TRB

Critical Issues in Transportation

2013

TRANSPORTATION RESEARCH BOARD
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Critical Issues in Transportation

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The United States depends on transportation to compete globally and to help revive a sluggish domestic economy. Individuals depend on transportation not only to get to work but to shop, socialize, and access health care, among other goals *(1)*. For all of its benefits to the nation and individuals, however, transportation imposes large costs—lost time in traffic congestion, deaths and injuries from crashes, demand for imported petroleum, and the release of greenhouse gas emissions and other forms of pollution.

Passengers wait for a delayed flight at an airport. Despite the nation's leading role in the world economy, its transportation system lacks reliability.

FOCUSING ON RESEARCH

The Executive Committee of the Transportation Research Board (TRB) has compiled a list of critical issues in transportation for 2013 to stimulate awareness and debate and to focus research on the most pressing transportation issues facing the nation:

- *The performance of the transportation system is neither reliable nor resilient,* yet transportation's role in economic revival and in global economic competition has never been more important.
- The nation suffers *significant, avoidable deaths and injuries every year,* although safety has improved markedly.
- Although essential in meeting economic and social goals, transportation exerts *large-scale, unsustainable impacts on energy, the environment, and climate.*
- *Inadequate funding sources for public infrastructure* impede the performance and safety of the transportation system, but alternative sources of funding may place a larger financial burden on users who are least able to pay.

The freight transportation system must adapt to a projected 80 percent growth in gross domestic product in the next 25 years.

- Although the United States is known for its creativity and its problem solving, *innovation in passenger mobility services and in public-sector infrastructure lags far behind that in the private sector.*
- *The research and development (R&D) investment necessary for finding and adopting new solutions is low and declining.*

The following discussion highlights information developed in recent reports by TRB and other divisions of the National Research Council.

SYSTEM SCALE AND SCOPE

The U.S. transportation system is enormous by any measure (see text box, below), and its tremendous scale and scope testify both to its importance and to its impacts, positive and negative. This massive transportation system may be adequate to serve today's population and economy, although highly congested locations make that contestable. Nevertheless, maintenance and expansion are necessary to accommodate an expected 20 percent growth in population—an additional 66 million people—and an 80 percent growth in the gross domestic product (GDP) in the next 25 years (*2*, *3*). Whether the transportation system can meet these needs is an open question.

This unranked list of critical issues presents recurrent themes made more prominent by the concerns of the day. The rancorous debate about deficits and taxes has precluded the national government from addressing the investment needed to improve transportation system performance. Congress reflects the differing visions that Americans have for the federal role in funding infrastructure—for

Transportation Modes and Usage

HIGHWAY: More than 250 million vehicles generate nearly 4 trillion passenger miles and 1.3 trillion motor carrier ton miles annually on 4 million miles of roadways.

AIR: 7,800 commercial aircraft generate 550 billion passenger miles annually between major airports.

TRANSIT: 7.5 percent of work trips in the largest metropolitan areas; 22 billion passenger miles by bus and trolley transit; commuter and urban rail transit generate 30 billion passenger miles annually on almost 11,000 miles of track.

WALKING AND CYCLING: Nearly 12 percent of daily trips are by walking or cycling, a total in excess of 45 billion trips annually.

RAIL: 24,000 Class I locomotives pull more than 1 million cars, generating 1.3 trillion ton miles on 96,000 miles of freight railroad track.

PORTS AND WATERWAYS: More than $1 trillion in commerce moves in the nation's 12 largest ocean ports. More than 9,000 vessels and 30,000 barges move 157 billion ton miles annually on 25,000 miles of navigable channels of the Inland Waterway System.

PIPELINE: More than 175,000 miles of crude oil and 325,000 miles of gas transmission lines move two-thirds of the nation's energy supplies.

SOURCES

Bureau of Transportation Statistics (BTS). *Pocket Guide to Transportation.* U.S. Department of Transportation, 2012, Tables 2-1, 2-2, 3-1, 4-6.

BTS. *National Transportation Statistics,* Table 1-51, www.rita.dot.gov/bts/sites/rita.dot.gov.bts/files/publications/national_transportation_statistics/index.html. Accessed May 25, 2013.

Census Transportation Planning Products, Chapter 4. www.fhwa.dot.gov/planning/census_issues/ctpp/data_products/journey_to_work/jtw4.cfm. Accessed May 20, 2013.

National Bicycling and Walking Study. U.S. Department of Transportation, 2010. http://katana.hsrc.unc.edu/cms/downloads/15-year_report.pdf. Accessed July 12, 2013.

Dynamic message signs alert motorists to upcoming congestion. On many of the nation's highways, population and traffic growth have outstripped capacity.

example, whether to raise federal taxes or to rely on the states or to fund intercity high-speed passenger rail. States are shouldering greater responsibility for funding, but whether they can—or should—without substantial federal support is part of the debate.

Continued uncertainty about the direction of federal policy and about funding shortfalls underscores the importance of research. The discovery and adoption of new solutions to the critical issues can help address the daunting challenges ahead.

CRITICAL ISSUES 2013

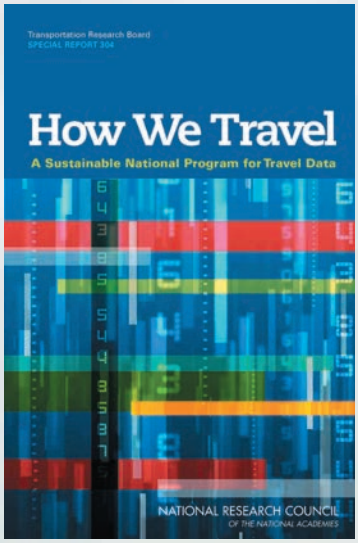
System performance is neither reliable nor resilient.

Transportation systems operate at capacity for substantial periods of the day. Unanticipated events, such as crashes or inclement and extreme weather, can greatly disrupt traffic and intensify congestion and delays. Motorists and motor carriers on metropolitan area highways and travelers on intercity planes, trains, and buses experience delays more routinely, because expansion of the system has slowed despite the continuing growth in the population and in the economy.

In many major metropolitan areas, motorists who must arrive at their destinations on time must allow 60 minutes for trips that take only 20 minutes in lighter traffic *(4)*. The delays to motor carriers raise the cost of goods shipped by truck, which account for three-quarters of the value of domestic goods shipped.

In the 2012 legislation reauthorizing federal highway and transit programs, Congress moved toward measuring the performance and increasing the accountability of recipients of funds. Meaningful performance measures, however, are difficult to define and implement. Many of the intended outcomes, such as improving safety and accessibility, are affected by far more than infrastructure capacity. Moreover, agencies do not collect the data required to measure other outcomes, such as system reliability or travel times in peak periods. A major effort is required to define appropriate performance measures; to develop consistent, valid indicators; and to support data collection *(5, 6)*.

Competition between modes and shortages of funding are forcing all modes to operate more efficiently; this challenge, however, particularly affects public infrastructure agencies, which lack the necessary resources *(7)*. Agencies that were established to build systems are only slowly adapting to the need to operate the systems efficiently. Because the individual modes of transportation are organized, funded, and managed independently, optimizing system performance to take advantage of the relative strengths of each mode is difficult. Research and policy analysis can guide agencies and Congress in making good decisions



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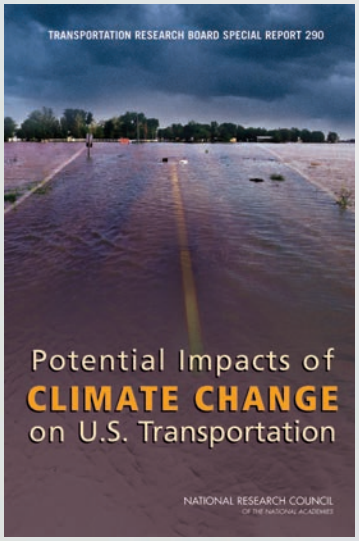
The damage to transportation systems caused by Superstorm Sandy in 2012 revealed a need for better preparation for and response to emergency weather events.

about technologies and operating practices that can improve system performance.

A major performance issue across all modes is the inadequacy of preparation for natural and human-made disasters, as well as for extreme weather events, which may become more frequent with climate change. For example, in 2012, Superstorm Sandy flooded subways, airport runways, roads, marine terminals, and railroad tracks in New York and New Jersey, causing tens of billions of dollars in economic losses and physical damage. Systems were quick to respond but slow to recover because of the amount of devastation, which vividly illustrated the physical and economic vulnerability of coastal infrastructure to storm surges and sea level rise *(8)*. Planning for adaptation, accompanied by an analysis of alternative strategies, is required to guide policy decisions about protecting and locating extensive vulnerable transportation assets, particularly in coastal areas where the majority of the U.S. population resides *(9)*.



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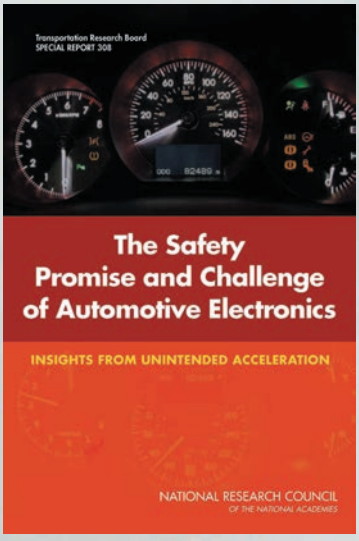

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Safety has improved, but avoidable losses are still significant.

The crash of the South Korean Asiana jet at San Francisco Airport in July 2013 was the first large passenger aircraft crash in the United States since 2001. Between 2007 and 2011, highway fatalities in the United States declined sharply. Yet despite improvements in safety, the toll in death and injury on U.S. highways is high, with more than 30,000 motor vehicle deaths annually *(10)*. Highway fatalities increased in 2012 *(11)*.

Almost all transportation fatalities—approximately 94 percent—occur on highways and mostly involve passenger vehicle crashes. New entertainment and navigation systems threaten to increase driver distraction. New technologies hold great promise for avoiding crashes, yet the unintended consequences of increasingly complex electronics systems can undermine public confidence and acceptance *(12)*. As safety technologies become increasingly automated and complex, the task of integrating the human with the system

Although highway safety has improved, the number of motor vehicle deaths remains high.

Field sobriety tests and other enforcement strategies can prevent highway fatalities and injuries.

becomes more important and demanding, as does the process of safety assurance to avoid electronic and software failures.

Meanwhile, well-known enforcement measures can prevent thousands of highway deaths and injuries every year. The United States could learn from successful programs and enforcement strategies used in other industrialized nations *(13)*.

Each mode has specific safety issues, but managing the fatigue from shift work in support of 24-hour operations is common to all. Rail, pipeline, commercial aviation, and air traffic control have good safety records, but must continually manage against the risk of low-probability, high-consequence events. Ongoing research on risk analysis, high-reliability organizations, safety culture, and fatigue management, with implementation of the findings, could yield important safety benefits.

The impacts on energy, climate, and the environment are unsustainable.

Dramatic increases in the U.S. domestic production of shale oil and gas have profound implications for national security, climate impacts, and transportation. Forecasts indicate that the United States may become nearly energy independent, although large oil imports are expected well into the future *(14, 15)*.

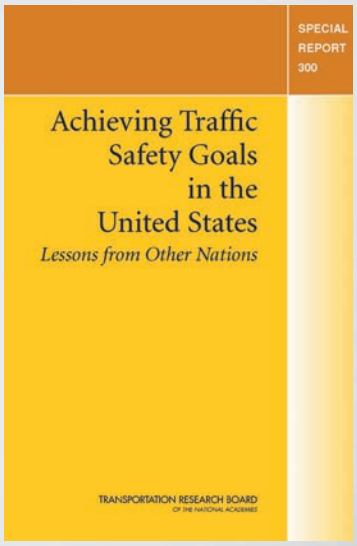
Transportation accounts for two-thirds of U.S. petroleum consumption and has driven the demand for oil imports, often from unstable parts of the world. A reduction in imports will be good for the economy, but the availability of fossil fuels for transportation will have significant climate impacts as transportation demand continues to grow. A combination of technological innovation and regulation is placing the nation on a trajectory of greatly reduced fuel consumption and greenhouse gas emissions for cars and possibly for trucks.

Greenhouse Gas Emissions

Despite projected improvements in fuel efficiency and a gradual shift to low-carbon energy—in the United States and elsewhere—nations may not achieve the shared policy goal of stabilizing atmospheric concentrations of greenhouse gases by midcentury. Reaching these goals would require emissions reductions of 60 to 80 percent worldwide in the next four decades *(16)*.

In the United States, transportation produces one-third of U.S. carbon dioxide emissions and is therefore a target for additional regulation, following the examples of California and other states. A policy debate will have to determine how to sustain and enhance the economic and social benefits of transportation while reducing transportation emissions of greenhouse gases. Objective research is sorely needed to inform this debate.

A drill pad in the Marcellus Shale gas play in southwestern Pennsylvania. Greater domestic oil and gas production has altered the U.S. energy landscape dramatically.



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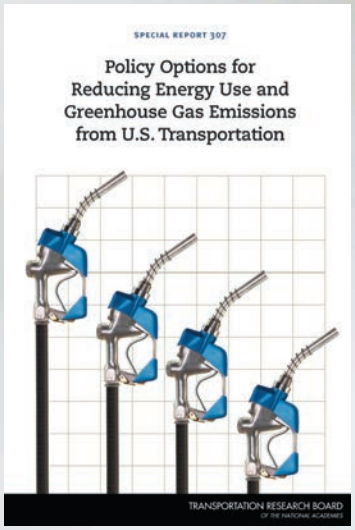

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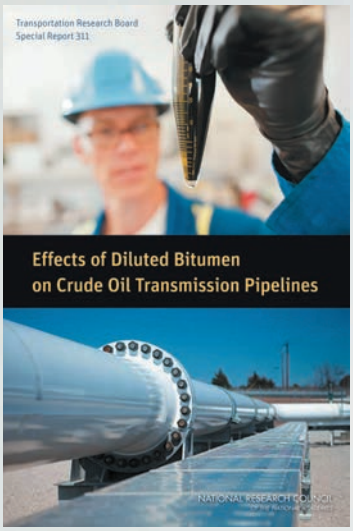

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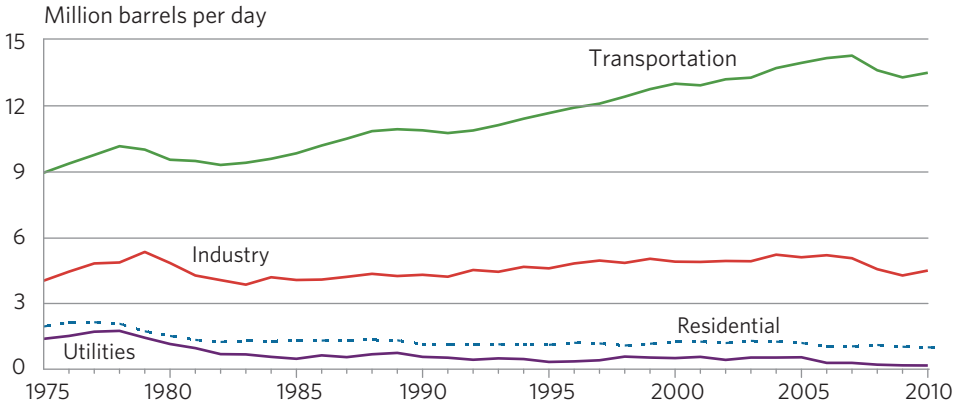
TRANSPORTATION'S SHARE OF U.S. PETROLEUM USE



Freight Repercussions

The changing energy supply is also affecting freight services. The increased regulation of emissions at coal-burning utilities, coupled with low natural gas prices from an abundant domestic supply, has contributed to natural gas displacing coal as the baseload fuel for generating electricity in many parts of the country. This is a positive change from a climate perspective but has affected railroads' traffic mix and revenues. Increased demand for coal exports may partly offset the reduced demand for coal transportation to domestic utilities but introduces other controversy over coal dust and the impacts of new export terminals in environmentally sensitive areas.

Geographic shifts in oil and gas supply, often in areas not well served by pipelines, leads to the greatly expanded transport of oil by truck and rail. The drilling of new oil wells requires transport of heavy equipment, fracking sands, and other supplies to rural locations, which may have inadequate roads and bridges for the heavy traffic. Despite growth in domestic production, the pipeline transportation of diluted bitumen from Canada's oil sands region is in high demand at U.S. refineries, stoking public concerns about continued dependence on fossil fuels and about the risks of spills.

Geographic shifts in U.S. oil and gas supply have led to increased rail and truck transportation of fuel.

Development Patterns

Motor vehicle use has rapidly expanded in the United States in recent decades, resulting in large increases in transportation energy demand. The nation's large land area has contributed to the increased travel. But development in the United States, compared with that in most other heavily populated industrialized nations, has spread population at a low density per square mile. The blessing of abundant land becomes a curse in terms of energy consumption and vehicle emissions.

The United States consumes far more energy per capita than other developed countries do—approximately twice as much as the European nations in the Organisation for Economic Co-operation and Development (*17*). Total automobile travel per capita in the United States is three times that of Japan and nearly twice that of Germany and the United

Although pedestrian and bicycle travel in the United States are growing, along with transit- and pedestrian-friendly development, automobile travel remains high.

Kingdom *(18)*, in part because origins and destinations in the United States are spaced farther apart. In addition, the United States has not invested as heavily as other developed nations in public transportation and has not placed constraints on patterns of development. Not surprisingly, more Americans have chosen travel by automobile than comparable travelers in other industrial countries.

Concerns about sustainability, personal physical activity, health, and livability have renewed debates about the form and density of development and about transportation's role. In response to changing preferences for urban lifestyles, many jurisdictions are changing policies to allow for denser development that supports greater reliance on transit, cycling, and walking. This has stimulated interest in reorienting autocentric places, as well as a vigorous debate about how much the strategies would reduce automobile demand and associated emissions *(19)*.

Other Effects

Total U.S. travel per capita appears to have leveled off, and the youngest driving-age cohorts appear to have different driving and lifestyle preferences from those of previous generations. The effects of the Great Recession on these changes, however, are unclear. A deeper understanding is needed of people's choices and how they change in response to the economy, lifestyle preferences, the use of information technologies and social media to replace travel and to provide more efficient travel options, the aging of the baby boom generation, and immigration. This knowledge could help localities improve planning for transportation services, infrastructure, and policies.

One of the biggest environmental success stories in the United States is cleaner air, partly the result of cleaner-burning engines and fuels. More improvements are expected from tighter emissions standards for transportation vehicles and fuel economy standards for highway vehicles. Nonetheless, 123 million people—more than one-third of the U.S. population—live in areas that do not meet federal standards for ozone *(20)*, resulting in respiratory and other health effects that likely contribute to premature deaths *(21)*.

Funding sources for public infrastructure are inadequate.

In the past century or more, the nation has invested in a massive transportation system

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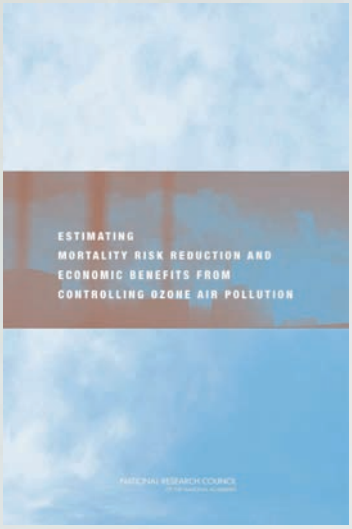

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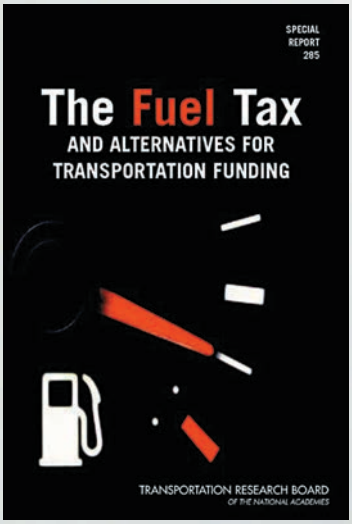

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that has to be maintained and expanded to accommodate the world's largest economy and a growing population. The cost is formidable. As with any asset, the infrastructure that supports the nation's transportation demand wears out and requires maintenance to avoid premature failure.

The costs for maintaining and improving public roads and highways exceed $100 billion annually; indications are that this level of investment is inadequate *(22–24)*. With the scale of federal deficits and the potentially dramatic reductions in transportation trust fund expenditures,[1] obtaining federal funds to maintain and expand the transportation system will be a challenge, as will increased reliance on state and local governments, which have been unable to close the funding gap.

Surface Transportation

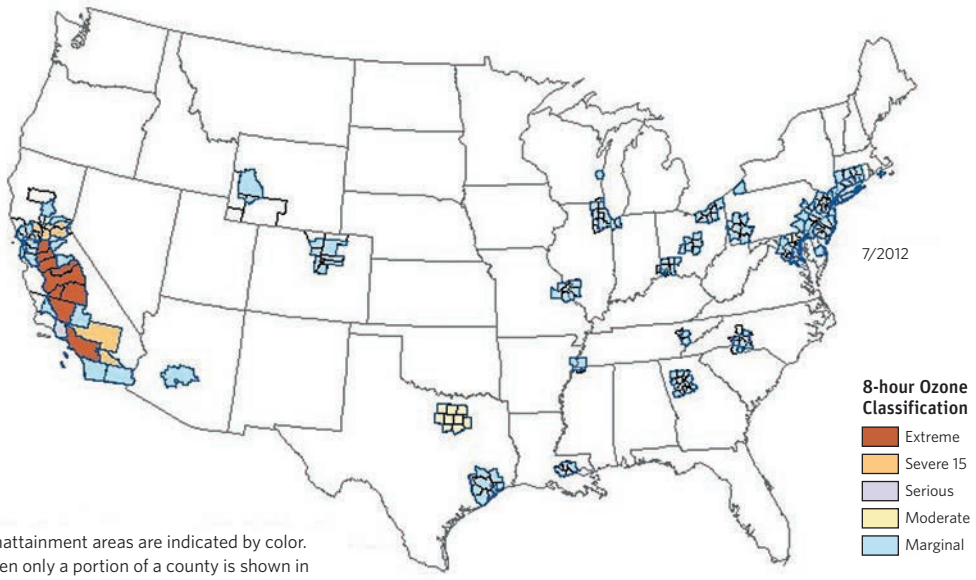
Federal and state highway taxes that generate revenues dedicated for highway and transit funding are declining as a result of fuel economy and inflation; increased wear and tear from growing travel exacerbates the decline in funding *(25)*. A federal emphasis on improving the state of good repair in transit systems and on overall asset management is occurring at the same time that funding to meet growing demand—and to address a backlog of capital needs—is in question.

Two national commissions have sounded alarms and have identified options and potential new revenue sources *(23, 24)*. Resistance at the state and national level to fuel tax increases reflects perceptions of public opposition, which nonetheless appears to be mutable.[2] Congressional inaction to evaluate

[1] Unless Congress acts to change expenditure levels or taxes, the trust fund will have fewer receipts than expenditures in 2015, continuing a trend of the past several years. Moreover, if Congress chooses not to transfer monies from the general fund in 2015—projected at $15 billion in 2015, compared with $6 billion in 2013—the trust fund would not be able to support any new obligation of federal funding in 2015, because any cash on hand would be required to liquidate previous obligations. This would result effectively in a cut of approximately $50 billion in federal aid in that year. See K. P. Cawley, *Testimony: Status of the Highway Trust Fund,* Congressional Budget Office, July 23, 2013.

[2] Many general opinion polls show majority opposition to fuel tax increases, but the answers depend on how the questions are framed. For example, one research project found that the majority supported increases under certain conditions, such as when the revenues are specifically dedicated to improving maintenance. See A. W. Agrawal and H. Nixon, *What Do Americans Really Think About Federal Tax Options to Support Public Transit, Highways, and Local Streets and Roads? Results from Year 4 of a National Survey,* Mineta Transportation Institute, 2013. http://transweb.sjsu.edu/PDFs/research/1228-American-tax-poll-2013-public-transit-highways-streets-roads.pdf. Accessed July 12, 2013.

8-HOUR OZONE NONATTAINMENT AREAS, JULY 2012 (2008 STANDARD)



Nonattainment areas are indicated by color. When only a portion of a county is shown in color, it indicates that only that part of the county is within a nonattainment area boundary.

alternative, innovative electronic means of charging highway users directly has postponed a national pilot test to determine the technical and political feasibility and affordability. The equity considerations of these financing approaches depend on the use of the revenues; in contrast, the growing state and local reliance on sales taxes, instead of user fees, places a greater burden on those who use the system least and who are least able to pay *(26)*.

Aviation

The demand for air travel has increased steadily but slowly since the Great Recession began. With capacity flat—or slightly declining—the number of passengers per flight has increased, and profitability has improved for many U.S. airlines, although marginally.

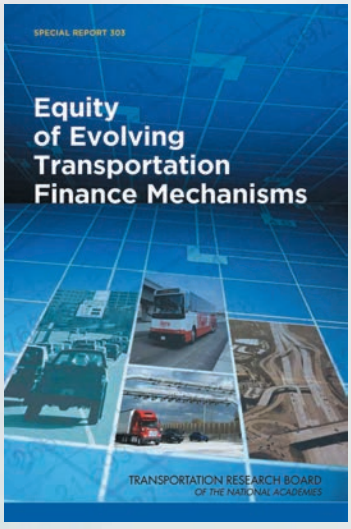
At the same time, however, collections to the aviation trust fund that supports the operating and capital costs of air traffic control and airport capital assistance have not kept pace with costs; as a result, transfers from the general fund have increased. Uncertainty about the federal government's willingness to pay as much as 25 to 40 percent of annual federal aviation agency budgets for operations from the general fund *(27)* threatens the level of air traffic services offered, the modernization of the air traffic control system, and capital grants to fund infrastructure renewal and expansion at airports.

Fuel tax revenues have declined steadily, even as infrastructure demands continue to grow.

Freight Railroads

Major freight railroads are privately owned and make extensive capital investments to sustain their systems; recent capital investments have reached record levels *(28)*. Federal policies that affect capital allocation can divert these private investments from essential needs. For example, a federal regulation requires freight railroads to invest in train control technologies that would avoid train-to-train collisions and that would allow passenger trains to mix safely on track shared with freight trains, including those carrying toxic inhalation hazards. Compliance involves large costs and significant technical hurdles for freight railroads *(29)*. Meanwhile, the

Airplanes line up for takeoff. Federal funds for air traffic control and airport capital assistance face an uncertain future.



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Private railroad capital investments have reached record levels.

proposed large-scale expansion of intercity passenger rail service, including services that would share track with freight trains, lacks funding at the federal and state levels.

Water Transportation

Marine transport moves low-cost shipments of coal and other bulk products and helps sustain agricultural exports, yet user-fee revenues to the inland waterway trust fund are well below the levels required to sustain and operate the system. National policy makers disagree about what share of the cost should be borne by general taxpayer revenue *(30)*.

Debates in Congress and at the state and local level are addressing who should pay—and in what proportion—for inland waterways and whether agricultural and other shippers can rely on other modes or have alternative markets for their goods. In 2012, low river levels from a prolonged drought in the Midwest sharpened debates about devoting water resources to transportation instead of to other public uses.

The nation's inland waterway system lacks the funding to address infrastructure needs.

Many ocean ports are seeking deeper channels and harbors in response to possible shifts in logistics and in port calls after the widening of the Panama Canal and the possibility of Asian imports arriving directly to East Coast ports instead of crossing North America by rail. A major realignment of shipping patterns would affect many large-scale investments and jobs. The federal harbor maintenance fund for improving harbors and channels for larger vessels has a surplus that Congress has been unwilling to spend, although many harbors and channels that could be affected by the Panama Canal expansion are not adequately maintained to meet current or expected demand *(31, 32)*.

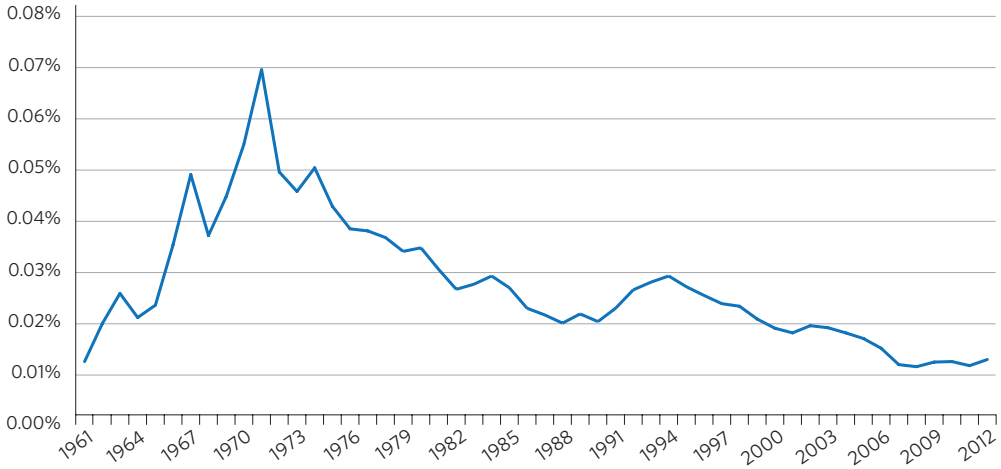
States, local governments, and special authorities share capital funding with federal sources but bear the majority of operating and maintenance expenses for public infrastructure. As the federal government struggles to constrain the budget deficit, more capital funding responsibilities may shift to these levels of government.

Increasing state sales and other general taxes to fund transportation, however, threatens to undermine the user-pay principle that has sustained highway funding for decades and raises broad equity concerns. The emergence of a few privately financed toll facilities, although supported by user fees, also raises questions about equity. For public infrastructure, a better economic basis is needed for deciding which investments to make, where, and how to finance such improvements *(33)*. More extensive evaluation research in this and other areas could pay large dividends.

Innovation lags—and R&D investment is low and declining.

New technologies and innovations that promise more efficient and sustainable travel have been implemented haltingly and incompletely, particularly in the public sector. For example, the long-needed upgrades to air traffic control

TRANSPORTATION RESEARCH AND DEVELOPMENT AS A PERCENTAGE OF GROSS DOMESTIC PRODUCT, 1961–2012



systems and technologies face controversy over the sharing of the expense between the private and public sectors and uncertain federal funding *(27)*. Safety regulators are hard-pressed to ensure that new safety technologies will work as intended *(12)*. The new required systems to avoid train crashes on shared track must overcome daunting technical challenges. Major public-sector investments in information and communications technologies have yet to produce the dramatic changes in mobility services—such as dynamic ridesharing or demand-responsive transit—that could play a large role in improving passenger transport efficiency, serving those without access to cars, and reducing greenhouse gas emissions.

Nevertheless, innovations are being introduced and implemented. Electronic stability control technology is saving lives by reducing motor vehicle rollover crashes *(34)*. Electronic toll passes are increasingly interchangeable across multiple toll collection systems. Real-time data on traffic and parking are being delivered to mobile devices

New vehicles and technologies face funding, regulatory, and other hurdles.

Investment in research and development can foster innovation in the technology and infrastructure of a changing transportation landscape.

to aid traveler decision making. New services, built on telecommunications technologies, to share rides, cars, and bikes, are gaining use in several metropolitan areas. New vehicles, including trucks and locomotives, incorporate multiple energy-saving technologies. Increasingly sophisticated logistics continue to reduce shipping and inventory costs. The increased automation of vehicles and the transformation in urban travel services offer exciting prospects. Another positive sign is that state transportation departments and the Federal Highway Administration are gearing up to implement a host of innovations developed through the second Strategic Highway Research Program *(35)*.

The public sector, however, remains averse to risk—sometimes for good reasons. Concerted R&D is needed to identify and manage the risks and to evaluate the benefits and challenges of new technologies. This funding also supports the technology transfer required to push innovation in the public sector.

R&D that informs public policy can accelerate innovation—for example, by reforming institutions and restrictive laws and policies that constrain the efficient and integrated performance of all modes. This funding also helps train the professionals who will design, implement, and maintain the needed innovations.

U.S. R&D has been increasing as a percentage of GDP and now approaches 3 percent *(36)*, but federal investments in transportation R&D have declined steadily in real terms and amount to a mere 0.01 percent of GDP. Yet this funding is the basic building block for innovation in the public sector—through discovery and through the education of the future workforce.

HARNESSING THE WILL

People use transportation as a means to achieve what they seek in their lives—access to employment; connections with family, friends, and communities; and access to consumer goods, health care, and recreational opportunities. Addressing the major challenges discussed above implies broad changes that may prove disruptive in the short run but also open up exciting new possibilities.

Although critical issues are identified one by one in this document, they do not stand alone. Technological innovations, for example, provide new means to increase fuel economy, and improve system performance, which reduces demand for new capacity and energy consumption and thereby reduces emissions. Technological innovations also could allow revenues to be raised from users more efficiently, equitably, and effectively. Institutional and policy reforms, if achieved, could allow wider exploitation of technologies and policies that improve performance and safety.

In the 21st century, transportation collectively can support or undercut national aspirations. The challenges are great, but the opportunities also are great, if the United States can harness the will to invest and innovate for a brighter future.

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