus. The federal government owns and operates the air traffic control system and is the major, but not exclusive, provider of harbor vessel management; with minor exceptions, however, it does not own or operate highways, transit, railroads, or pipelines. Highway and transit infrastructure is owned and operated by the 50 states, hundreds of major cities, and tens of thousands of counties and towns. Research programs, like the modes, are also decentralized, none more so than in the case of highways, where the federal program is one among many.

Because of the modal orientation of federal and state transportation research programs, TRB's reports on transportation research policy have tended to have a similar focus, addressing research related to the highway, transit, rail, and maritime modes. TRB committees have also examined strategic planning for R&D, environmental research, and transportation statistics.

Special Report 261:
The Federal Role in Highway Research and Technology
(TRB 2001)

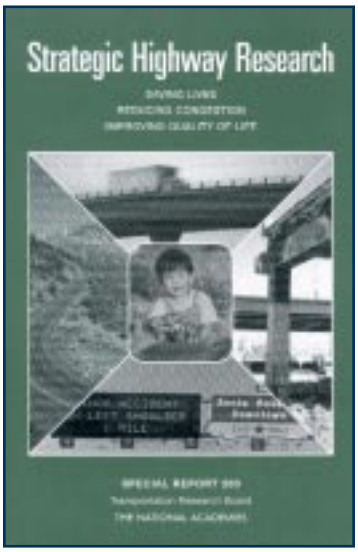
Highway Research

The Federal Role

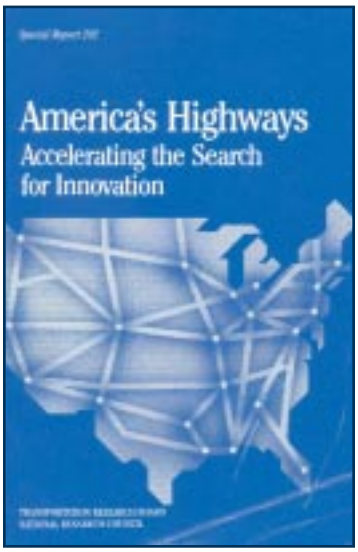
Since 1991, the Federal Highway Administration (FHWA) has supported the Research and Technology Coordinating Committee (RTCC), which brings together experts in highway research and stakeholders in highway research programs to provide an ongoing review of the agency's research program and to suggest priorities for highway research. In its most recent report, the committee examines whether the focus and activities of the federal highway research and technology (R&T) program are appropriate in light of the needs of the nation's highway system and the roles and activities of other highway R&T programs. The committee's recommendations for FHWA include a substantial shift in investment toward long-term, high-risk research; more stakeholder involvement in program direction, priority setting, and merit review; and systematic evaluation of research outcomes.

Related Reports of the Research and Technology Coordinating Committee

Since its inception, RTCC has issued a number of reports that provide guidance for the federal highway research program. Topics addressed include the management and conduct of technology transfer, and opportunities to design and build pavements with much longer performance periods than are currently routine.



Special Report 260:
Strategic Highway Research: Saving Lives, Reducing Congestion, Improving Quality of Life **(TRB 2001)**



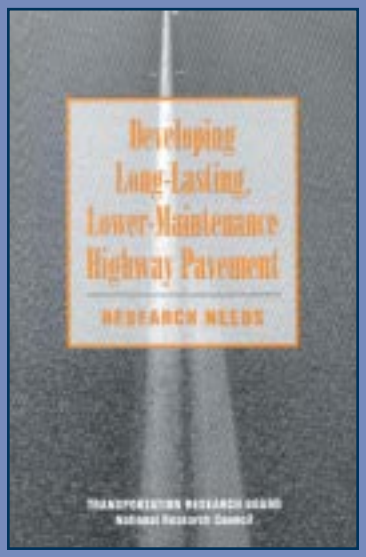
Special Report 202:
America's Highway: Accelerating the Search for Innovation
(TRB 2001)

Strategic Research Programs

The 1984 report *America's Highways: Accelerating the Search for Innovation,* articulates the need for a focused, time-constrained, high-cost R&D effort to develop a short list of priority products for state highway agencies. The report served to spark renewed interest in state and federal investments in highway research and led to congressional authorization of a 5-year, $150,000,000 effort known as the Strategic Highway Research Program (SHRP). SHRP was managed through a special unit of the National Research Council (NRC), whose purposes were to support a high-level executive committee to guide the program, create expert panels to select and manage individual contracts, and implement processes to ensure the highest quality in merit review and competitive award of contracts. SHRP produced many valuable products for the highway industry and is widely viewed as a successful program. After completion of the research, implementation of SHRP products was transferred to FHWA and the states, and NRC's program was disbanded.

As requested in the Transportation Equity Act for the 21st Century, a TRB committee examined the goals, research agenda, administrative structure, and administrative needs for a new strategic highway research program. After extensive outreach to the highway community, the committee recommended the establishment of a Future Strategic Highway Research Program (F-SHRP). F-SHRP would comprise four research program areas: accelerating the renewal of America's highways; making a significant improvement in

highway safety; providing a highway system with reliable travel times; and providing highway capacity in support of the nation's economic, environmental, and social goals. The committee recommended that F-SHRP be administered by a credible, independent organization capable of managing a large-scale contract research program in a manner that would ensure the highest-quality research. The initial SHRP program was managed by The National Academies for just these reasons. The committee recommended that F-SHRP be funded at $75 million per year through a 0.25 percent takedown of federal-aid highway funds apportioned under the next surface transportation legislation. As recommended by the committee, the American Association of State Highway and Transportation Officials (AASHTO) has funded the development of detailed research program plans. These plans will be implemented if F-SHRP is authorized.



Developing Long-Lasting, Lower-Maintenance Highway Pavement: Research Needs **(1997)**

Pavement Research

Together, the nation's federal, state, and municipal highway agencies spend upwards of $35 billion each year on pavement construction, repair, maintenance, and associated engineering. Pavement is the most significant physical asset of these agencies. As a result, pavement research is especially prominent in highway research programs.

At the request of FHWA, TRB committees have addressed the need for and the content and conduct of highway pavement research programs. In 1997, RTCC offered recommendations on the need for research directed at dramatically increasing the service life of highway pavements. The TRB Workshop on Pavement Renewal for Urban Freeways was held to identify innovative techniques for the reconstruction of America's urban freeway pavements. In 1999, FHWA and the national concrete paving industry invited TRB to create a committee to review and advise on a congressionally mandated program of research aimed at improving the use of portland cement concrete pavements on federal-aid highways; the committee produced a white paper setting forth a strategy for such research (A Research Plan for Concrete and Concrete Pavements, Letter Report, 2001). Finally, TRB's Long-Term Pavement Performance Committee has counseled FHWA and AASHTO on the necessary components of the Long-Term Pavement Performance Program (*Fulfilling the Promise of Better Roads,* TRB 2001). This program, managed by FHWA with the participation of the state departments of transportation, is the largest single highway research program in the world.

Get In, Get Out, Stay Out! Proceedings of the Workshop on Pavement Renewal for Urban Freeways **(2000)**

Implementing Innovation

In addition to meeting the nation's transportation needs, federal, state, and local transportation agencies must always guard the public safety and the public treasury. These strictures necessarily induce conservative attitudes among transportation officials; the tried and true is preferred to the innovative and unusual. As a result, even the most beneficial products of research can be difficult to implement among transportation agencies without strong, well-focused technology transfer efforts. FHWA and AASHTO have often turned to TRB for advice and guidance in undertaking such efforts.

FHWA was charged with implementing the products of the $150 million SHRP among the state departments of transportation. At the request of FHWA and AASHTO, TRB created the TRB SHRP Committee to advise and assist in this massive technology transfer effort. (Implementation of SHRP Research 1991–1998: Learning from Experience, Letter Report, 1998.) When legislation enacted in 1998 interrupted FHWA efforts to implement Superpave®, an improved system for the design of asphalt pavement materials, AASHTO assumed responsibility for the technology transfer program and requested that TRB convene a committee for continuing review and advice. An early product of that committee was a long-range plan subsequently used by all parties to manage the implementation program (Superpave 2005 Long-Range Plan: Revisiting Key National Goals, Letter Report, 2000).

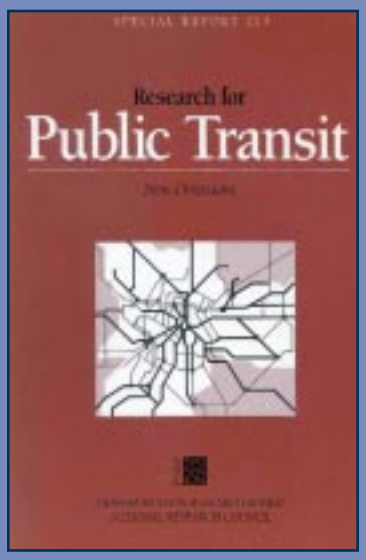
Motor Carrier Safety

Each year approximately 5,000 fatalities and 130,000 severe injuries result from crashes involving large trucks. At the request of the Federal Motor Carrier Safety Administration (FMCSA), a TRB committee is reviewing the agency's major, multiyear study on the causes of such crashes. In creating the agency, Congress required that it conduct this study to develop the most cost-effective strategies for reducing the mortality associated with truck crashes. The committee is advising FMCSA on the study's design, sampling, and data collection; the interpretation of pilot test results; and the conclusions that can be drawn from the preliminary results. The committee's 2002 letter report urges FMCSA to finalize an analysis plan and complete the development of procedures and protocols for data collection and interpretation.

Intelligent Transportation Systems

At the request of USDOT, TRB formed a committee to conduct a peer review of a new intelligent transportation systems (ITS) R&D effort—the Intelligent Vehicle Initiative. In this initiative, USDOT is partnering with individual companies in research projects to facilitate and accelerate marketplace acceptance and adoption of crash-avoidance technologies. The TRB committee meets annually to review the program and issued its initial letter report in June 1999. The committee has urged that the ITS program emphasize human factors issues, such as the inadvertent

introduction of risk in the automation of safety systems. The committee has also stressed the importance of studying driver distraction resulting from the introduction of new telecommunication systems into automobiles.



Special Report 213:
Research for Public Transit: New Directions **(TRB 1987)**

Transit Research

During the 1980s, national support for transit research declined sharply. At the same time, however, new and growing transit systems throughout the country faced the continuing challenge of providing safe and reliable service at a cost taxpayers would support. With support from the Urban Mass Transit Administration (now known as the Federal Transit Administration), TRB assembled a committee to review transit research programs and recommend improvements. The committee's report called for an operator-sponsored, problem-solving research program focused on priority topics of common interest to transit providers. The committee urged Congress to allow the agencies to pool their funds to organize and conduct such research. With strong support from the transit industry, Congress subsequently endorsed these recommendations and in 1991 created the Transit Cooperative Research Program.

Railroad Research

In 1995 Congress requested that TRB convene a committee to review the R&D programs of the Federal Railroad Administration (FRA). Beginning in 2002, the scope of the committee's work was expanded to include review of FRA's management of the Magnetic Levitation (Maglev) Technology Deployment Program.

The committee's initial letter report under its expanded charge includes a number of recommendations. For FRA's research programs, the committee recommends that the agency conduct an ongoing review of emerging issues within the railroad industry, continue to explore the efficacy of performance-based safety regulations, focus on primary causes of incidents, and identify ways to improve existing incident data. For the agency's incremental high-speed rail development program, completing the development of positive train control systems should be the highest priority. Without this technology, speeds on rails serving both passengers and freight are limited to 79 mph. For the Maglev Program, the committee recommended that FRA not conduct any in-depth environmental impact analysis until investment-grade revenue estimates and refined financial analyses for each project have been completed.

Maritime

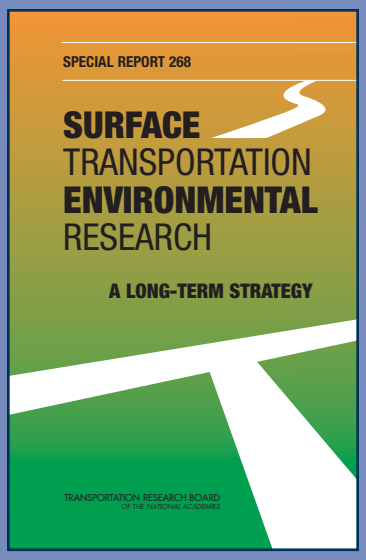
At the request of the Office of Naval Research (ONR), TRB/the Marine Board convened a committee to investigate and evaluate alternative approaches for structuring cooperative research programs in naval engineering. ONR is concerned about having both research products in "total ship design" and designers who are capable of designing complex warships according to this approach. In a fast-track study, the committee evaluated four approaches to structuring a cooperative research program and provided its assessment of these options. Each model was assessed in terms of its ability to balance the perspective of the various stakeholders (Navy, shipbuilding industry, and universities) in the development of a research agenda, the production of useful research, and the ability to attract students into the field.

Special Report 266:
Naval Engineering: Alternative Approaches for Organizing Cooperative Research
(TRB 2002)

Strategic Planning for R&D

The Transportation Equity Act for the 21st Century calls on USDOT to carry out a program of strategic planning for surface transportation R&D in a manner consistent with the requirements of the Government Performance and Results Act of 1993. A TRB committee reviewed USDOT's strategic plan for research and technology (R&T), its performance plan, and its performance reports. The committee recommended a sharper alignment and clearer articulation between

USDOT's R&T activities and strategic goals. It also urged the department to identify the budgetary resources required to carry out the R&T activities identified in the plan. In addition, the committee encouraged USDOT to identify and articulate more clearly the appropriate federal role in research, to undertake more coordination with other public agencies that have transportation missions and also conduct research, and to seek more stakeholder involvement in the various agency R&T programs.



Special Report 268:
Surface Transportation Environmental Research: A Long-Term Strategy
(TRB 2002)

Environmental Research

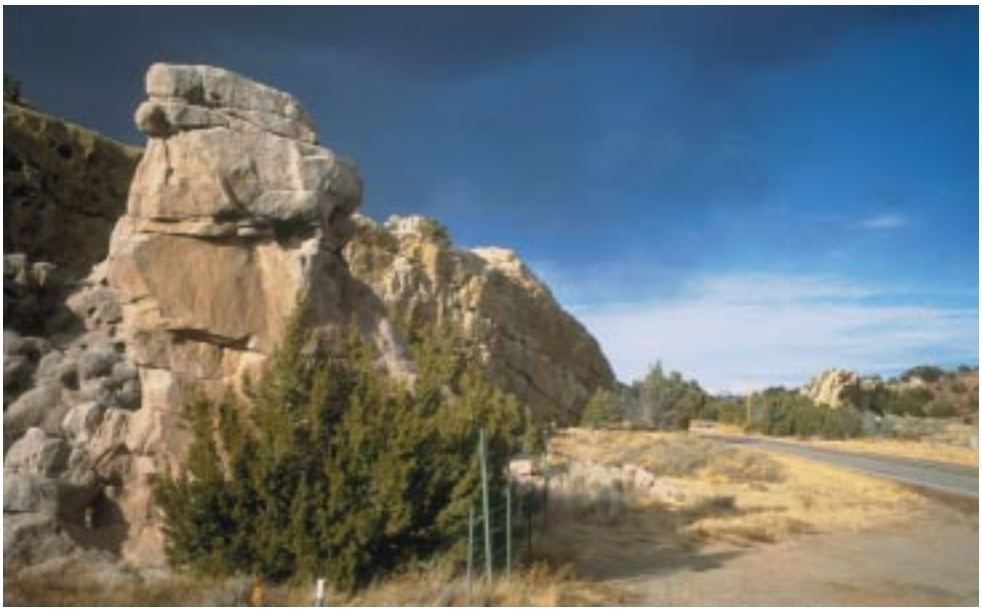
In the Transportation Equity Act for the 21st Century, Congress authorized the creation of a surface transportation environmental cooperative research program, to be guided by an independent advisory board. Although the program was approved, funding was not provided. A TRB study, requested by the Federal Highway and Federal Transit Administrations and funded by the Federal Highway Administration, resulted in the definition of a broad and ambitious research program to address and inform major public policy debates about the effects of surface transportation facilities and operations on the human and natural environments. The committee that conducted the study identified major gaps in knowledge that could be filled through a cooperative program of research involving federal agencies, states, and environmental organizations. The committee recommended creation of a new cooperative research program to carry out its recommended research agenda.

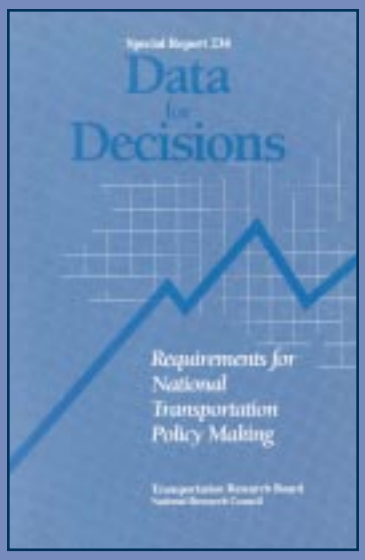
Statistics

In 1989 the Secretary of Transportation initiated a strategic planning process to take stock of the state of the nation's transportation system—the first such national assessment in more than a decade. The process revealed significant deficiencies in data on the use and performance of the transportation system, prompting USDOT to request a TRB study on data requirements to support strategic transportation policy making and the institutional changes necessary to make those data available on a permanent basis. The committee that conducted this study produced a report that was influential in the creation of the Bureau of Transportation Statistics (BTS). The report calls for the establishment of

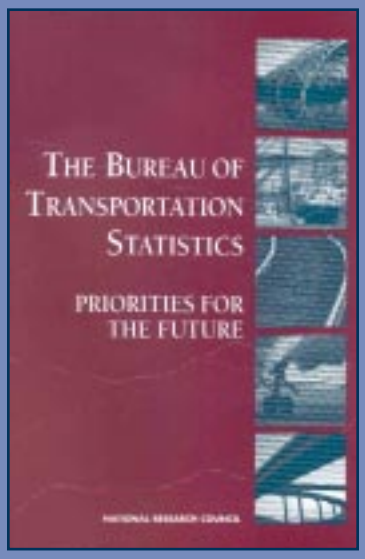
a statistical agency within USDOT, the development of performance indicators, and regular reporting to the Secretary and Congress on important trends in system performance.

At the request of BTS, a committee operating under the auspices of TRB and the Committee on National Statistics is charged with reviewing BTS's survey programs in light of transportation data needs for policy, planning, and research, as well as the characteristics and functions of an effective statistical agency. In its first letter report, the committee reviewed the National Household Travel Survey, which combines the former Nationwide Personal Transportation Survey (short-distance travel) and the American Travel Survey (long-distance travel). The committee identified opportunities for BTS to improve its personal travel surveys in terms of both their value to a wide range of users and the quality of the data provided. To help deal with low response rates and other issues affecting data reliability and quality, the committee recommended that BTS consider developing a family of personal travel surveys aimed at meeting the needs of a variety of users. The committee also issued a second letter report reviewing BTS's Omnibus Survey program. The committee endorsed BTS's addition of regular opinion surveys as a service to USDOT and encouraged BTS to adopt a number of measures to ensure that it will fulfill its role as an independent provider of high-quality statistics. The committee will issue a complete report summarizing its comments on each survey program in 2003.





Special Report 234:
Data for Decisions: Requirements for National Transportation Policy Making **(TRB 1992)**



The Bureau of Transportation Statistics: Priorities for the Future
(NRC 1997)

SUMMARY

The shape and prosperity of modern life depend heavily on extensive and efficient transportation. In the United States, transportation's scope and scale are truly enormous. So, too, are its consequences for personal mobility, urban form, employment, economic efficiency, public health, the environment, and dependence on foreign sources of petroleum. Although many aspects of transportation are handled through the private sector, the public role in economic, safety, and environmental regulation and the provision of infrastructure and transportation services is broad and complex. Many of the most controversial policy choices at the national, state, and local levels depend heavily on technical analyses of the consequences of current or changed policies. The Transportation Research Board of The National Academies contributes to the resolution of these issues by convening and facilitating the work of balanced committees of experts who provide dedicated service, without financial compensation, in the public interest.

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