MAY–JUNE 2014
NUMBER 292

TRANSPORTATION RESEARCH BOARD
OF THE NATIONAL ACADEMIES

TR NEWS

King Coal Highway

Model Public–Private Partnership

U.S. Energy Outlook: Positive Implications for Transportation

Automated Vehicle Technology: Research Areas to Follow

Driverless Cars: Promises and Pitfalls

Programming Funds for Research

Plus:
Practical Findings from Cooperative Research Programs

THE NATIONAL ACADEMIES
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COVER: Completed Red Jacket section of the King Coal Highway, a public–private partnership project in West Virginia, part of the Interstate 73–Interstate 74 North–South corridor. (Photo: Mingo County Redevelopment Authority)

TR NEWS

features articles on innovative and timely research and development activities in all modes of transportation. Brief news items of interest to the transportation community are also included, along with profiles of transportation professionals, meeting announcements, summaries of new publications, and news of Transportation Research Board activities.

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North Carolina DOT's website dashboard presents statistics on performance, providing accountability at all levels and across all program areas.

The Rapidly Improving U.S. Energy Outlook

Positive Implications for Transportation

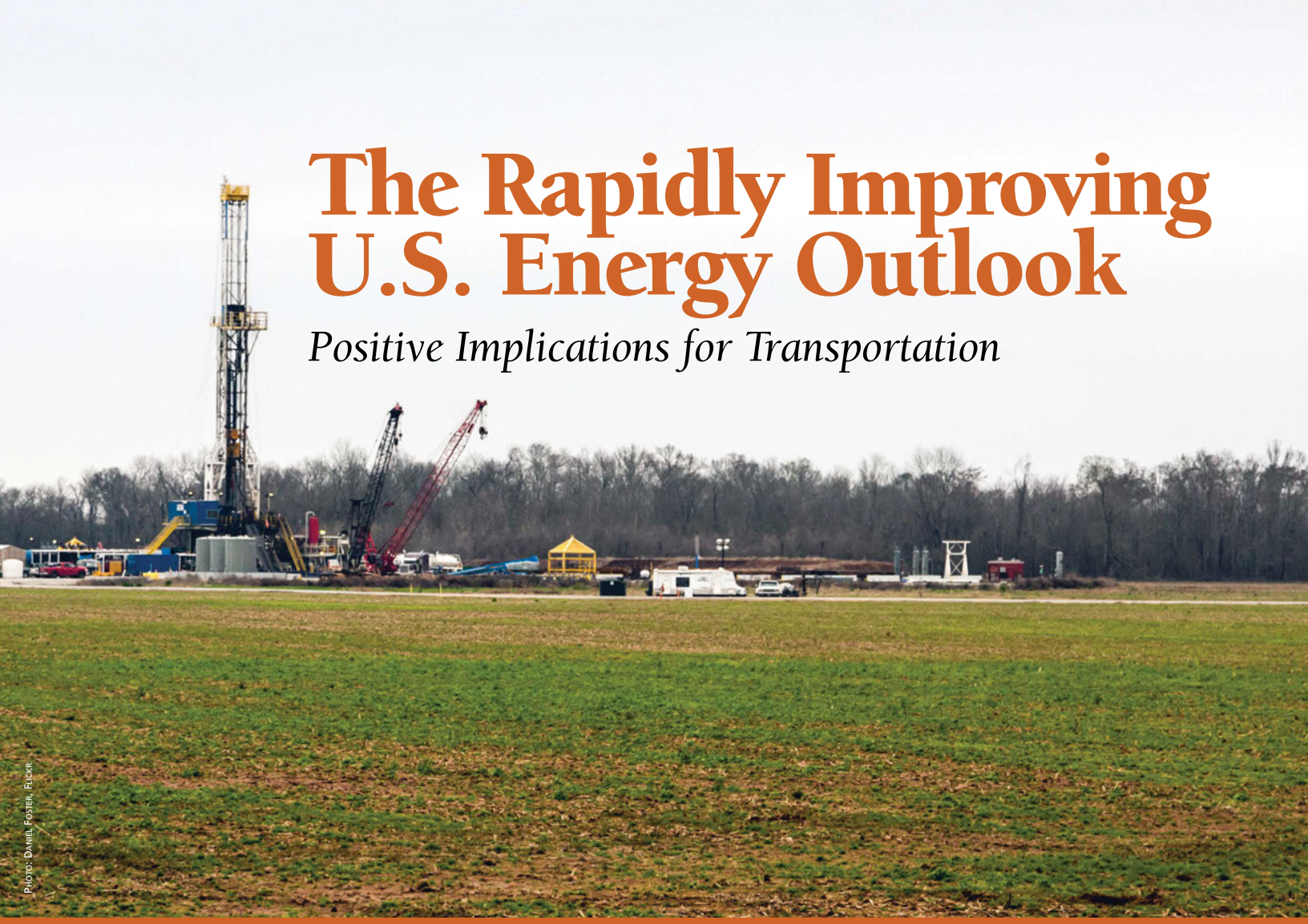


PHOTO: DANIEL FOSTER, FLICKR

GARY MARING AND MARIANNE MINTZ

Maring, a transportation policy consultant, retired as head of the Freight Office of the Federal Highway Administration and subsequently worked with Cambridge Systematics, Inc., for eight years. Mintz, an emeritus member of the TRB Transportation Energy Committee, leads the Deployment and Analysis Team, Systems Assessment Section, Energy Systems Division, Argonne National Laboratory, Argonne, Illinois.

(*Photo above:*) More than one-quarter of America's energy comes from natural gas; new technologies have opened gas plays and have greatly increased supplies.

During the past five decades, the U.S. transportation system became increasingly dependent on foreign oil and vulnerable to disruptions of supply. Two oil crises and tightened standards for fuel economy did little to alter the dependence.

In the past five years, however, the long-term trend of declining domestic supply and increasing dependence on imports underwent a dramatic reversal. Advances in exploration and production technologies opened up vast new reservoirs that previously were not economically viable. U.S. oil production grew by more than 40 percent, and imports declined to record lows—in some cases, to the lowest levels in decades (*1*). Although the world market continues to set oil prices, U.S. supplies are now much less vulnerable to world events.

PHOTO: ENVIRONMENTAL PROTECTION AGENCY VIA NATIONAL ARCHIVES

World oil prices quadrupled between 1973 and 1974, prompting gas rationing in some states. Recent technological advances have reduced U.S. dependence on foreign oil.

New Energy Resources

Even more dramatic is the surge in U.S. natural gas production. Shale gas production in the United States has grown rapidly after a long-term effort by the natural gas industry, in partnership with the Department of Energy (DOE), to improve drilling and extraction methods in parallel with increased exploration.

Shale gas has entered the market, prices have plummeted, and market forces have encouraged the utility, manufacturing, and transportation sectors to consider switching fuels. Natural gas now accounts for more than one-quarter of America's total energy use, and more than one-half of the U.S. natural gas supply comes from shale and other unconventional sources (Figure 1, page 4) (*2*).

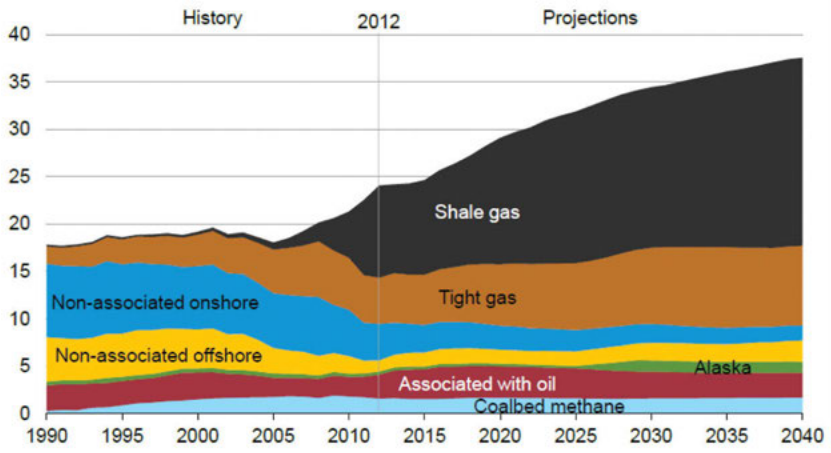


FIGURE 1 U.S. natural gas production, in trillion cubic feet, 1990–2040 (Source: EIA).

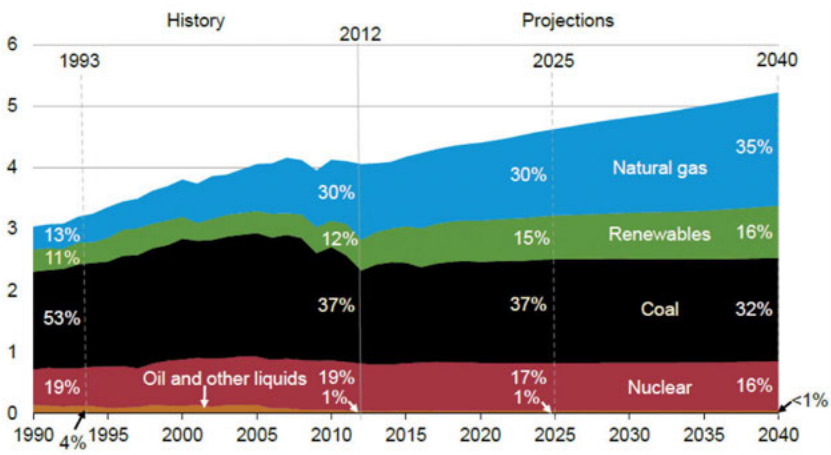


FIGURE 2 Electricity generation shifting to natural gas and renewables, in trillion kilowatt-hours per year, 1990–2040 (Source: EIA).

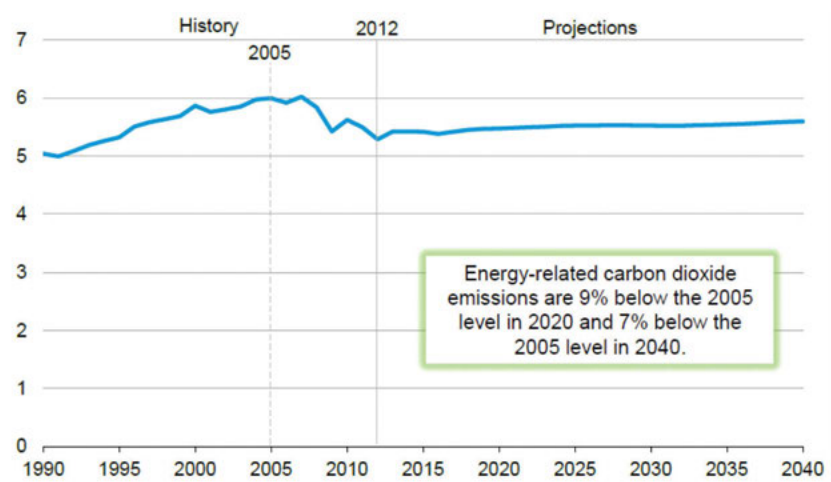


FIGURE 3 U.S. energy-related CO_2 emissions, in billion metric tons, 1990–2040 (Source: EIA).

DOE's Energy Information Administration (EIA) predicted correctly last year that the United States would be the world's top producer of petroleum and natural gas hydrocarbons in 2013, surpassing Russia and Saudi Arabia, and that imports would continue to decline. With upwardly revised estimates of Canadian and Mexican oil reserves, North America technically should have little need to import oil in the near future. The current mix of U.S. oil imports is an indicator—36 percent comes from North America, while only 16 percent originates in the Persian Gulf (*3*). This represents a major decline in U.S. vulnerability to disruptions in the oil supply from the Middle East and from other volatile areas, such as Venezuela and Nigeria.

New exploration and production technologies are not the only contributors to the changing U.S. energy outlook. Newly acquired data and updated computer models have enabled reassessments of the resources. EIA now concludes that discovered, economically recoverable resources are much larger than previously estimated. The United States, then, is not only moving closer to energy independence but may well become a net exporter of energy in the not too distant future.

Utilities Emissions

Compared with coal, natural gas is a cleaner fuel for electric power plants and could serve as a bridge for the transition to carbon-free energy sources, reducing greenhouse gas emissions to safe and acceptable levels. That process may be well under way, as the number of coal plant retirements and changeovers to cleaner sources—primarily to natural gas—reached record levels in 2012 (*4*). According to EIA projections, natural gas will generate 35 percent of all electricity by 2040, more than double the share in 2000.

Two developments are likely to increase this share: the Obama Administration's plan to issue new regulations for greenhouse gas emissions by currently operating power plants and the U.S. Supreme Court's decision upholding the authority of the Environmental Protection Agency to regulate coal plant emissions that drift across state lines. Replacing old coal-fired power generators with new natural gas–fueled units could reduce carbon dioxide (CO_2) emissions by an estimated 36 to 59 percent (*5*).

Shifting from coal- to gas-fired power plants is the main reason that U.S. greenhouse gas emissions have fallen to their lowest level in 20 years, the largest drop for any country. Figures 2 and 3 (at left) show the shift to cleaner power generation and to lower CO_2 emissions, respectively (*2*). According to EIA projections, with improved energy efficiency in all sectors and a shift away from the most carbon-inten-

sive fuels, U.S. energy-related CO_2 emissions could meet the President's goal of 17 percent below the 2005 levels by 2020 and could remain below the 2005 levels through 2040.

Transportation Emissions

New Corporate Average Fuel Economy standards are expected to reduce U.S. surface transportation fuel use and CO_2 emissions by approximately 30 percent by 2030 (*6*). If natural gas replaces a significant portion of diesel fuel consumption, particularly for bus fleets and freight transportation, emission reductions could be even greater.

Engines fueled with natural gas instead of petroleum have a well-documented record of reducing criteria pollutant emissions. The benefit of switching from petroleum to natural gas engine fueling is less clear for greenhouse gas emissions, however. The principal component in natural gas, methane, is a potent greenhouse gas.

For a net reduction in greenhouse gases, engines fueled by natural gas must have total life-cycle emissions lower than the status quo. Measuring the emissions for all the steps involved in exploration, well development, and production—and averaging them over the life of the well—is no small task.

Research is under way to measure greenhouse gas emission rates for natural gas production from a large sample of shale and conventional onshore gas wells. Preliminary results suggest that greenhouse gas emissions from shale gas production may be somewhat higher than those from conventional gas wells but produce a net benefit in a full life-cycle comparison with petroleum (*7*). Nonetheless, methane can leak during gas processing, in distribution, at transfer into a vehicle, and during vehicle operation; the leakage must be kept to a minimum if natural gas is to have a substantial net positive impact.

The shift from coal to natural gas by utilities promises another transportation environmental benefit. If electricity is produced from sources with lower greenhouse gas emissions, electric vehicles can achieve greater reductions. EIA therefore projects that greenhouse gas emissions from transportation energy consumption will decline slightly or will remain stable from 2012 through 2040, despite an increase in transportation activity (*2*).

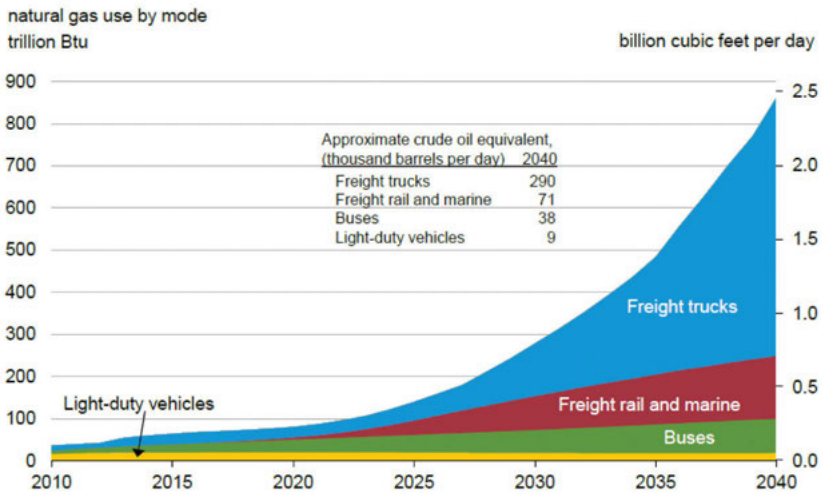


FIGURE 4 U.S. projected natural gas use by mode of transportation, in trillion Btu (*left*) and billion cubic feet per day (*right*), 2010–2040 (Source: EIA).

Photo: MARTA

Metropolitan Atlanta Rapid Transit Authority buses fuel with natural gas.

Photo: Wikimedia Commons

LA Metro converted its entire bus fleet to run on CNG fuel; the last diesel bus was retired in 2011.

Opportunities for Natural Gas

The boom in domestic natural gas production presents multiple opportunities for expanding the use of natural gas in transportation (Figure 4, page 5). Of the more than 250 million vehicles on U.S. roads, only about 140,000 are fueled by natural gas (*8*). In the rest of the world, more than 15 million natural-gas vehicles are in use (*9*), and nearly 35 million are projected by 2020 worldwide, including significant growth in the United States (*10*). Historically, natural-gas vehicle penetration has been highest in countries with abundant natural gas resources. With newly plentiful domestic supplies, the United States appears poised to enter that group (*11*).

Freight trucks present the largest long-term opportunity (*2*). In the 1990s, natural gas was introduced in buses, refuse trucks, delivery vehicles, and port drayage trucks to help urban areas meet air quality rules and manufacturers of heavy-duty engines to comply with exhaust emission standards. Because these vehicles return to a base location each day, fleet operators could use their own infrastructure for fueling. Many of these fleets today are making their compressed natural gas (CNG) stations available to others; fuel providers are building new publicly accessible stations to dispense CNG and liquefied natural gas (LNG), and the growing availability of low-cost fuel is encouraging additional fleets to convert to natural gas.

A similar sequence of events underlies natural gas expansion into other over-the-road truck, rail, and marine applications. Because its higher energy density reduces onboard storage needs and allows vehicles to travel farther before refueling, LNG may prevail as the fuel of choice for longer-haul trucks and locomotives (*12*).

Urban Fleets

The waste industry and bus fleets have made the largest push into natural gas. With Waste Management, Republic Services, and other large haulers in the lead, more than one-half of all refuse trucks placed into service in 2013 were fueled by natural gas. In the transit market, more than one-quarter of all new buses are fueled by natural gas.

LA Metro, for example, has the largest fleet of CNG buses in the nation—approximately 2,200. Officials estimate that the conversion to natural gas has cut the release of particulates from LA Metro by 80 percent and of greenhouse gases by approximately 300,000 pounds a day (*13*).

State and municipal fleets are another promising

Photo: UPS

A UPS driver fuels an LNG vehicle. UPS and other companies are investing in natural gas–fueled freight truck fleets.

Photo: Wikimedia Commons

GE designed the Evolution Series of locomotives to meet the U.S. Environmental Protection Agency's (EPA's) Tier 2 locomotive emissions standards. Development is under way of a dual-fuel version that will meet EPA's Tier 4 standards.

market for natural gas. Vehicles include not only trucks and buses, but increasing numbers of light-duty cars, vans, and pickups. In 2012, for instance, 22 states established a consortium "to work with car manufacturers in the United States to produce affordable, high-quality natural gas vehicles for their fleets—something that would be available not only to state governments, but to consumers in households and the private sector" (*14*). By aggregating their purchasing power, the states hope to create economies of scale so that manufacturers could lower the cost differential between natural gas vehicles and comparable gasoline or diesel vehicles.

Limited data suggest that the strategy is working, but barriers remain. For example, several state agencies in Colorado, an initiator of the consortium, have purchased competitively priced natural gas vehicles in the past year. But Denver's Regional Transit District (RTD) recently decided to purchase 52 diesel buses instead, because the cost of retrofitting the RTD bus barns to accommodate indoor CNG fueling would have added more than $28 million to the project (*15*).

Freight Trucks

Factory-produced natural gas–fueled trucks generally cost more than petroleum-fueled trucks—from $5,000 more for a light-duty model to more than $80,000 more for a heavy-duty, over-the-road tractor. Although truck manufacturers are working to reduce these costs, the fuel savings alone are compelling (*16*).

Natural gas fuel typically costs $1.50 less per gallon-equivalent of diesel; therefore the additional vehicle costs often can be recouped within two years, even without major reductions in the price of the vehicle. Trucking companies such as Dillon Transport and Ryder and private fleets such as UPS and Proctor and Gamble have announced major purchases (*17*). Proctor and Gamble plans to convert 20 percent of its truck fleet to natural gas in the next few years.

Locomotives

Natural gas is an attractive option for railroads, both for the cost savings and for the environmental benefits. Railroads consume approximately 4 billion gallons of diesel fuel per year; the prospect of saving $1.50 per diesel gallon-equivalent has prompted the railroad industry to consider LNG.

Companies are cautious, however, because of the costs of retrofitting or replacing locomotives, adding fuel tenders and fueling infrastructure, training personnel, revamping logistics, and securing Federal Railroad Administration (FRA) approval. These outlays would compete for funds with route expansion and upgrades to accommodate the fast-growing crude oil traffic.

Both BNSF and Union Pacific are planning to test dual-fuel LNG locomotives on their networks but no specific announcements have been made. In Canada, Westport is teaming with Caterpillar and the Canadian rail industry to demonstrate the first high-pressure direct-injection natural gas locomotive in 2014.

Canadian National already operates two dual-fuel locomotives with LNG tenders between Edmonton and Fort McMurray in Alberta and has ordered additional tenders that would increase the range of the LNG trains beyond that of conventional diesels. CSX is purchasing two bifuel locomotives from General Electric (GE) and has established a testing program to evaluate GE's NextFuel natural gas retrofit kits on the Evolution series locomotives (*18*).

Indiana Harbor Belt is converting 31 switcher locomotives to CNG as part of a multiyear program funded by the Congestion Mitigation and Air Quality Improvement Program to reduce emissions in the Chicago metropolitan area (*19*). The strategy also indicates the impact of tightened Tier 4 exhaust emissions standards that go into effect for locomotives in 2015.

The final Tier 4 standards for hydrocarbons, nitrogen oxides, and particulate matter require reductions of 50 to 70 percent from current standards for line-haul locomotives and more for switcher locomotives (*20*). Meeting these standards will require technologies such as selective catalytic reduction or dual-fuel operation.

Initially, dual-fuel locomotives may substitute LNG for 60 to 70 percent of diesel; in the longer term, newer technologies could substitute for 80 to 90 percent (*21*). EIA's 2014 reference case predicts that by 2040 natural gas will supply 35 percent of freight rail energy (*2*).

Ships

As with rail, LNG offers significant cost and environmental advantages in marine applications. Environmental benefits are important for ships operating in Emission Control Areas (ECAs) subject to a 1 percent sulfur limit. Set under Annex VI of the International Maritime Organization's International Convention for the Prevention of Pollution from Ships (MARPOL), the sulfur limit will ratchet down to 0.1 percent in 2015 and 2016 within ECAs and from 3.5 percent to 0.5 percent for all other areas in 2020.

ECAs encompass the waters within 200 miles of most of the North American, European, North African, and Japanese coasts, as well as around Hawaii and Singapore, in the Mediterranean, and much of the Caribbean. Until now, MARPOL Annex VI has largely affected vessels operating within European and North American waters. Most have switched from intermediate or heavy fuel oil to marine diesel oil at considerable cost. Every seagoing vessel must comply with Annex VI if calling at a port within an ECA.

To meet MARPOL limits in the long term, vessel owners and operators are trying three strategies:

- Securing a relatively expensive Annex VI–compliant distillate fuel with less sulfur than MDO under long-term contract,
- Continuing to burn high-sulfur fuel but using scrubbers to reduce emissions, or
- Switching to a lower-cost alternative such as LNG (*22*).

Although current pricing looks favorable, LNG will likely take some time for major inroads into the marine fleet. Dozens of LNG-capable vessels are on order, but as yet only a handful have been delivered.

Fueling Infrastructure

In the United States, the infrastructure for fueling and maintaining gasoline and diesel vehicles is ubiquitous. Equipment is standardized; fire codes and safety standards are well developed and known; first responders are familiar with potential hazards; and trained mechanics and other service personnel are widely available.

Photo: Anthony Veder, PR060

A high-speed, low–fuel consumption carrier by Anthony Veder, which is building natural gas–fueled ships.

The lack of fueling outlets for natural gas is a barrier for penetration into the transportation sector. Nevertheless, because of the clear economic advantage of natural gas in many transport applications, an industry is developing to supply the compressors, the small-scale liquefaction units, the storage tanks, and the dispensing facilities; to train the personnel; and to distribute the LNG and CNG to fueling locations on roads, railways, and in ports, as well as to provide the natural gas engines for drilling and for pressure-pumping the shale oil and gas wells.

According to *Reuter's* columnist John Kemp, "The fuel market appears to be nearing a tipping point. If the present gap between natural gas and crude oil prices remains for another 2 to 3 years, it should be enough for natural gas to establish a major beachhead in the transport market" (*23*).

Transporting Energy

The demand for the transportation of energy is on the rise. Major pipeline projects are under way that will have dramatic effects on North America's infrastructure for oil and liquids transport during the coming years.

By Pipeline

North America leads the world in pipeline construction, with 41,810 miles of new or planned lines for oil and natural gas, according to a January 2013 report (*24*). For example, the newly completed southern leg of the Keystone Pipeline route—also called the Gulf Coast Pipeline—has begun carrying more than 700,000 barrels of oil per day from Cushing, Oklahoma, to Nederland, Texas, relieving a major bottleneck in moving domestically produced oil from Oklahoma to Gulf Coast refineries.

The northern leg of the Keystone Pipeline primarily will deliver crude from Canadian tar sand oil fields to the Gulf Coast for refining before export. This pipeline segment awaits the environmental clearances for crossing an international boundary.

Although pipelines transport the bulk of the nation's crude, capacity is limited, and competition is increasing from trucks, barges, and railroads in Canada and in the United States. According to EIA's June 2013 Refinery Capacity Report, U.S. refineries received more than 1 million barrels per day by rail, truck, and barge in 2012, a 57 percent increase from 2011 (*25*).

By Rail

Rail shipments have had the largest increase. In 2008, U.S. Class I railroads originated 9,500 carloads of crude oil; by 2012, the total had expanded to nearly 234,000 carloads; and approximately 400,000 carloads are likely to originate in 2013 (see Figure 5, page 10) (*26*). Other oil-related products such as frac sand—used in hydraulic fracturing for wells—also are increasingly transported by rail, with an estimated 200,000 carloads in 2012.

Photo © TransCanada Corporation

Welder working on construction of the TransCanada Keystone Pipeline. The southern leg of the pipeline transports more than 700,000 barrels of oil per day.

Recent major rail accidents involving the shipment of oil from North Dakota have raised concerns about the safety of energy transport and have intensified the debate about the relative merits of pipelines versus rail for the transport of petroleum. FRA issued Emergency Order 28 on August 2, 2013, increasing the requirements for securing hazardous freight rail movements.[1] U.S. DOT Secretary Anthony Foxx has stated that additional regulatory actions to strengthen rail tank car standards are under consideration.

For Export

In addition, many U.S. energy companies are looking to export LNG to Europe and Asia, where prices are higher. This has implications for energy transportation both domestically and internationally, as well as geopolitical implications.

Six LNG import terminals have received permits

[1] FRA Emergency Order 28, Establishing Additional Requirements for Attendance and Securement of Certain Freight Trains and Vehicles on Mainline Track or Mainline Siding Outside of a Yard or Terminal; see *Federal Register*, Vol. 78, No. 152, August 7, 2013.

The number of barrels of oil transported to U.S. oil refineries by rail, truck, and barge increased nearly 60 percent between 2011 and 2013.

to export up to 9.3 billion cubic feet of LNG per day—Sabine Pass, Freeport, Lake Charles, and Cameron on the Gulf Coast; Jordan Cove in Oregon; Kenai in Alaska; and Cove Point on Chesapeake Bay—and more than 20 additional applications are pending (27). The first LNG exports are expected by 2016. Only a few years ago the United States was building facilities for the import of LNG.

U.S. permitting agencies are proceeding cautiously, however, because of concerns that LNG exports could raise domestic natural gas prices closer to world levels and that gas supplies from outside the United States could cut demand for U.S. shale gas. EIA's reference case forecasts modest growth in LNG exports starting in 2016, reaching more than 2 trillion cubic ft (Tcf) by 2020, and 3.5 Tcf by 2029 (2).

For Domestic Industries

Increased domestic natural gas production also has the potential to spur domestic manufacturing—including reshoring, or the return of manufacturing to the United States—by offering lower energy input costs. If this occurs, the transportation costs of supply chains could be reduced.

Industries likely to be affected by natural gas supply and pricing include steel, chemicals, glass, plastics, and fertilizer. For example, EIA is forecasting a growth of 3.4 percent per year from 2012 to 2025 in domestic industrial shipments of bulk chemicals, compared with the 2013 projected growth of 1.9 percent per year (2).

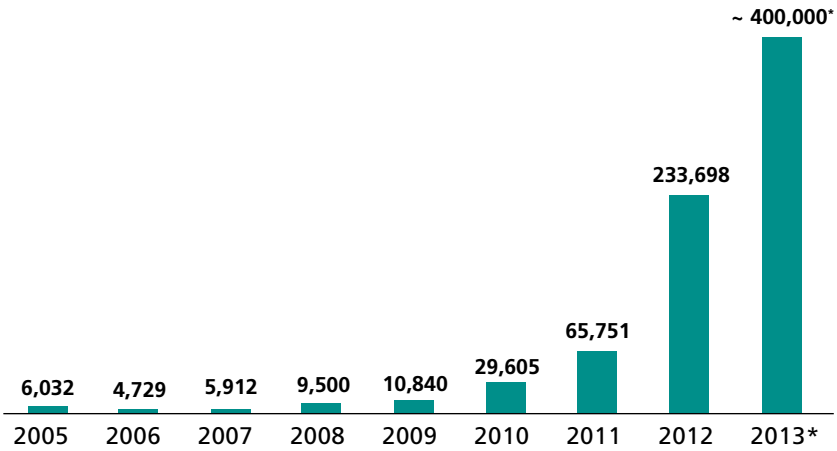
Energy Outlook Implications

Dramatic changes in energy supply and in technology development are leading to a more economical, cleaner, and more secure U.S. transportation system. EIA projects that by 2035 the United States will have reduced oil imports significantly and may even have eliminated dependence on imports. EIA predicts continued rapid growth in natural gas production, with the United States becoming a net exporter in the next decade (2).

In the short to medium term, new vehicle emissions standards, a plentiful supply of relatively cheap fuel, and growing numbers of natural gas–capable vehicles are likely to spur a significant shift to natural gas in over-the-road vehicles and in rail and marine applications. Conversion to natural gas offers economic benefits, energy security, and reductions in vehicle emissions. The increased use of natural gas for generating electricity also will reduce power source emissions for the increasing supply of electric vehicles.

Finally, the demand for transportation of energy is likely to change dramatically, with significant increases in pipeline construction and use of rail for energy transport. The safety of petroleum transport will become a more significant issue. Freight vehicles will increasingly use natural gas, supported by the necessary fueling infrastructure and responding to

FIGURE 5 Rail carloads of crude oil, 2005–2013 (* = estimate based on first three quarters, annualized. Source: American Association of Railroads).



changes in global supply chain patterns. Ports will be at the forefront of natural gas conversions for the marine industry both in landside drayage vehicles and in encouraging and facilitating the use of gas liquefaction and LNG in shipping.

Unique Win–Win

Transportation planners and operators need to stay abreast of these rapidly changing developments, which will affect local transportation system plans and energy, air quality, and climate plans at regional and state levels.

In summary, the positive developments in the U.S. and North American energy supply and technological development could represent a unique win–win for U.S. transportation, economic development, energy, air quality, and climate policy in the next few decades. Meeting these needs will be a challenge, but the rapidly improving U.S. energy outlook could lighten the task.

Photo: Ian Fuller, Flickr

A natural gas–powered truck in Sa Khwan, Thailand. U.S. exports of LNG to Asia and Europe are expected to begin in 2016.

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Photo: Mingo County Redevelopment Authority

The King Coal Highway

West Virginia Department of Transportation's First Public–Private Partnership

SABRINA DeVALL AND MICHAEL PUMPHREY

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In 1991, the U.S. Congress determined that a National Highway System corridor was needed to connect the Great Lakes and the coast of the Carolinas. Known as the Interstate 73–Interstate 74 North–South Corridor, the roadway stretches from northern Michigan to South Carolina, passing through several states, including West Virginia. The multilane corridor was listed as a high priority in 1995, and the West Virginia Department of Transportation's (DOT's) Division of Highways (DOH) was tasked with constructing a portion (*1*).

West Virginia's portion of the new, partially controlled-access corridor extends approximately 150 miles from Huntington to Bluefield and is divided into two distinct sections:

◆ The Tolsia Highway, which starts at the interchange with I-64, south of Huntington in Wayne County, and extends approximately 51 miles south to a terminus at the intersection with US-119, north of Williamson in Mingo County; and

◆ The King Coal Highway (KCH), which continues approximately 95 miles southeast from Williamson to a terminus at the interchange with I-77 in Bluefield.

Work on the KCH employed innovative methods that have saved on costs and construction time.

Immediate Challenges

The KCH section of the I-73–I-74 corridor is a four-lane replacement of US-52, a two-lane highway with steep grades, narrow to no shoulders, and many driveway entrances that have sight-distance problems. The geometric characteristics of US-52, along with high levels of truck traffic transporting coal, have contributed to hazardous conditions and a high crash rate. In addition, many sections of US-52 are

adjacent to streams in narrow valleys, and flooding is common.

West Virginia DOH realized that the new highway, with its geometric improvements, would increase motorist safety and enhance economic development opportunities for the counties of Mingo, McDowell, Wyoming, and Mercer in the southeastern portion of the state. Like most of the state, the southern part consists of steep, mountainous terrain.

The rugged terrain and the high cost of excavation have presented challenges in the design and construction of the KCH, and funding has posed additional challenges. The cost of building the KCH corridor was estimated initially at $1.6 billion (*2*). Insufficient transportation funds and the inability to use conventional methods of raising funds—for example, through tolling—meant that West Virginia DOH would have to find innovative ways to fund the construction.

Unique Partnership

Another complication was that a local coal operator, Nicewonder Contracting, Inc. (NCI), was surface mining in the area. To construct the roadway in an active mining location, West Virginia DOH engineers had to work closely with NCI representatives to coordinate mining operations with the eventual alignment of the KCH.

During the discussions, NCI, in conjunction with the Mingo County Redevelopment Authority (MCRA), suggested a unique partnership between the mining company and West Virginia DOH that could work in the favor of both.

The initial proposal from NCI and MCRA included the construction of approximately 3 miles of the KCH roadbed as a postmine land use project (PMLUP). Under the state code, counties with surface mining can develop master plans that allow the mining companies to incorporate various postmining land use needs into reclamation plans. These may include agricultural, residential, commercial, industrial, highway, and transportation uses identified by the county's economic development agency.

MCRA had experience working with mining companies and PMLUPs, and had achieved success with a "number of projects that benefited from the creation of the Appalachian Development Highway Corridor G" along US-119 (*1*). This knowledge and experience made MCRA a key partner, with interests in the "distribution centers, agritourism, aquaculture, recreation, and automotive manufacturing" that would be made possible by the usable flat land that the PMLUP would create (*3*). MCRA helped NCI comply with the Mingo County Land Use Master Plan.

Photo: FHWA

Difficult terrain and high excavation costs—as well as funding restrictions—made road construction a challenge.

(*Photo, facing page*:) Two lanes of the King Coal Highway (KCH) are open to traffic at the eastern terminus of the Red Jacket section. Roadbed construction is visible past the intersection with the Horsepen Connector (*left*) and the Beech Creek and Left Fork of Ben Creek Connectors (*right*).

Photo: West Virginia DOT

Typical conditions of the US-52 roadway: a curve in a valley with a steep hillside, narrow shoulders, and a stream nearby.

Photo: FHWA

Excavation of coal and overburden material along the KCH alignment.

Surface Mine to Roadway

The mining company and MCRA identified and proposed highway construction as the PMLUP for the surface mine. The company would construct the KCH roadbed as part of the mining excavation, at no cost to West Virginia DOH. As NCI removed coal from the area, the excess, overburden material could be used to construct roadway fills along the KCH alignment. When the surface mining and the construction of the KCH roadbed were complete, NCI would convey the highway right-of-way to West Virginia DOH.

In early 2003, NCI agreed to construct the KCH roadbed and commercial site pads as a PMLUP; this eliminated the expensive and time-consuming process of having to restore the mine site to its approximate original contour. Constructing the roadbed and grading the land as a PMLUP offered the coal company a desirable alternative, with cost and time savings.

Major Issues

In reviewing NCI's proposal, West Virginia DOH and the Federal Highway Administration (FHWA) identified some major issues to address before work could proceed. One involved the techniques that NCI used to construct valley fills in its mining operations. The mining standards did not meet the West Virginia DOH standard specifications for highway fill sections.

A field review was necessary to ensure that NCI's normal practice of constructing valley fills would be acceptable for highway construction. NCI agreed to use dynamic compaction to test the consolidation of fills for the 3-mile section. For comparison, dynamic compaction also was conducted on highway fill sections constructed by a highway contractor in accordance with West Virginia DOH specifications. The tests found that NCI's methods would be acceptable for highway construction.

The basic proposal received approval, and NCI prepared the information necessary for compliance with environmental policies. The U.S. Army Corps of Engineers issued NCI an amended Section 404 permit for the disposal of fill material under the National Environmental Policy Act, and NCI began construction of the 3-mile KCH section.

Photo: FHWA

Dynamic compaction equipment was used to test the consolidation of fill sections.

Expanding the Project

The initial concept and the work that followed proved successful. In late 2003, NCI, MCRA, West Virginia DOH, and FHWA met to discuss the possibility of expanding the project. The expansion, based on mining data collected by NCI, proposed an additional 11.37 miles of the KCH, from Taylorville to Horsepen Mountain. Known as the "Red Jacket Section," the segment was to be constructed with the same methods as the 3-mile section.

A notable difference, however, was that NCI requested that West Virginia DOH and FHWA fund part of the construction cost. Because of previous mining in the area, not enough coal was available to offset the cost of construction; NCI could not complete the additional 11.37 miles strictly as a PMLUP.

New Partnership

The developing partnership linked West Virginia DOH to its first public–private partnership (P3). FHWA defines a P3 as "a contractual agreement between a public agency and a private entity for private-sector participation in the delivery of transportation projects" (*4*). This type of partnership opens new approaches to expedite and finance projects, effectively enabling the West Virginia DOH to "do more with less."

The State of West Virginia similarly defines a P3 as a "consortium that includes…a governmental entity, a highway authority, or any combination thereof, together with a private entity or entities…to finance, acquire, plan, design, construct, expand, improve, maintain, or control a transportation facility" (*5*).

Preliminary discussions, however, revealed several issues to resolve before establishing the final P3. The issues involved the following:

- Federal-aid contracting and administrative considerations;
- Acceptable contracting arrangements;
- The environmental processing reevaluation;
- The public interest and ensuring cost-effectiveness;
- Technical issues about construction methods;
- Lack and unpredictability of funding;
- Significant differences in methods of doing business, in terminologies, and in treatment by regulatory agencies; and
- Proper allocation of risk between affected parties.

Calculating Savings

As representatives from NCI, MCRA, West Virginia DOH, and FHWA worked to resolve these issues, NCI evaluated the potential cost savings that West Virginia DOH would receive from the partnership. A comparison of the preliminary cost data with the historical cost data showed that the joint approach could save the state millions of dollars.

Photo: Mingo County Redevelopment Authority

Mining company equipment transporting excavated material on the King Coal Highway roadbed during construction. Completed roadway cut and fill sections are visible in the background.

West Virginia DOH and FHWA reviewed the NCI findings and agreed that the potential savings would be significant. According to estimates based on traditional contracting methods, the Red Jacket Section of the KCH would cost $339.4 million, including $290 million to complete all the design activities, purchase the necessary rights-of-way, relocate utilities, construct the roadway cuts and fills, and place major drainage features for the mainline Red Jacket Section of the KCH, as well as for the access roads to Horsepen Mountain and WV-65. An additional $49.4 million was included for paving, signage, markings, and roadway drainage.

In comparison, NCI developed two estimates based on the amount of marketable coal that would be mined from the Red Jacket Section. The lower estimate of the negotiated contract presented a total cost of $146.1 million, and the higher estimate presented a total cost of $169.1 million. These cost estimates were roughly one-half of the high and low estimates for completing the project under traditional contracting methods.

West Virginia DOH also would realize savings in construction time. Completion of the project to construct the Red Jacket Section under traditional methods would take approximately 7 years. The P3 arrangement, however, would accelerate the construction start time by approximately 5 years and would complete the project approximately one year sooner (*6*).

Removing Roadblocks

A P3 for the Red Jacket Section of the KCH therefore would benefit all parties. West Virginia DOH, FHWA, MCRA, and NCI worked to remove the roadblocks to forming a P3. These included restrictions on mixing public and private funds, the environmental review requirements, labor and employment laws, and public procurement standards. Few states had model legislation authorizing P3s.

In West Virginia, the code pertaining to P3s established the "opportunity to enter into contractual or joint venture agreements with a nonprofit corporation for the purposes of the economic development of West Virginia, and funded from sources other than the state" (5). The mining company, however, was not a nonprofit corporation. Constructing the Red Jacket Section through a P3 would require the passage of state and federal initiatives.

At the federal level, provisions of the Intermodal Surface Transportation Efficiency Act of 1991 had allowed the private sector to act as a funding source for transportation improvements. The National Highway System Act of 1995 also offered greater flexibility in funding, which worked in favor of the Red Jacket P3. Moreover, the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users, enacted in 2005, provided funding and encouraged investments in infrastructure safety.

At the state level, the West Virginia Legislature in 2001 passed Senate Bill 603, empowering county governments, such as MCRA, to institute PMLUPs to save money for the counties and the state by cutting construction costs and developing flat land for infrastructure needs and for diversifying economies.

Negotiated Agreement

Building on these federal and state laws affording flexibility in funding and innovative methods of contracting, the Red Jacket P3 became a reality. Under the negotiated Red Jacket Agreement, the coal company agreed to construct two road systems:

◆ Road System 1 includes the KCH mainline, running south of and parallel to US-52. The KCH mainline begins at the intersection with WV-65, between the communities of Red Jacket and Taylorville, and continues 11.37 miles to the east, ending southwest of the Sharon Heights community. The system also includes the two-lane Horsepen Connector from the KCH mainline north to the intersection with US-52.

◆ Road System 2 comprises the North and South Taylorville connectors—the western terminus of the project—and the Left Fork of Ben Creek and Beech Creek Connectors, the eastern terminus of the project.

According to the Red Jacket Agreement, the project scope includes the following:

◆ Construction of the two road systems up to the dirt grade elevation or roadbed;

◆ Excavation, crushing, sizing, and stockpiling of

Two lanes of the KCH Red Jacket section opened to traffic in summer 2011. US-52 is visible in the valley in the background.

Photo: Mingo County Redevelopment Authority

Photo: Mingo County Redevelopment Authority

Commercial site pad constructed by NCI near the KCH roadbed.

250,000 cubic yards of suitable subgrade material for use by West Virginia DOH on the paving project;

◆ Obtaining necessary environmental permits;

◆ Assisting West Virginia DOH in acquiring ownership for the rights-of-way; and

◆ Paying for tasks within the project scope, such as clearing and grubbing, seeding and mulching, installing culverts of up to 48-inch diameter, drainage and mitigation, excavation and blasting, presplitting of roadway cut-slopes, project engineering, and project engineering management.

Determining Payments

The Red Jacket project was defined in time parameters of 6 years, in three separate reimbursement components:

◆ The construction of Road System 1;

◆ The construction of Road System 2; and

◆ The processing and stockpiling of subgrade material.

West Virginia DOH would perform the final paving of the KCH and of the connector roads through a conventional construction contract with a highway contractor.

The West Virginia DOH payment to Alpha Natural Resources (ANR), which purchased the coal reserves and operations of NCI in 2005, was a function of the quantity of marketable coal recovered from overburden and spoil—or previously blasted—material. For every ton of marketable coal recovered, ANR gave West Virginia DOH a discount on the cost of excavation. The cost reduction, however, applied only to recovered marketable coal quantities between 1.5 million and 2.5 million tons.

An independent, third-party engineering firm developed baselines for the site before, during, and after construction to verify the accuracy of the excavation units for payment. The firm also verified other pay items, including linear feet of culvert installed, clearing and seeding acreage, cut-slope presplitting footage, and other ancillary items.

Benefits from the KCH

Construction of the KCH with a P3 has provided West Virginia DOH with invaluable benefits in cost and time savings; the southern portion of the state has received additional economic benefits. For example, coal dominates the economy of Mingo County, which has gained the following direct benefits:

◆ After the KCH roadbed construction was complete, a flattened parcel of land—a borrow site used by NCI for the construction of the roadway fills—was designated for the new Mingo County Central High School.

◆ West Virginia DOH agreed to place a 206-foot-long, 10-foot-diameter culvert beneath the KCH for future use as a tunnel crossing for the Hatfield–McCoy Trails, a system of more than 500 miles of recreational vehicle trails that has created 25 jobs and has pumped $7.7 million into the state economy. A cooperative effort with the Hatfield–McCoy Regional Recreation Authority, the tunnel crossing will be part of a planned 40-mile trail from Matewan to Gilbert; the Authority will take on future modifications, required safety measures, maintenance, and liability.

Working Model

The roadbed for the four lanes of the KCH Red Jacket Section has been completed. Two of the KCH lanes

Ground-level view of the King Coal Highway.

Photo: Mingo County Redevelopment Authority

and the five connector roads have been paved and have opened to traffic (see photograph, above). The opening of these roads with reduced construction time and costs could not have been achieved with conventional construction and contracting procedures.

Mingo County Central High School opened in August 2011.

Photo: Mingo County Redevelopment Authority

Other potential P3 agreements—for example, with CONSOL Energy for the 5-mile-long Buffalo Mountain Section of the KCH—are following the Red Jacket P3 model developed by NCI and West Virginia DOH. At least one neighboring state is looking to build corridors through mountainous coal country by applying the model: the Commonwealth of Virginia is establishing a P3 to build portions of the 51-mile-long Coalfields Expressway.

With the success of the initiatives like the Red Jacket Section, P3s are gaining momentum for financing infrastructure projects. A properly executed P3 can benefit the state, the industry, the market, and the community by providing faster and more cost-effective construction and enhancing economic stability.

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Automated Vehicle Technology

Ten Research Areas to Follow

ROBERT P. DENARO, JOHANNA ZMUD, STEVEN SHLADOVER, BRYANT WALKER SMITH, AND JANE LAPPIN

Automated vehicles are coming. The vehicles will operate without the real-time input of a human driver into the steering, acceleration, and braking, and with varying levels of driver monitoring in conditions ranging from limited roadway environments ultimately to all roads.

Potential benefits could include increased road safety, decreased energy costs, increased roadway capacity for vehicles, greater mobility for those who cannot currently drive, opportunities to improve land use, and new uses of commuting time. More than a dozen companies are now testing a variety of automated driving systems.

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Levels of Automation

The National Highway Traffic Safety Administration (NHTSA), SAE International, and a German expert group have defined multiple levels of automation to categorize the emerging and deployed technologies. These levels generally distinguish the technical necessity for—and the amount of—driver monitoring, as well as the road environments in which the vehicles can operate.

Some automation systems may operate only in limited environments, such as at low speed in congested traffic or only on highways; in contrast, a fully automated vehicle one day may operate on all roads, from rural unmarked roads to crowded city centers. Similarly, the need for monitoring by a human driver ranges from active monitoring of, and response to, changes in the driving environment to no involvement in monitoring or response—or even to having no identifiable human driver or steering wheel or pedals. Evolving from highly monitored operation in limited environments to the ultimate level is one of the great challenges in the development of automated vehicles.

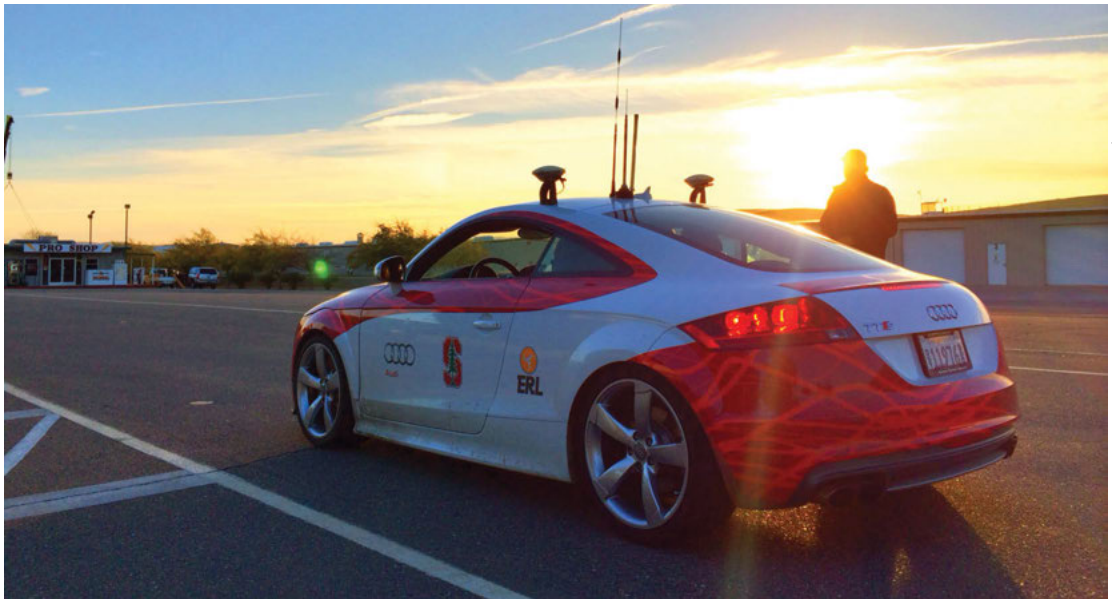

PHOTO: JOSEPH THORNTON, FLICKR

An automated car developed by Stanford University undergoes testing on a racetrack. Newer-model cars and trucks already come equipped with some automated technology; fully automated vehicles may not be far behind.

Photo: Nozilla, Flickr

Automated safety features in cars include Volvo's laser emergency braking systems.

Technological Developments

Key technological developments in vehicle operations have fueled the emergence of vehicle automation. Some vehicles already include adaptive cruise control and lane-keeping assistance, collision mitigation systems, automated parking assistance, predictive cruise control enabled by digital maps, driver attention warning systems, and adaptive headlights.

These features are possible with the development of advanced, affordable sensors, including the Global Positioning System (GPS) receivers, solid-state gyros and accelerometers, camera systems, radar, lidar, and ultrasonic sensors. Vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communications, which many experts believe are essential to vehicle automation, are emerging independently of the development of automated vehicles. NHTSA recently started a process to consider rulemaking that could mandate V2V communications on all new light-duty vehicles.

Automation extends beyond passenger cars—commercial and transit vehicles also have potential. Truck platoons, convoys of automated vehicles led by a professional driver, already have demonstrated significant gains in fuel efficiency. Automated transit vehicles may improve customer service, including potential door-to-door trips. The continued growth of ridesharing and shared-use vehicles depends in part on increases in vehicle automation.

Testing and Research

Federal and state governments are engaging with vehicle automation and connectivity. NHTSA released a "preliminary statement of policy concerning automated vehicles" in 2013. Florida, Nevada, California, Michigan, and the District of Columbia have enacted laws specifically to regulate automated driving, and other states are considering related bills. Most of these laws address testing for research and development, and policies for more general operation vary from outright prohibition to conditional affirmation.

TRB is contributing to the research agenda through several activities addressing connected and automated vehicles, including a series of workshops on the future of road vehicle automation. In 2012, TRB conducted an interactive workshop for industry, government, and academia in Irvine, California.

In 2013, TRB and Stanford University cosponsored a workshop on the challenges and opportunities related to the increasing automation of motor vehicles and the environments in which they operate. Government, industry, and academic experts convened from around the world to identify research needs and to advance research in a range of disciplines (see box, page 21). Following are the major topics and research questions from the workshop's breakout sessions; additional information is available at http://2013.vehicleautomation.org.

1 Human Factors and Human–Machine Interaction

Automated vehicles must be designed to fit drivers' capabilities, limitations, and expectations. The consideration of human factors is necessary to ensure safety, mobility, and sustainability.

◆ **Driver characteristics and acceptance.** How should drivers' needs for vehicle automation be identified? Should automation adapt to the individual user or to a user group? To what extent should drivers be allowed to personalize automated systems to accommodate tolerances for action and motion and to feel safe and comfortable? What information will other road users need about an automated vehicle, and how will other drivers become aware that a vehicle is under automated operation?

◆ **Function allocation.** How much time will a driver need to regain familiarity with the vehicle after

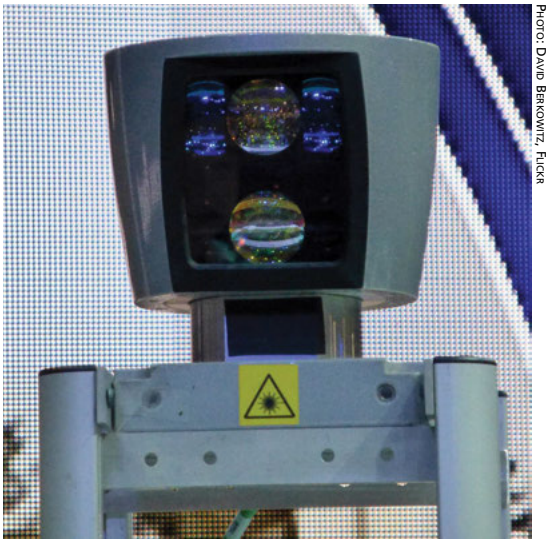

Photo: David Berkowitz, Flickr

The 2013 Consumer Electronics Show featured Toyota's automated car technology.

Authors' Note: This article summarizes key findings from the Transportation Research Board (TRB) Workshop on Road Vehicle Automation, July 16–19, 2013, in Stanford, California. The findings were reported in the *Synopsis of Proceedings* published by the Volpe National Transportation Systems Center (http://2013.vehicleautomation.org). That document also previews the issues to be covered in the program of the Automated Vehicles Symposium, July 15–17, 2014, in San Francisco, California (www.automatedvehiclessymposium.org).

disengaging the automated driving mode? How will a severe failure of the automation affect a driver's ability to resume actively driving?

◆ **Driver and vehicle interface design.** What feedback should drivers receive from the automation? How should driver takeover alerts be distinguished from collision-avoidance alerts?

2 Infrastructure and Operations

Automated vehicles have the potential to improve transportation operations and the efficiency of the transportation network.

◆ **Traffic management.** How will automation shift demand across the network? What role will traffic control devices—such as signals, signs, and pavement markings—play in support of automation?

◆ **Mapping and positioning.** What elements of mapping and positioning will be needed for automation, and what standards are required?

◆ **Infrastructure.** In what ways can infrastructure support vehicle automation functions? How will automation affect geometric design?

◆ **Accommodating mixed traffic.** How can nonautomated vehicles and travelers be identified in mixed traffic? How will regional agencies and operators decide on open or limited access for automated vehicles?

◆ **Managed lanes.** How much market penetration and what levels of automation will necessitate changes in system operations?

◆ **Impacts on long-range planning.** How should the impacts of automation be quantified, and how can long-range planning integrate the metrics? How should planning models be adjusted to accommodate disruptive technologies such as automated vehicles?

◆ **Value of connectivity.** Do core requirements need to be standardized into a baseline system to provide a social benefit? What are the roles of communications and connectivity?

3 Testing, Certification, and Licensing

Determining what should be done to protect the public safety when automated vehicles are deployed in traffic is paramount. National and possibly international consistency in the testing, certification, and licensing of automated vehicles will be necessary for these vehicles to thrive.

◆ **Testing.** What test-track and simulation trials are needed before automated vehicles can be tested on public roads by authorities or by manufacturers?

◆ **Certification.** What forms of certification are required, and who should administer the certifications? What documents should be required from developers to support claims of vehicle safety?

◆ **Licensing.** Will drivers need special training or licensing to operate automated vehicles? If so, how could the training be incorporated into driver licensing processes? Is a higher level of performance expected for automated driving systems than for human drivers, and how would this affect licensing tests?

Photo: Toyota UK

A driver reverse parks with the help of integrated parking assist. The interface between technology and driver is a subject of human factors research on automated vehicles.

4 Energy and Environment

When deployed on the roads in significant numbers, automated vehicles are likely to influence vehicle operations, vehicle design, traffic flow, trip and mode choices, vehicle ownership, choices of locations for activities, and ultimately, patterns of land use that will have substantial impacts on energy and the envi-

Planning Committee for the Workshop on Road Vehicle Automation 2013

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James Misener, Independent Consultant; Workshop Demonstrations Coordinator

Gregory M. Fitch, Virginia Tech Transportation Institute; Workshop Social Media Coordinator

Approximately 60 volunteers assisted in organizing the workshop.

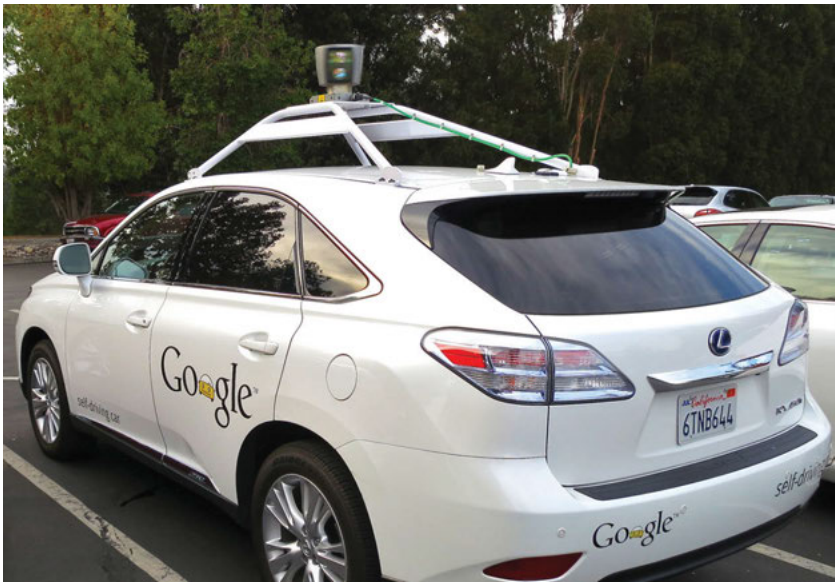


Photo: Steve Jurvetson, Flickr

Google retrofitted a Lexus RX450 with automated technology. New driverless designs may lead to lighter, more efficient vehicles.

ronment. The net effect on energy consumption and the environmental footprint of these vehicles remain uncertain and require systematic investigation.

◆ **Environmental impact.** What policies will encourage the development and deployment of automated vehicles specifically to gain the energy and environmental benefits? What interventions will be most cost-effective in reducing energy consumption and negative environmental impacts?

◆ **Vehicle design.** Could the innovations accelerate improvements in vehicle efficiency or the adoption of alternative drivetrains and fuels? Could improvements in safety and in on-demand and shared mobility services lead to smaller, lighter vehicle designs and operations?

◆ **System effects.** Could the reduced burden on the driver and the potentially productive use of in-vehicle time produce other behavioral responses, such as driving longer distances or shifting from public transportation to personal vehicles? What effects will latent and induced demand have on travel distances, energy consumption, and environmental impacts?

5 V2X Communications and Architecture

Although completely autonomous vehicles operating independently of any real-time communication with other vehicles, information systems, or infrastructure may be possible, automated vehicles likely will benefit from cooperative interactions, known as V2X.

◆ **V2X functions.** What V2X functions would be likely in automated vehicles? How might V2X reduce costs for sensors and extend a vehicle's perception range? How would V2X sensor range extension and the increased situational awareness benefit an individual car system and driver? How might V2X data improve a road system's efficiency and the stability of traffic?

◆ **Architecture.** What is the required system architecture, and who would operate the information network? What communication architectures could serve as models? How will standards and tools contribute to the deployment of the communications network?

◆ **Communications networks.** What are the requirements for data quality, quantity, and latency?

6 Automated Commercial Vehicle Operations

Commercial vehicle operations (CVO) apply intelligent transportation systems in the transport of goods and services. CVO is subject to specific government regulations and could be affected by more advanced levels of automation. A primary area of interest is platooning, which could enable drivers to relax and perform other tasks.

◆ **Technology.** What attributes determine the optimal sequence of trucks in a platoon? Are single trucks more suitable than combination trucks to lead the way in advanced automation?

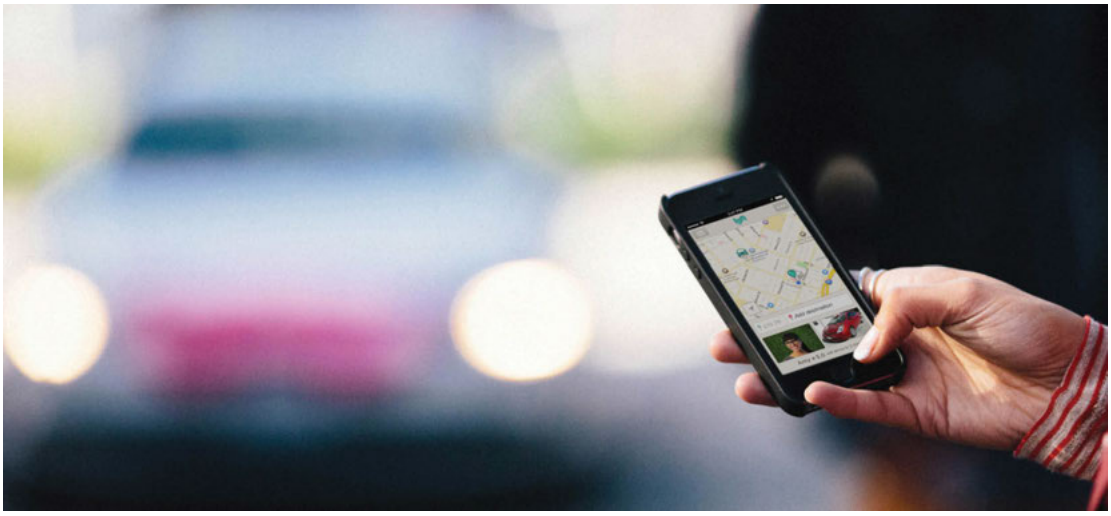
◆ **Automated CVO business case.** What CVO applications will benefit most from automation?

◆ **Policy and human factors.** What training and skills maintenance are necessary for automated CVO? Will higher levels of automation redefine driving time or introduce a new concept of hours of service?

Photo: Scania Group

An automated Scania truck platoon.

Photo: Lyft



A surge in smartphone-enabled ridesharing has opened a new avenue of public transportation.

7 Shared Mobility and Transit

Automation of road vehicles may create new models for public transportation. Information technology allows private vehicle sharing, community pooled cars, distributed rentals, and car pools that are arranged dynamically; these have begun to blur the distinctions between public transportation and private vehicles, and more blurring can be expected as automation increases among taxi services and bus fleets.

◆ **Exclusive guideway versus open road.** What are the trade-offs for exclusive infrastructure compared with the shared use of roadways?

◆ **Automation in transit.** What are potential near-term applications for transit, and what are the costs and benefits for deployment?

◆ **Hazards framework.** What would a standard hazards framework for automated transport safety look like?

◆ **Integrating automation and shared mobility into the urban fabric.** What are the implications of major vehicle automation for the built environment and institutional infrastructure? What are the spatial constraints or opportunities related to land use planning? How will automation affect the quality of life, architecture, and urban development? What are the public transit needs that automation may address? How does automation affect paratransit and public transit use, as well as walking and biking?

◆ **Assisting the mobility impaired.** What are the opportunities and challenges for automation in assisting those with impaired mobility?

◆ **Autoparking.** What are the impacts of automated parking? What problems does autoparking solve or create?

◆ **Performance measures.** Do current concepts of automation have unforeseen long-term consequences? What types of performance measures should be developed?

◆ **Alternatives analyses.** How might metropolitan planning organization agendas and National Environmental Policy Act processes change? What updates might be made to the Federal Transit Administration's *Characteristics of Urban Transportation Systems,* the standard guide for evaluating alternative systems?

8 Liability, Risk, and Insurance

The regulation of motor vehicle transportation, the adjudication of automotive lawsuits, and the provision of automotive insurance assume that a vehicle has a human driver. In addressing technologies that change the human role in driving, legislators, regulators, courts, and private entities must promote safety, encourage innovation, and ensure compensation to those who are injured—a difficult balancing act.

◆ **Safety risks.** How safe is reasonably safe, and will automated vehicles be held to a higher standard than a reasonable person? What are the likely legal implications of designing a vehicle that poses some foreseeable risks, including violating laws or harming others in certain circumstances?

◆ **Toolkit to address safety risks.** Might information about safety incidents from these technologies, including near-miss crashes, be centrally collected so that insurers can aggregate data? How might crash data be used in designing algorithms for risk assessment?

◆ **Role of insurance.** If exposure shifts from individual drivers to manufacturers and other companies, how might the insurance industry change? How will insurers quantify safety risks and financial risks? How might new insurance models evolve?

PHOTO COURTESY OF STEVEN SHLADOVER

A panel of automated vehicle developers discusses the implications of automation for the California industry in an interactive workshop held concurrently with the TRB workshop.

◆ **Policy Making.** How might restatements or model laws help clarify statutory and common law questions? What are arguments for and against the nationalization of insurance and tort law issues?

9 Cybersecurity and Resiliency

Automated vehicles depend on a digital infrastructure, and malicious attacks can undermine the benefits of vehicle automation. Cybersecurity, the measures taken to protect against unauthorized access or attacks, and cyberresiliency, the response and recovery in a crisis, are essential.

◆ **Architecture.** How does system architecture affect cybersecurity and resiliency, and do the architectural differences between autonomous and connected automated systems lead to different security challenges?

◆ **Risk and threat identification.** Do the public sector, private sector, and general public have different views of cybersecurity? How confidently can threats to the information security of vehicles and infrastructure be addressed?

◆ **Resiliency.** How can cybersecurity and resiliency be initiated, operated, and maintained while meeting standards of privacy and reliability? Can cybersecurity be ensured, or should resilience be engineered to cope with inevitable failures?

10 Data Ownership, Access, Protection, and Discovery

Automated vehicles require data for movement and gather data while moving. The deployment of automated vehicles will raise issues of data access, data ownership, privacy, and protection.

◆ **Data needs.** What data are needed to make an automated vehicle work, how long should these data be held, and how can they be disposed of or destroyed?

◆ **Ownership, access, and privacy.** Who owns and who manages the data, and are the data or metadata discoverable? What legal rights will the various users have to the vehicle's data?

◆ **Primary and secondary use.** Do the data have secondary value, beyond moving the vehicle? How much value do the data have and to whom? Who should have access to the data, and for what secondary uses?

Interdisciplinary Endeavors

The 2013 workshop was a success in the number and caliber of participants and in the sustained engagements during plenary, breakout, and ancillary sessions. The questions raised in this article are still being explored. Developments in vehicle automation require the careful, rigorous study of many interdisciplinary issues and concerns—this makes the research area interesting and challenging.

The next automated vehicles symposium, cosponsored by TRB and the Association of Unmanned Vehicle Systems International, July 2014 in San Francisco, will feature plenary and breakout sessions on key topics in automation (see sidebar at left). In addition, attendees will participate in automated vehicle demonstrations. Specialized meetings and workshops are scheduled for the days preceding and following the symposium.

Dramatic Improvements

Automobile manufacturers and government agencies are emphasizing the dramatic safety improvements that may be realized through vehicle automation. For this reason, NHTSA's public statements about these developments have been positive. Moreover, vehicle automation interests much of the public, with the popular media covering the topic almost daily. TRB is playing a key role by identifying and fostering research into all aspects—including the societal and environmental—of automated vehicles.

Automated Vehicle Symposium 2014

Breakout Sessions

- The State of the Art and Future Direction of Automated Vehicle Human Factors
- Truck Automation Opportunities
- Evolutionary and Revolutionary Pathways to Automated Transit and Shared Mobility
- Roadway Management and Operations with Automated Vehicles
- Regional Planning and Modeling Implications of Automated Vehicles
- Near-Term Connected and Automated Vehicle Deployment Opportunities
- Legal Accelerators and Brakes
- Traffic Control Devices
- Technology Roadmap, Maturity, and Performance
- Personal Vehicle Automation Commercialization

POINT OF VIEW

Who Is in Charge?

The Promises and Pitfalls of Driverless Cars

M. L. CUMMINGS AND JASON RYAN

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With the move toward driverless cars, including automated driving assistance in the short term, the appropriate levels of shared authority and what the interaction should be between the human driver and the automation remain open questions. How robust driverless cars may be against system failures—including human failures—and operating in degraded sensor environments is unclear; more principled research and testing are needed.

Automation on board vehicles is inherently brittle and can account only for what it has been programmed to consider. Communication between a technically complex system and humans with a varying range of driving and attention management skills is difficult, because the driver must be appropriately informed about the state of the system, including its limitations, and will need to build appropriate trust—neither too much nor too little—in the capabilities of the automation.

Further complicating the problem is that automated systems can lead to boredom, which encourages distraction, as a significant body of research has demonstrated. The operator therefore may be unaware of the state of the vehicle—leading to mode confusion—and may not respond quickly and appropriately in an accident. Over time, the degradation of operator skills as a result of automation can reduce the ability to respond to emergent driving demands and will likely lead to risk homeostasis—the increased tolerance of risk—even in normal operations.

PHOTO: STEVE JURVETSON, FLICKR

Automated cars will depend on a complex and changing interaction between technological systems and a human operator.

Tests and Design Considerations

These issues are well-known to the human systems engineering community, but it is unclear whether driverless car designers are considering these issues or whether manufacturers are conducting appropriate human-in-the-loop tests with representative members of the driving population. Until tests show that the vehicles account for these issues, driverless cars will not be safe for unrestricted access and use on U.S. roadways.

Moreover, significant sociotechnical considerations do not appear to be a concern in the push to introduce this technology on a wide scale. The utilitarian approach, quoted by many in the press, is that driverless cars eventually will kill people, but that this is acceptable because of the likely reduction in total deaths. Nonetheless, the likelihood of a reduction is not yet proved. The utilitarian approach demonstrates insensitivity to a deontological perspective—that is, to moral obligations—which causes many people to be uncomfortable about a significant shift of responsibility and accountability from humans to computers.

Driverless or Driver Optional?

Driverless car technologies in development include the ability to navigate roadways, change lanes, observe traffic signals, and avoid pedestrians, without human input. These technologies require Global Positioning System (GPS) information, internal navigation maps, outward-facing cameras, and possibly the use of laser and other range-finding systems—the specifics of the systems vary by company.

The first two of these technologies allow the vehicle to understand where it is in the world, where it should be going, and how to get there; the latter two allow the vehicle to track where it is on the road and where other vehicles, traffic indicators, and pedestrians are. The active cruise control (ACC) systems now in some vehicle models are early forms of this technology; this limited form of autonomy can serve as a forerunner to more advanced systems.

Although termed driverless, the vehicles are better classified as driver optional, particularly under the National Highway Traffic Safety Administration's (NHTSA's) Levels 2 and 3 of automated driving, in which human operators have either primary or secondary control responsibilities (*1*). Although these vehicles supposedly are capable of driving in any traffic situation without requiring the human driver to apply pressure to the pedals, shift, or steer, the driver still may choose to do so and may play a role in avoiding crashes.

In the distant future, the driver will not be needed; the current autonomous driving systems, however, require a human to be in the driver's seat and allow and—in some cases, expect—the driver to assume control at specific points. This is the problem: as long as a human operator has some expectation of shared authority—whether primary or secondary—the design of the automation must ensure that the operator fully understands the capabilities and limitations of the vehicle, maintains full awareness of what the system is doing, and knows when intervention might be needed. Failure to do this may lead to a variety of automation- and human-induced crashes.

Interacting Weaknesses

Google's driverless cars already have logged more than 300,000 miles, with two reported crashes (*2*). One occurred when the car was traveling under manual control on roads not previously mapped into its system (*3*). The actual causal chain is disputed, but the event illustrates the brittleness of automation—the car may not be able to handle uncertainty in its internal model, and this can be exacerbated by human error.

These problems are aggravated by an inherent human limitation known as neuromuscular lag—even when paying attention perfectly, a person experiences a lag of approximately one-half second between seeing a situation develop and taking a responsive action. Instances of human error like this are not the fault of the human alone but of the interaction between the human and the automation and

Photo © Volvo Car Group, Public Affairs, SE-405 31 Gothenburg

Test equipment for a Volvo prototype of autonomous driving support technology includes radar sensors and a camera to control speed, brakes, and steering to help a driver stay in the lane and follow traffic flow.

the weaknesses of each—the human's imperfect attention and execution of a response and the automation's brittleness in perception and in generating a solution.

Although computing reliable accident statistics would be premature, if driverless cars could sustain this crash rate, they would be an improvement over teenage drivers. According to the Insurance Institute for Highway Safety, teenagers are three times more likely to have a crash than drivers age 20 or older.

Lessons from Aviation

The driverless car community can look to aviation for lessons learned from the introduction of automation to relieve pilot workload and—in theory—improve safety. Since the introduction of increasing automation in flight control and navigation systems in the mid-1970s, the accident rate in commercial jet operations has dropped from approximately 4 per million departures to 1.4 (*4*).

Automation has been key in reducing this accident rate. Nevertheless, many accidents labeled as human error by the Federal Aviation Administration (FAA) and the National Transportation Safety Board would be better categorized as failures of human–automation interaction. These include the following examples:

◆ A faulty indicator light that appeared on final approach caused the 1972 crash of Eastern Airlines Flight 401. Distracted by the disagreement between the warning light and other gauges, the crew failed to notice that the autopilot had been disengaged accidentally. No alert or warning notified the pilots, who focused on the indicator problem and failed to notice that the aircraft was descending steadily into the Everglades.

◆ Air France 447, which crashed off the coast of Brazil in 2009, involved two failures: failure of the automation and a failure of the displays to present information to the operator. A clogged pressure sensor caused the autopilot system to act as if the altitude of the airplane was too low. The autopilot put the aircraft into an increasingly high climb, eventually triggering the stall warning alert. With the aircraft on autopilot, the pilot was distracted and was not fully engaged in monitoring the aircraft; this is a common occurrence. When the stall warning activated, the pilot was not aware of what was happening and made the worst of all possible decisions—he attempted to increase the aircraft's climb angle, which worsened the stall and contributed to the crash.

◆ Northwest Flight 188 overshot Minneapolis, Minnesota, by roughly an hour in the fall of 2009 as a consequence of operator boredom and resultant distraction. With the aircraft on autopilot, both pilots became distracted by their conversation and failed to monitor the aircraft and its status. As they opened their laptops to obtain information to supplement their conversation, they misdialed a radio frequency change, missed at least one text message sent by air traffic control inquiring about their location, and only realized what was occurring when a flight attendant asked about the landing time. Luckily, the result was only a late landing; more severe consequences could have occurred.

Photo: Roberto Maltchik, TV Brasil

Wreckage of Air France Flight 447, which crashed in May 2009 off the coast of Brazil, is returned to land at the Port of Recife. The pilot had become distracted and was not monitoring the aircraft while it was on autopilot, leading to a series of actions that stalled the plane and led to the crash.

Attention and Distraction

These issues are common to many other domains involving human interaction with automated systems and are well known to the human systems engineering and experimental psychology communities. In general, the research community agrees that human attention is a limited resource to be allocated, and that the human brain requires some level of stimulus to keep its attention and performance high.

Without this input, humans seek it elsewhere, leaving them susceptible to distraction by either endogenous or exogenous factors. Operators may miss important cues from the automation or from the environment—as in Eastern Flight 401; or they may see the cues but not have all of the information required to make a correct decision—as in Air France 447; or they may use their spare capacity to engage in distracting activities, leading to a loss in situational awareness—as in Northwest Flight 188. An operator also may enter a state of mode confusion and make decisions believing that the system is in a different state than it actually is.

Although these examples and research come from aviation, the role of a pilot monitoring an aircraft autopilot system is similar to that of the human driver in a driverless car. Recent research in human–automation interaction has expanded to automated driving systems and is showing the same

Point of View presents opinions of contributing authors on transportation issues. Readers are encouraged to comment in a letter to the editor on the issues and opinions presented.

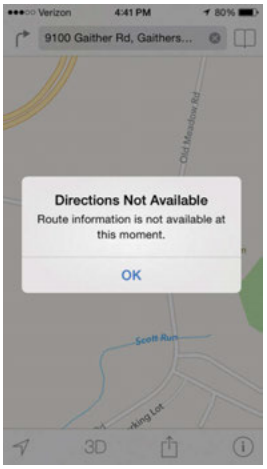
Photo: SARTRE Project, European Commission

Studies on human interaction with automated systems have shown that human attention is limited and distraction common when automation is active.

effects (*5, 6*). Drivers in an autonomous or highly automated car were less attentive to the car while the automation was active, were more prone to distractions, especially to using cellular phones, and were slower to recognize critical issues and to react to emergency situations, for example, by braking.

In tests, automated systems used at lower average speeds and with greater separation between vehicles yielded benefits, but at the cost of poorer performance by humans in emergency situations (*5, 6*). In other words, when the automation needed assistance, the operator could not provide it and may have made the situation worse. The operator cannot be assumed to be always engaged, always informed, and always ready to intervene and make correct decisions when required by the automation or the situation. This applies to highly trained pilots of commercial airliners, as well as to the general driving population of the United States and other countries, who receive little to no formal training and assessment.

GPS is essential to help automated vehicles determine routes; if a signal is lost, the vehicle may not function correctly.



Technology Robustness

Much of the development of driverless cars is proprietary, and the exact capabilities of the technologies are not known. This prevents definitive statements about a specific vehicle, but not comments on the limitations of the technology overall or specific questions of concern. Google's autonomous car—generally regarded as the most advanced—relies on four major technologies: lidar, or light detection and ranging; a set of onboard cameras; GPS; and maps stored in the vehicle's onboard computer. The GPS signal tells the car where it is on the stored map and where its final destination is, and from this, the car determines its route. Cameras and lidar help the vehicle sense where it is on the road, where other vehicles are, and where to find and follow stop signs and streetlights.

Each of these systems is vulnerable in some way, and the extent of redundancy is not known, or whether the car will function correctly if any one of the four systems fails. If the GPS or maps fail, the car does not know where it is on its route and where it should be going. If the lidar fails, it may not be able to detect nearby vehicles, pedestrians, or other features. If the cameras fail, the vehicle may not be able to recognize a stop sign or the color of the traffic light. Also not clear is how much advance mapping and how often map updates are required to maintain an effective three-dimensional world model by which the onboard computer makes decisions. Moreover, GPS signals can be unreliable in urban canyons in which tall buildings, tunnels, and other forms of structural shielding cause a lost or degraded signal.

Flaws in the Systems

The security of GPS is questionable. Spoofing or mimicking a GPS signal to provide false location information, as well as jamming or forcibly denying a GPS signal, has been observed by the U.S. military (*7, 8*) and in civilian applications (*9*). An individual or group of individuals spoofing GPS signals in major metropolitan areas during rush hour, for example, could force cars off the road, into buildings, or off bridges, or could cause other damage.

Google's researchers admit that they have yet to master inclement weather and construction areas (*2*). Precipitation, fog, and dust create problems for lidar sensors, scattering or blocking the laser beams and interfering with the image detection capabilities of the camera. As a result, the vehicle is unable to sense the distance to other cars or to recognize stop signs, traffic lights, and pedestrians.

Other research has noted that the technology cannot currently handle construction signs, traffic directors—a task that requires sophisticated recognition of gestures—and other nonnormal driving conditions (*2*). A related question is how well the system can anticipate the actions of other drivers; avoiding a car calmly changing lanes is entirely different from anticipating the actions of a reckless and irrational driver. Previous research has shown that people are prone to distraction; any failures or degradations in a technology that requires monitoring by humans will increase the likelihood of a serious or fatal crash significantly.

Trust and Skill Degradation

How drivers adapt to the presence and performance of the automation is not a trivial issue. If the automa-

Photo: Virginia DOT

Current automated vehicle technology is not capable of interpreting hand signals and movements of traffic directors and road workers during temporary road work and other irregular traffic conditions.

tion is perceived to be unreliable or not proficient, then the operator refuses to use the system, despite the potential benefits. When automation is perceived as proficient, however, operators rely more heavily on the technology and fail to use their own skills. This leads to a loss of skill and increases reliance on the automation, possibly leading back to mode confusion, as discussed earlier.

Skill degradation from overreliance on automation is a problem in aviation; FAA recently released a safety notice recommending that pilots fly more often in manual mode than with the autopilot. Risk homeostasis is another possible concern—drivers perceive the automation to be more capable and begin to accept more risk; this leads to increased distraction and overreliance on the automated system.

Research into ACC systems already has observed some of these concerns. The 2014 Jeep Grand Cherokee owner's manual states that ACC "is a convenience system…not a substitute for active driving involvement," and the *BMW Technology Guide* notes that "the system is not intended to serve as an autopilot" (*10*). Nevertheless, studies addressing public knowledge of the capabilities of ACC systems show that the public is not fully aware of the limitations of the technology and has a poorly-defined sense of when to trust the autonomy and when driving should be a manual operation. In a series of experiments, many drivers displayed riskier behavior when given the ability to use the limited autonomy of ACC systems, including the failure to shut off the automated systems when conditions were not suitable (*5*).

Providing appropriate feedback to the operator on the performance of the operator and of the automation is crucial to mitigate these problems, but designing a system for appropriate trust is a challenge (*11*). The automation should be capable of describing its performance and its limitations to the driver, who should then be able to learn how best to use the automation in the course of driving. The automation also should be able to sense when the human operator is performing poorly, or even dangerously, so that it can either support the driver or take control. The end result is more of a partnership—each side understanding and accounting for the abilities and limitations of the other.

Sociotechnical Considerations

A common argument in favor of inserting driverless car technology as soon as possible is that accidents and fatalities will be reduced dramatically. According to Google's Sebastian Thrun, "more than 1.2 million lives are lost every year in road traffic accidents. We believe our technology has the potential to cut that number, perhaps by as much as half" (*12*). Although a logical argument in keeping with rational decision-making theory, such a utilitarian approach is not universally shared. A deontological approach could assert that machines should not be allowed to take the lives of humans under any circumstances—which is similar to one of the three laws of robotics drawn up by author Isaac Asimov.

A lower fatality rate is not a guarantee with autonomous cars, particularly at NHTSA Levels 2 and 3, but if the fatality rate is lower than that with human-operated vehicles, the killing of a human by a machine, even accidentally, will not resonate well with the general public. Recent intense media and public campaigns, for example, have protested autonomous weaponized military robots. Similar issues are likely to be raised if driverless or driver-assisted technology is responsible for a fatality or a serious accident that receives intense media attention.

Furthermore, the chain of legal responsibility for driverless or driver-assistive technologies is not clear, nor is the basic form of licensure that should be

Drivers may overrely on an automated system and fail to shut it off and take control when necessary.

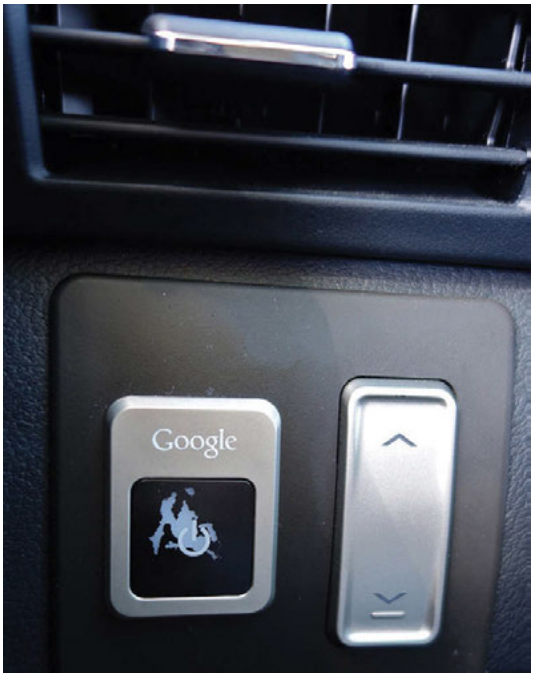


Photo: Steve Jurvetson, Flickr

required for operation. Manufacturers of driverless technologies and the related regulatory agencies are responsible not only for considering the technological ramifications but also the sociotechnical aspects, which have not been addressed satisfactorily.

Tenuous Transition

Driverless car technology promises potentially safer and more efficient driving systems, but many questions remain. The robustness of the technology and the interaction between the human driver and the driverless technology are unclear. Boredom and distraction, mode confusion, recovery from automation errors, skills degradation, and trust issues are major concerns and have been observed in experimental and real-life settings. Solutions to these problems will come through proper design, supplemented by extensive testing to confirm that the solutions are having the intended effect.

Manufacturers have not provided any documentation, including extensive, independent, and principled testing, describing how their designs have addressed these issues. Moreover, these issues lie outside the typical tests that regulatory agencies perform in assessing safety. Until these issues have been addressed through independent human-in-the-loop testing with representative user populations, these vehicles should remain experimental. Public- and private-sector organizations alike should develop testing programs, as well as programs to test the reliability and robustness of the core technologies such as GPS and lidar, and should set requirements for driver training, continuing education, and licensure related to these vehicles.

The development of driverless car technologies is critical for the advancement of the transportation industry. The majority of the promises and benefits will likely only be realized when all cars are equipped with these advanced technologies, enabling NHTSA's Level 4 of fully autonomous driving. This is a tenuous period of transitioning new and unproved technologies into a complex sociotechnical system with significant variation in human ability.

In addition, public perception can become a major but surmountable obstacle. Great care should be taken, therefore, in experimenting with and implementing driverless technology—an ill-timed, serious accident could provoke unanticipated public backlash, which also could affect other robotic industries.

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SIGNALS

A Note About Programming Research Funding

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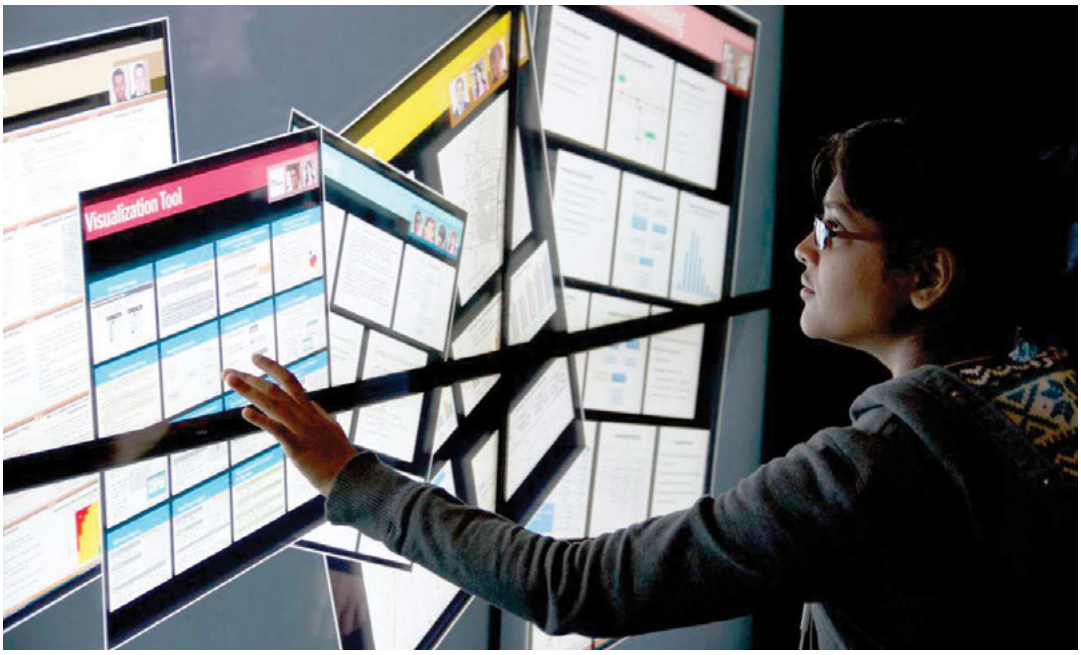


PHOTO: CENTER FOR TRANSPORTATION RESEARCH, UNIVERSITY OF TEXAS AT AUSTIN

(*Photo above:*) Research funding must support the innovation process—development, testing, technology transfer—as well as research activities themselves.

SIGNALS is an occasional column featuring insights and commentary from transportation leaders to stimulate discussion on topics related to research, practice, and policy. Reader response is encouraged in the form of letters to the editor.

Allocating funds to support research is a formidable task for the public agencies that fund transportation research and for the legislative bodies that oversee the agencies. The funds not only must be spread across an array of topic areas in science, engineering, and the social sciences, but also must be assigned to various types of research, development, and technology transfer activities, to maximize the positive effects for users and for the delivery of transportation services. This task is particularly challenging when public decisions are expected to be evidence-based and subject to after-the-fact performance measurement.

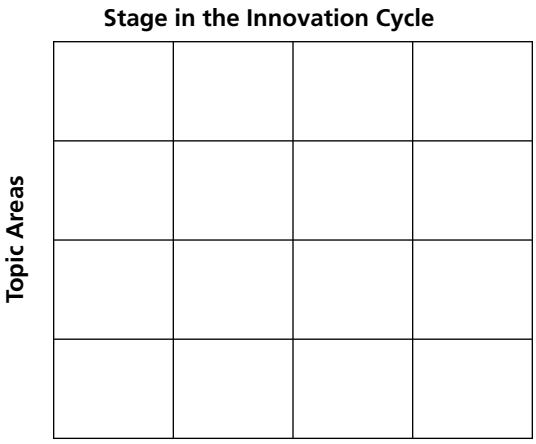
Within a given topic area—for example, bridge engineering or travel demand forecasting—researchers and practitioners working collaboratively can identify research needs and opportunities and can make consensus judgments about priorities. This is part of the mission of the standing technical committees of the Transportation Research Board (TRB). Establishing priorities across topic areas, however, is far more complicated. Few researchers and practitioners, if any, can claim to grasp the technical opportunities across the full range of science, engineering, and social sciences that research might fruitfully pursue.

Scope and Complexity

Available funds also must be programmed to specific types of research—for example, long-term, high-risk, high-payoff research and short-term, problem-solving research—as well as to development, pilot testing, and technology transfer. In other words, research funding must support more than research and must extend to the range of activities that comprise the innovation process. Research is a means to an end, and the work necessary to move promising research results into routine practice must be taken into account.

Conceptually, this programming problem could be approached in terms of a two-dimensional innovation matrix, with topic areas as one axis and activities or stages in the innovation process as the other. Each cell would represent a specific combination of a topic area, such as pavement design, and a stage in the innovation process, such as incorpo-

FIGURE 1 Sample innovation matrix for programming and mapping research investments.



rating research results into specifications and design aids. This matrix formulation is presented principally to illustrate the complexity of allocating research funds in a rational manner, not to serve as part of a proposed method for programming research. The formulation, however, may be helpful to visual thinkers and, in a simplified form, may serve as a mapping exercise to examine how funds are currently allocated.

The task remains—how should agencies and legislative oversight bodies program funding across topic areas and stages in the innovation process? On the one hand, this question seems almost intractable. On the other, agencies and legislative bodies make programming decisions year after year. The decisions may be far from optimal, but the research programs and other innovation activities proceed accordingly. Perhaps a sensible middle ground would be to proceed more intentionally and deliberatively in deciding on programs, with a view to incremental, evolutionary gains in effectiveness.

Following are four ways to look at funding allocations for research and innovation that may help in making incremental improvements.

The author (*center*) participates in discussion of research directions at a meeting of the American Association of State Highway and Transportation Officials (AASHTO) Standing Committee on Research, with (*left to right*) John Halikowski, Arizona Department of Transportation; Christopher Jenks, TRB; Jim McDonnell, AASHTO; and Michael Trentacoste, Federal Highway Administration.

1. Alignment with agency goals, plans, and needs.

Agency goal statements, such as "improve customer service," are often too imprecise to be of much help in programming research funding. Exercises that match agency research activities to broadly stated agency goals purport to show that the research program is in alignment with the goals. Nonetheless, these exercises are seldom useful in making choices about the content and funding of research activities.

Taken together, agency goals, needs statements, and strategic plans can be expected to identify the opportunities and challenges that an agency faces and how the agency hopes to address them. Logically, an agency's research program should align with these plans. After all, developing and applying innovations is one way an agency can address its challenges and exploit its opportunities. For operating agencies, innovation can be a workaround for constraints in funding.

Specifically, the how—the proposed action steps in a strategic plan—can point the way to research and other innovation activities and can assist in selecting the specific components of a research program. Associated with research is a legitimate "maintenance of effort" issue, with specialized laboratories, equipment, and research talent; strategic plans may not cast their nets broadly enough to cover all valuable agency research. Nonetheless, examining the link between agency plans and the research program can help identify appropriate course corrections for research and will raise questions that should be answered in a meaningful way.

2. Context.

Research investments also should fit the context in which they are made. Context is shaped by a variety of factors, such as the scale of the organization; the type of organization—such as an operating, funding, or regulatory agency; the available or potentially available funding; the research capabilities in-house or accessible elsewhere; the presence or absence of complementary research programs; and the connections with other transportation organizations.

Whereas the alignment between research investments and an agency's goals and plans can be especially relevant to the selection of topic areas, the consideration of context can be particularly helpful in selecting the research innovation activities that are most appropriate. For example, facing the day-to-day challenges of delivering transportation services, an operating agency may conclude that it needs to focus scarce resources on shorter-term, problem-solving research and technology transfer activities that identify and promote promising research results

and technologies from other sources.

National agencies and programs can take a broader perspective in looking at systemic problems across many operating agencies. Arguably, national agencies are better positioned to undertake longer-term research and research with higher risks and potential rewards. At an international level, the wealthy, industrialized countries can support a full range of innovation activities by transportation research programs. Developing countries, however, may be better served by emphasizing the critical assessment of technologies and methods from other countries and by promoting the technologies and methods that are most appropriate to their circumstances. With limited resources, an emphasis on long-term research would be impractical.

Operating agencies will be—and should be—primarily concerned with research and innovation activities that serve their specific needs. National agencies, with their broader perspectives, not only have the latitude for a longer-term view but are best positioned to identify and help fill gaps. For instance, where does responsibility lie for promoting innovation on the transportation networks operated by counties, towns, and cities, which generally have little or no formal research and innovation programs? National transportation agencies working with states could see this as a part of their mission.

Although context may be especially helpful in choosing where to invest in the innovation process, it may also be helpful in selecting topic areas for research. If other agencies and research institutions have some topics well covered, an agency's focus should shift to topics that are less well covered. Considering context with respect to innovation activities and topic areas will help promote a pragmatic approach to the allocation of research funding that in turn should increase cost-effectiveness.

3. Balance across topic areas and stages in the innovation process.

Aligning research and innovation activities with an agency's plans, as well as with contextual considerations, will limit the scope of the agency's research and innovation activities and help avoid any tendency to be overly and inefficiently comprehensive. Nonetheless, agencies and research organizations should review their programs, and complementary programs elsewhere, with regard to balance.

Balance means that important and emerging topic areas are being meaningfully addressed, that both short- and longer-term approaches are being pursued, and that appropriate activities are in place to develop promising research results and to transfer the findings into practice. No single agency is responsible for fulfilling the balance requirement on its own, but in the aggregate with other agencies. Ideally each agency should understand where its programs fit into the broader scheme and work with other agencies and research institutions to ensure that, at a national level, when all programs are considered, the entire enterprise is appropriately balanced.

Photo: Transportation Technology Center Inc.

Innovation can be incorporated into a research agency's strategic plan. (*Above:*) Transportation Technology Center, Inc., conducts research into phased-array ultrasonics—with an inspection beam that can be steered and focused without reorienting the probe—to find flaws in the railhead or web.

4. Stakeholder involvement and engagement.

Making decisions about funding allocations for research and innovation involves more than picking the best or most appropriate topic areas and activities. How the decisions are made is important. Engaging stakeholders in the process not only provides the input necessary for decision makers to make better decisions but also promotes the commitment and buy-in necessary for the development and implementation of promising results.

A variety of people, groups, and organizations are

Photo: WarrenU, Wikimedia Commons

Newmark Civil Engineering Lab at the University of Illinois. Considering the context of research investments can help organizations to serve the needs of their communities and customers in the long term.

The Safety Data, Analysis and Evaluation Committee met at the TRB 2014 Annual Meeting to determine future research activities. Researchers must be engaged in the funding decision process.

PHOTO: RISDON PHOTOGRAPHY

stakeholders in the process, but two stakeholder groups should be involved routinely. First are the agencies and their staffs, along with their private-sector partners, that are responsible for constructing, maintaining, and operating the transportation infrastructure. These stakeholders are most in tune with the day-to-day challenges of delivering transportation services. They have the most immediate contact with users, and they must embrace new technologies and innovations for implementation to succeed.

The second stakeholder group is the researcher community. Researchers can help frame research topics and provide insights about the appropriateness of various approaches. In addition, researchers—including those who work outside of transportation—can identify new and emerging scientific findings and technologies that may have important applications in transportation.

Both of these stakeholder groups should provide advice in varying degrees throughout the research and innovation process. The operating agencies—

Assessing Highway Research and Development Priorities

WALTER E. DIEWALD

The Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) provided a substantial increase in funding for research, development, and technology (RD&T) activities. The act provided for a continuing, independent assessment of the RD&T program of the Federal Highway Administration (FHWA) and the development of broad-based priority research recommendations.

FHWA began discussions with the American Association of State and Highway Transportation Officials (AASHTO) and the Transportation Research Board (TRB), and asked the National Academies, through TRB, to convene the Research and Technology Coordinating Committee (RTCC). Funded by FHWA, the committee has provided a continuing, independent assessment of FHWA's RD&T program since 1991.

The RTCC membership rotates regularly and includes officials from state departments of transportation (DOTs) and metropolitan planning organizations (MPOs), university researchers, highway contractors, consultants and suppliers, highway users, and environmental and highway safety specialists.

The RTCC has addressed a variety of topics, some at the request of FHWA and others selected by the committee in consultation with the agency. Of particular interest to the committee is the structure and funding of highway RD&T; the setting of RD&T priorities; the way that the various highway research programs are coordinated and interact; and how technology transfer is organized so that highway agencies use the research products effectively and efficiently in building, operating, and maintaining the nation's highways.

The author is past Senior Program Officer for the second Strategic Highway Research Program and for TRB's Studies and Special Programs; he served as study director for the Research and Technology Coordinating Committee and was a longtime member of the TR News *editorial board. He retired at the end of March 2014, after 24 years at TRB.*

The Research and Technology Coordinating Committee reviews the highway research, development, and deployment efforts of the Federal Highway Administration.

Highway RD&T Characteristics

In the course of its work, the RTCC has noted several characteristics of the highway RD&T endeavor that set the context for decisions about the federal highway RD&T program. These include the following:

◆ *Many stakeholders.* Although state DOTs and MPOs are principal customers and users of FHWA-sponsored research, highway RD&T has many other stakeholders because of the way that the highway system is built, maintained, and operated; the public nature of highway ownership; the multiple users of the system; and other factors.

◆ *One program among many*. The federal highway RD&T program is one of the largest programs funding highway RD&T; others of note include the University Transportation

that is, the operating personnel within the operating agencies—must be increasingly involved as the process gets closer to short-term research, development, and technology transfer. Researchers, however, may have the most to offer earlier in the process, providing advice on longer-term research and the potential adaptation of new scientific findings and technologies from other fields. Together, these perspectives will help agencies at all levels shape research programs that are sensitive to current problems, attentive to the long-term promise of new technologies, and mindful of the efforts required to develop and implement promising research results.

Understandable Rationale

Examining research and innovation funding allocations in these four ways is not a panacea to produce an optimal program. Although these considerations may help point the way to quantitative performance measures for research and innovation activities, they will not readily produce such measures. What this approach will do is help provide a better, more understandable rationale for research investments and promote investments that will be more cost-effective in the long term.

Acknowledgment

The work of the TRB Research and Technology Coordinating Committee and its discussions have been instrumental in shaping the author's views about research organization and priority setting (see sidebar, page 34).

Centers Program, the RD&T programs of the individual states, and pooled-fund research programs such as the National Cooperative Highway Research Program. Moreover, programs outside the highway field have become increasingly important to highway infrastructure.

◆ *Barriers to innovation*. The structure and governance of the highway transportation system is a complex and multilayered, public–private activity with many barriers to innovation, including a low tolerance for risk in the public sector. Technology transfer, therefore, is fundamental to the success of FHWA and state RD&T programs.

◆ *Important federal role*. The federal role in highway RD&T is vital to highway innovation. Only the federal government has the resources to undertake and sustain high-risk, potentially high-payoff research and the incentives to invest in long-term, fundamental research. FHWA also can identify and fill gaps in highway research that other highway RD&T programs have not addressed.

Advice and Guidance

The RTCC has prepared numerous letter reports to FHWA and has published several book-length studies on highway RD&T for wider audiences. Key publications have included the following:

◆ TRB Special Report 244, *Highway Research: Current Programs and Future Directions*, (1994) documented the state of highway RD&T for the committee and formed a baseline for later discussions.[1]

◆ TRB Special Report 256, *Managing Technology Transfer: A Strategy for the Federal Highway Administration* (1999), addressed the need for a systematic strategy for FHWA's technology transfer efforts.[2]

[1] www.trb.org/Publications/Blurbs/153308.aspx.
[2] www.trb.org/Publications/Blurbs/152249.aspx.
[3] www.trb.org/Publications/Blurbs/153339.aspx.
[4] www.trb.org/Publications/Blurbs/160405.aspx.

◆ TRB Special Report 261, *The Federal Role in Highway Research and Technology* (2001), helped lead to the establishment of FHWA's Exploratory Advanced Research Program.[3]

◆ Special Report 295, *The Federal Investment in Highway Research, 2006–2009: Strengths and Weaknesses* (2008), guided Congress in making important reforms that were adopted in the current surface transportation authorization, Moving Ahead for Progress in the 21st Century.[4]

The committee continues to provide advice and guidance to FHWA as the environment for federal research changes with reductions in highway programs, fewer restrictions on how states can use federal highway funds, and the increasing need for new technologies to address problems caused by the heavy use, congestion, and deterioration of facilities. Nevertheless, as the committee has noted, "Every member of the RTCC views research, technology, and innovation as essential for thriving in today's world and for meeting such challenges as addressing the congestion and air quality problems of our urbanized areas, using communications technologies and new materials to make highway transportation safer and more efficient, and reexamining the role highways play in the multimodal transportation system of the 21st century."

NCHRP REPORT

Automated Enforcement for Speeding and Red Light Running

REBECCA FIEDLER AND KIM ECCLES

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Speeding and red light running are traffic violations that cause significant problems for highway safety. Both violations are major contributors to fatal crashes:

◆ According to the National Highway Traffic Safety Administration (NHTSA), speeding was a factor in almost one-third of all fatal crashes nationwide in 2011 (*1*).

◆ In crashes that involved red light running in the United States in 2011, 714 people were killed, and an estimated 118,000 were injured (*2*).

Enforcement, however, can be effective in preventing both of these dangerous driving behaviors. States and local agencies can use automated enforcement to reduce the prevalence of excessive speeding and red light running and can improve roadway safety for all users.

Agencies that operate successful automated enforcement programs provide valuable models. By understanding what makes a program successful, other agencies can improve or start their own programs. The National Cooperative Highway Research Program (NCHRP) has published NCHRP Report 729, *Automated Enforcement for Speeding and Red Light Running,* which examines successful automated enforcement programs and explores the factors contributing to success; the report also describes and draws lessons from the experiences of programs that were not successful (*3*). The research project performed a comprehensive assessment of automated speed and red light running enforcement activity in the United States and Canada.

Digital photo radar vans—above, in Portland, Oregon—are among the enforcement techniques explored in NCHRP Report 729.

Effective enforcement of laws against speeding red light running can decrease injurious crashes and increase road safety.

PHOTO: AAA FOUNDATION FOR TRAFFIC SAFETY

Guidelines for Success

The guidelines presented in NCHRP Report 729 span the initiation and operation of an automated enforcement program that will enhance safety, garner public support, adequately use resources, and have a strong legal foundation. The guidance applies both to agencies that currently have programs and to those interested in starting a program. The following provides a brief overview of the guidelines.

Problem Identification

The first step is to determine if a traffic safety problem exists and to confirm that red light running or speeding is causing crashes. This helps the stakeholders establish a communication strategy to help the community understand the problem and the

potential solutions. Jurisdictions should rule out other contributing factors that may increase the occurrence of violations, such as improperly timed traffic signals or limited sight distance, because these may require countermeasures other than enforcement.

Planning

Before installing or deploying a system, a jurisdiction must undertake several planning steps to establish an automated enforcement program. The planning stages are critical to the success of the program. First, a jurisdiction must obtain authorization; the enabling legislation varies from state to state. Next, determine the lead agency and the other entities that should be involved.

A variety of groups within an agency or department of transportation can operate an automated enforcement program, but the police department is recommended for the role of lead agency. Because the camera programs are a function of enforcement, this logical organizational structure has proved successful for many programs, particularly in collaborating with other agencies within the jurisdiction.

Although one agency should lead the automated enforcement effort, many jurisdictions involve several agencies in the development and management of the program. The other agencies should be able to contribute their perspectives and concerns early in the process, to ensure a truly collaborative approach to reducing speeding and red light running. Agencies that should be involved in the planning and operations of the program include the police department, the traffic engineering department, the department of motor vehicles, and the court system.

Photo: Wayan Vota, Flickr

A police officer uses a speed gun to enforce traffic laws in Washington, D.C.

In Portland, advance warning signs of photo enforcement are posted at city limits. Informing the public is a crucial step in implementation.

Creating an enforcement program within a jurisdiction may necessitate the establishment of a new traffic unit or the hiring of personnel to oversee the program. This will depend on the size of the program and the lead agency. Agency personnel will be needed to manage and oversee the program, as well as to respond to public and media requests for information.

The agency should maintain control of the program and not delegate management and oversight to the vendor or contractor. Nonetheless, the agency should take advantage of the expertise and resources of private company personnel. This balance will affect the agency's staffing.

Informing the Public

Informing the public about the program is key, particularly about the location of the camera installations, the process for adjudication of citations, and the use of the revenue, as well as how the program will be evaluated in terms of its effect on violations and crashes. A warning period before the full implementation of an automated enforcement program, in conjunction with a comprehensive public information campaign, has proved effective.

During the warning period, which should last at least 30 days, the jurisdiction operates the cameras and sends warning notices in lieu of citations. The warning period also allows the lead agency to work out any glitches in the system before citations are issued.

Photo: American Traffic Solutions Inc.

Before the installation of red light or speed cameras, an initial screen to identify sites and an engineering and feasibility analysis are recommended.

Vendor Contract, Payment, and Fines

After establishing system specifications, jurisdictions should solicit vendors through a competitive bidding process. The specifications should stipulate agency control of the program and should avoid favoring a single vendor or proprietary technology. A flat fee structure for the payment of vendor services is the most acceptable arrangement from the public's perspective, because the fee paid to the vendor is not dependent on the number of citations.

The fines for red light and speed violations documented on camera will depend on the state's enabling legislation, which may specify the fines and types of penalties. The allocation of the proceeds from the automated enforcement program, including surplus funds, should be identified and communicated at the start of the program, because this can become a subject of contention and a target for criticism by the media. Unless the legislation specifies otherwise, any revenue remaining after payment for the cost of the program should be allocated to highway safety functions.

Camera Installation

The most defensible and successful programs are based on a clearly identified safety need and an engineering analysis. A formal, documented process helps identify the most effective locations for deployment. A two-stage process is recommended: an initial screen to identify sites from data and statistics; then an engineering and feasibility analysis of the flagged sites.

Violation Data Collection and Adjudication

The location of the license plates on a vehicle—as well as the responsibility of the driver or the owner for the penalty—will determine what kind of images of the vehicle are needed—front, rear, or both. In addition to the images, a citation should include other relevant data such as the time, date, and location.

Information from red light cameras should include the amount of yellow time displayed before the red signal, the duration of the red signal at the time of the image, the date and time of the violation, and the location of the violation. For speed cameras, the data bar should include the speed of the vehicle, the posted speed limit, the date and time of the violation, and the location of the violation.

A violator who has received a citation in the mail usually has the option to contest it in court. A jurisdiction should be open to precourt meetings between a police officer and an individual who wants to contest a citation. These meetings often can resolve the issue and often result in a paid ticket, saving time and court costs.

Program Monitoring and Problem Intervention

Program monitoring should be conducted on two levels. The program's operation should be monitored daily; regular reviews can help identify and resolve concerns before the public, the media, or others raise the problems. The program also should be monitored on a regular, longer-term basis—such as annually—to identify the effect on crashes. If an annual evaluation is not affordable, an evaluation should be conducted one year after the program's initiation and then semiregularly, such as every three years.

When technical issues are identified, the system should be taken offline immediately; a faulty mobile unit for automated speed enforcement should be removed from the field. A multidisciplinary review team—including the program manager plus staffers from enforcement, traffic engineering, and public works—should meet in the field to assess the problem and discuss possible solutions. A collaborative approach to solving the problem speeds resolution.

Photo-enforced warning sign for right turns in Virginia Beach, Virginia. Transparency is key to public acceptance of enforcement programs.

Keys to Success

When used appropriately, automated enforcement can be a valuable tool to prevent speeding and red light running. Agencies seeking to implement an automated enforcement program should learn from the experiences of other agencies. At a minimum, a program should have the following qualities:

◆ ***Open to the public***—The public must have knowledge, awareness, and assurance about the systems. Transparency and accessibility are important to the success of the program and to general public acceptance.

◆ ***Motivated by safety***—Properly identifying red light running or speeding as the cause of crashes is critical to establishing a program. A program that is not motivated by safety will not succeed.

◆ ***Strong enabling legislation***—Enabling legislation should be tailored to the local community needs and to legislative constraints. The legislation should provide authority for operating an automated traffic enforcement program without attempting to specify every component of the program.

◆ ***Repeatable***—A well-run automated enforcement program should be repeatable at all stages, from initiation to site selection and evaluation. A program with well-documented, repeatable processes will help gain the trust and respect of the public and will encourage neighboring jurisdictions to follow the same protocol.

◆ ***Monitored and evaluated***—Regular monitoring should evaluate the performance and operation of the program. Monitoring can help determine if the goals of the program are being met, ensure that the systems are operating correctly, and identify any conditions that may have changed that would require a modification to a system or to the program.

The guidelines in NCHRP Report 729 can help agencies looking to start an automated enforcement program or to improve a current program. Automated enforcement, however, should only be used as a supplement to traditional engineering, enforcement, and education countermeasures, never as a replacement for these measures. Officers should continue to provide traditional enforcement at locations equipped with automated enforcement.

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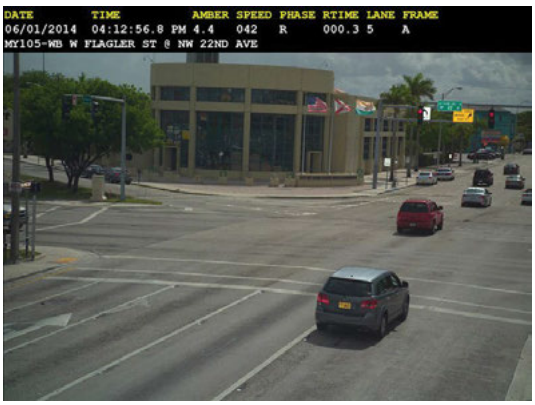
For more information on NCHRP Report 729, visit www.trb.org/main/blurbs/167757.aspx.



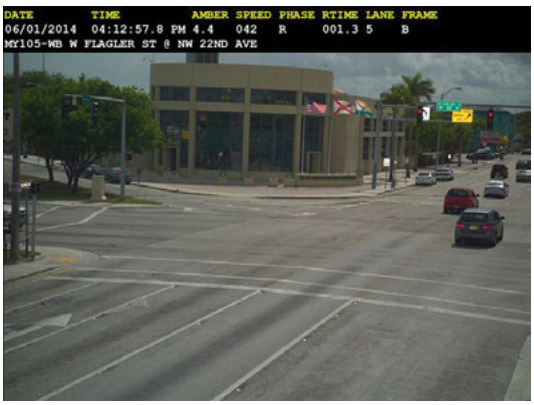


Photo: American Traffic Solutions Inc.

Information collected by a red-light camera includes a vehicle's license plate; time, date, and location; and the duration of yellow and red signals.

Communicating the Value of Preservation

A Playbook

JOE CROSSETT

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From parcel trucks delivering online orders to urban subways connecting workers with their jobs, transportation is an anchor for economic prosperity and quality of life. Yet aging system elements—whether highway or transit assets—are buckling under levels of use unforeseen by the engineers and planners who built them decades ago. Moreover, study after study shows a multibillion-dollar gap in infrastructure investments.

Despite frequent warnings, elected officials and the public remain unconvinced about the need to make improvements in the transportation infrastructure. Why? Part of the answer may be the inability of transportation professionals to communicate effectively about the importance of infrastructure investment. To convince decision makers, transportation practitioners must start delivering their message more clearly.

A transportation planner or an engineer should not dismiss communication as someone else's job. Communication can advance plans for sustaining and improving America's infrastructure by creating effective, memorable messages.

A recently completed National Cooperative Highway Research Program (NCHRP) project developed guidance for officials at state departments of transportation (DOTs) and other agencies to develop and implement strategies for communicating the role and importance of maintenance and asset preservation in sustaining highway system performance. The findings are summarized in NCHRP Report 742, *Communicating the Value of Preservation: A Playbook*. The three basic steps are presented below.

Transportation agencies can craft messages about preservation and can deploy message delivery methods targeting audiences and stakeholders.

A sinkhole in downtown Washington, D.C., resulted in road closures. Successful communication can convince decision makers of the importance of investing in transportation infrastructure.

1. Identify audiences.

A good place for transportation agencies to begin a communication effort is by getting to know the audience for their preservation messages. Infrastructure professionals should ask: "What does my audience value, what will make them trust my message, and what do I want them to do?"

Audience identification seeks to satisfy key stakeholders according to their definition of what is valuable; this is important to a proposal's success. If stakeholders are not satisfied, something will change, whether budgets, priorities, or staffing.

To get started with audience identification, conduct a brainstorm session about potential audiences with a cross section of internal staff to consider audience characteristics that may affect communication about preservation and maintenance. After assembling a list of audiences, discuss the interests, values,

and emotions that drive the support of maintenance and preservation in each group, in interrelated segments or clusters, and all together. Audience segments may include elected officials, industries that depend on reliable infrastructure, and advocacy groups.

With the list of audience segments, map out the stakeholders on an interest–influence matrix that characterizes interest level in preservation along one axis and power and influence over preservation issues along the other axis. The completed matrix will provide a graphic representation of audience clusters that support, oppose, or are indifferent to preservation issues and will enable identification of four distinct groups: promoters, defenders, latents, and apathetics (see Figure 1, right).

The interest–influence matrix, which maps audience segments according to their level of interest in preservation and their ability to influence outcomes, helps focus attention on how to move each audience segment into the top right corner of the matrix—indicating medium or high interest–high influence—and how to keep them there.

These stakeholders already are supportive but need to be buttressed with resources and information; moreover, they share sufficient interests to form a support coalition. This group can be the basis for developing an ongoing coalition of support for maintenance and preservation.

2. Design the messages.

Audience identification leads naturally into message design. Engineers and other transportation professionals often resist efforts to craft messages, preferring more technical conversations. Effective messages about preservation should have a strong analytical foundation but must be succinct and must resonate with their audience on an emotional level to compete in a world crammed with messages.

When crafting a message, tap the technical expertise, data sets, and analyses that the transportation agency possesses; take advantage of expertise that is well established in the arena of infrastructure preservation. Create concise and compelling messages that not only deliver powerful facts clearly but also appeal to the emotions and interests of audience segments and work in multiple delivery channels (see Figure 2, right).

◆ **Use data about system attributes.** Facts about the size and scope of transportation infrastructure can give a sense of its scale and importance. Identifying the age of a system or its elements can convey its historical significance and the sense of urgency to protect critical infrastructure investments.

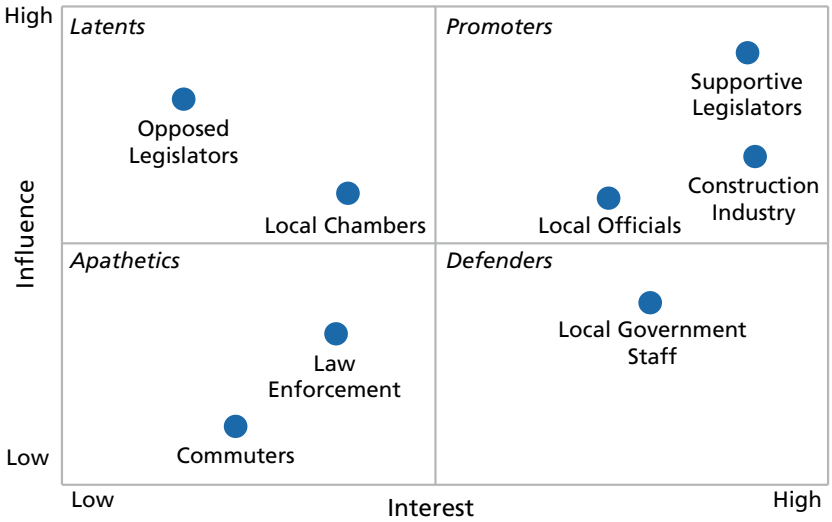


FIGURE 1 Audience interest–influence matrix helps focus communications on target audiences.

◆ **Use data about the system's condition.** Measures of asset condition, remaining service life, and many other attributes of a system's condition can help communicate how the condition relates to customer expectations, how the condition has improved or declined, and the scale of the preservation task at hand.

◆ **Use the system's economic value.** Conveying how the infrastructure system provides economic value to communities is increasingly important for public agencies. By conveying a sense of the importance of system elements, this information infers the importance of preservation.

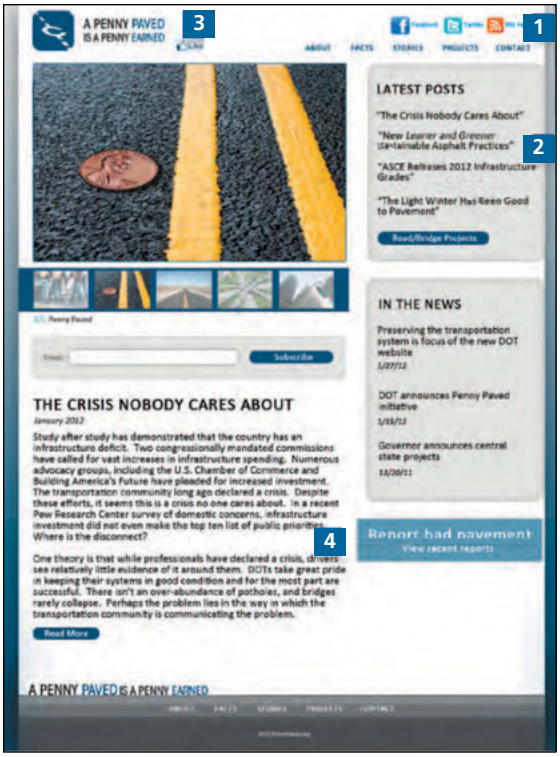


FIGURE 2 Sample state DOT website to support and promote preservation, offering 1 links to social media; 2 blog posts by state DOT professionals and supporters of the preservation initiative; 3 a link to news directly related to the initiative and to other preservation information from around the country; and 4 a one-stop shop for materials and news related to the effort, allowing the state DOT to communicate with citizens and stakeholders in an inexpensive way.

FIGURE 3 Sample message to engage audiences and offer a positive call to action.

Raw data, even translated into a simple and clear message, rarely resonate. Present the information in ways that surprise the audience and catch attention (see Figure 3, left). The best messages do not rely entirely on numbers; instead they build on data to tell a story that resonates with audiences personally and emotionally. Facts and logic alone are not sufficient to move key audience segments to action.

Observe some basic principles for effective messages:

◆ **Be relevant.** Audiences should relate to the message; they should instinctively agree with the premise and feel that the message is directed to them and applies to them.

◆ **Be engaging.** Messages should draw the attention and interest of the audience—or risk being ignored and forgotten.

◆ **Stay positive.** A negative message that criticizes or that evokes fears can turn off an audience; aim to inspire instead.

◆ **Offer a call to action.** The message should inspire the audience to do something or to feel a certain way.

3. Deliver the message via multiple channels.

No matter how clever and memorable a preservation message is, without the right delivery tactics, the message will not reach the audience at the right time and motivate them to action. The volume of messages Americans receive each waking hour continues to skyrocket, and sending preservation messages on autopilot will not gain attention. For a message to be heard and remembered requires building a "surround sound" presence that establishes a constant drumbeat across multiple delivery channels from face-to-face conversations, speaking engagements, press articles, and editorial opinions to blog entries, social media conversations, and websites.

◆ **Direct contact.** Direct audience contacts are easy to implement, low in cost, and contribute to successful message delivery abut preservation; direct contacts range from formal speaking engagements to open dialogue sessions or invitation-only meetings. With regular use, direct audience contact is a powerful delivery tool, because no filter comes between the speaker and the audience, the message can be explained in depth, and feedback on effectiveness is immediate.

◆ **Traditional media.** Traditional media strategies range from printed factsheets and brochures to media events designed to land stories in newspapers and on radio, television, and cable programs. Traditional media remain a core delivery method for messages. Through their recognizable and credible branding, newspapers and television stations confer status on a message. In addition, the traditional media often feed the new media, such as blogs.

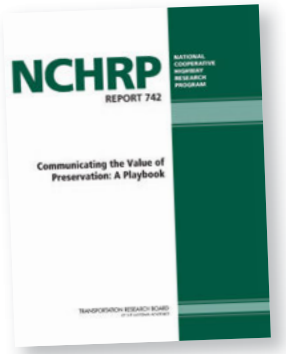
Photo: North Carolina DOT

On a local television program, North Carolina DOT Secretary Tony Tata discusses Fortify, a project to rebuild two major highways in the Raleigh area.

◆ **New media.** New media channels, commonly defined as Internet-based, have evolved in the past decade from e-mails and modest websites into an extensive and sophisticated portfolio of information channels, including blogs, YouTube, podcasts, Twitter, Facebook, and other electronic tools. New media tools offer a low-cost alternative to traditional media; moreover, DOTs can enter into two-way conversations with their stakeholders that can strengthen connections. New media can convey visual or narrative messages and can support dissemination of detailed technical information.

Message delivery options come in many shapes and sizes. Use all or many to create a surround-sound campaign that gets messages heard, seen, and remembered via traditional media, on the Internet, and in face-to-face settings. Some versions of the message may be delivered visually through photographs, video, or charts and graphs; verbal versions may appear as newspaper op-eds or as presentations from agency leaders; yet other versions may combine visuals and words in blog posts or brochures. Catchy slogans delivered via a website, in e-mails, or on slides will resonate with high-impact, high-interest audiences and can enhance more detailed deliveries via a full presentation at a stakeholder forum or on the agency's website.

For more ideas and guidance about communicating preservation needs, see NCHRP Report 742, *Communicating the Value of Preservation: A Playbook*, which is available online at www.trb.org/main/blurbs/168322.aspx.



For more information on NCHRP Report 742, visit www.trb.org/Publications/Blurbs/168322.aspx.

Engineering Economic Analysis Practices for Highway Investments

MICHAEL J. MARKOW

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Does an engineering economic analysis contribute worthwhile information about a highway investment or does it impede timely decision making? This question essentially underlies the problem statement for National Cooperative Highway Research Program (NCHRP) Synthesis Topic 41-03, Engineering Economic Analysis Practices for Highway Investments.

The results of the study, published ias NCHRP Synthesis 424, affirm the benefits of using engineering economic methods by showing how select U.S. transportation agencies have applied exemplary practices in benefit–cost analyses and similar procedures.[1] The results indicate a remarkably wide range of applications in highway investment decision making.

Economic Versus Financial Analyses

NCHRP Synthesis 424 distinguishes between economic analyses and financial analyses of highway investments; both involve streams of dollars and can easily become confused in practice. For example, in an economic analysis, questions may arise about whether or not to include inflation; whether to use base-year or current-year dollars; the differences between an interest rate and a discount rate; and what to do when funding contributed by others reduces the project's apparent cost to the highway agency.

The report provides brief explanations highlighting the differences between the two types of analyses, along with examples of good practice by highway agencies. A project may be economically feasible—that is, worth doing—but financially infeasible, because it cannot be paid for. The opposite is also true: a project can be economically infeasible—the expenditure of taxpayer dollars is not economically justified—but financially feasible, because the money can be found to pay for it, although the project could prove a poor use of tax dollars.

Table 1 (page 44) illustrates these and other combinations of economic and financial possibilities to distinguish between the two types of analyses. The synthesis focuses solely on the economic analysis of agency investments.

Developing Proficiency

Many U.S. state departments of transportation (DOTs) routinely conduct economic analyses for certain categories of investment—for example, for pavement and bridge preservation, by applying economic models in pavement and bridge management systems; for safety improvements, by considering the social costs avoided by reducing collisions; and for major projects, such as expanding the capacity of trunk lines or of large, complex urban transportation facilities.

The findings from this synthesis have demonstrated, however, that agencies conversant with economic concepts and methods regularly conduct more extensive applications of engineering economic analysis. These agencies have developed a proficiency that enables the integration of economic analyses into daily operations and the application of economic results to managerial and executive decision making.

[1] www.trb.org/Publications/Blurbs/167096.aspx.

Photo: Washington State DOT

Crews work during a weekend closure on the SR-520 bridge replacement and high-occupancy vehicle project in Washington State. Transportation agencies often analyze highway safety investments in economic terms, considering the social costs of fewer collisions.

A roundabout is installed on SR-92 in Washington State to reduce collision risk and improve traffic flow. Roundabouts are a priority in Washington State DOT's strategic highway safety plan.

Photo: Washington State DOT

Case Examples

Case examples were critical to the findings of the synthesis. Many regard benefit–cost analysis and similar methods solely as tools for project appraisal, for application early in project planning and design. This synthesis has shown, however, that state DOTs and other transportation organizations have applied engineering economic analysis successfully and productively to a much wider range of highway investment decisions, from project conception and planning to project delivery.

The cases presented in NCHRP Synthesis 424 are listed as follows; the cases detail the practices of a sampling of agencies identified through a screening survey. The list is not exhaustive; other agencies also may have attained similar levels of proficiency in the use of economic analysis.

◆ **Planning.** One case example applies to critical Interstate bridge and tunnel crossings owned and operated by the Port Authority of New York and New Jersey, with a supporting economic analysis by the U.S. Army Corps of Engineers of maritime shipping to the Port of New York and New Jersey. Another case example covers mobility planning by the Washington State Department of Transportation (DOT).

TABLE 1 Economic Versus Financial Assessments of Project Candidate Solutions

Economic Justification	Financially Feasible	Financially Infeasible
Economically justified	Solution is economically worth doing. The benefits justify the cost. Of the alternatives considered, the solution maximizes benefits to the public. Solution is financially feasible—funding is available in the amount and time needed to pay for the candidate project, including anticipated cost inflation. *Implication:* With good management of delivery, a worthwhile project can be completed with the available budget.	Solution is economically worth doing. Its costs are justified by its benefits to the public. Funding is not sufficient, however, to cover the estimated costs including inflation; or the candidate project is ineligible for funding in the amount and schedule needed. *Implication:* Although worth implementing, the solution cannot be paid for with the current design and funding. The candidate project should not be recommended. Other financially feasible solutions to the need or problem should be explored.
Economically not justified	Solution is economically not worth doing. The benefits do not justify the cost. Unless justified by other, noneconomic considerations, the project could be seen as a waste of taxpayer money. Funding is available to support the candidate project if worthwhile. *Implication:* Consider revisiting the original need or problem to explore other solutions that are stronger economically, that increase benefits or reduce costs. Otherwise, consider redirecting the funding to viable project candidates that address other needs.	Solution is neither economically nor financially defensible. Even with other, noneconomic reasons to consider the solution, funding is not available in the amount and time needed. *Implication:* Reassess the original need or problem to gauge its priority in relation to other needs. If the priority is relatively high, develop new, economically viable solutions and consider other financing options (including innovative funding mechanisms or redirecting funding from lower-priority project candidates) to fund the solution. Otherwise, move on to other needs and solutions.

◆ **Programming and budgeting.** Two case examples illustrate methods used by Washington State DOT for mobility programming and safety programming; another presents the California DOT (Caltrans) approach to bridge programming and permitting, including environmental permitting considerations; and a fourth case illustrates the methodological development for an economics-based trade-off analysis by New York State DOT.

◆ **Resource allocation following budget approval.** The New York State DOT case example of economics-based trade-off analysis is instructive for projects at the resource allocation stage as well.

◆ **Project design and development.** A case example of pavement type selection, comparing the practices of Colorado DOT and Caltrans, addresses this aspect of project design and development, supplemented by a value engineering case example, which compares the practices of Caltrans and Florida DOT.

◆ **Accelerated project delivery.** Conventional construction and design–build options are considered in the case example for acceleration of project delivery, developed with Minnesota DOT.

Economic analyses involve comparisons of alternatives to evaluate differences in costs and benefits and to identify the preferred—or economically justified—approach that delivers the best value to road users and the public at large. For example, Figure 1 (right), from the Minnesota DOT accelerated project delivery case, illustrates the comparison of road user benefits from conventional construction (upper graphic) and from accelerated construction with design–build (lower graphic). The additional benefit component (B2) in the lower graphic denotes additional savings to road users from the faster completion of the project.

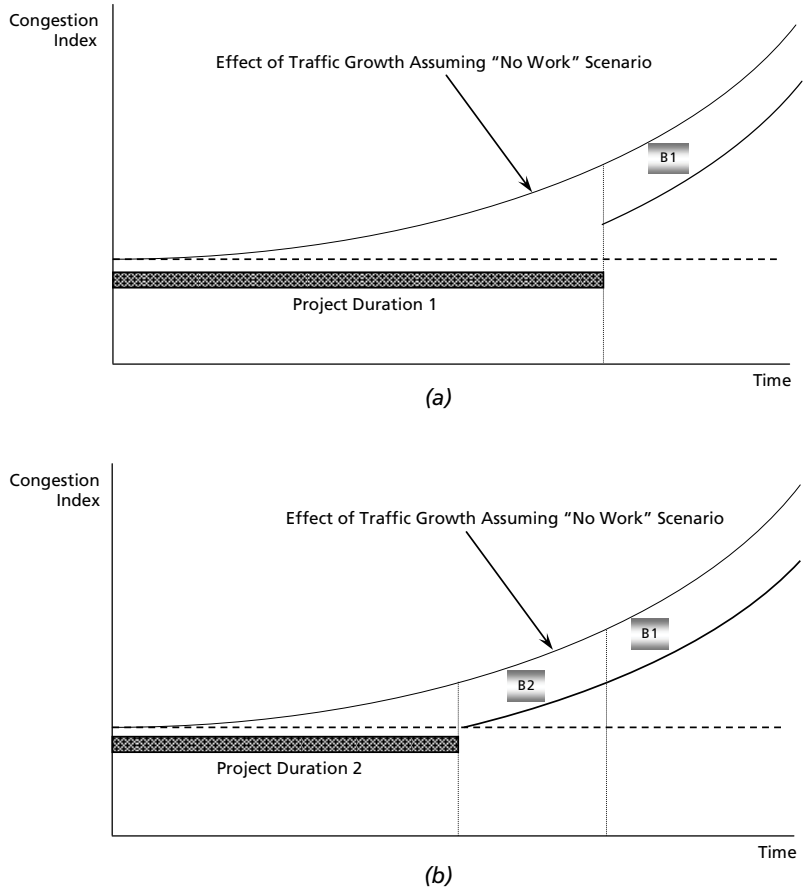


FIGURE 1 Illustration of highway user cost savings from project acceleration: (*a*) conventional construction; (*b*) accelerated construction with design–build. (B1 = benefit; B2 = additional benefit. Source: HDR–HLB Decision Economics, Inc., 2006, Figure 7, p. 11, with additional annotations by author.)

Practical Frameworks

Although economic results are important to investment decisions, they are not the sole criterion in the final decision. Agencies may consider other factors, quantitative and qualitative, in a comprehensive assessment of which project alternative to recommend.

In addition to the application of engineering economic methods to various decisions in highway investment, the case examples also reveal agency practices in building analyses—such as compiling data, selecting a discount rate, accounting for risk or uncertainty in estimates, defining alternatives, and so forth. The case examples represent a variety of program areas, such as preservation, mobility, and safety; life-cycle stages in the decision process, such as planning, programming, resource allocation, design, and project delivery; and levels of the system analyzed—for example, link or project, corridor, program, and network.

Considered individually, the case examples show how engineering knowledge and the need to understand the impacts of particular decisions can be organized within a practical economic framework. Considered collectively, however, the case examples reveal common characteristics among agencies that successfully apply engineering economic practices across a range of projects.

Value engineering was integrated into the project development and environmental study of the I-595 expansion project in Florida.

Photo: Doug Kerr

PHOTO: COLORADO DOT

Concrete work on US-160 near Cortez, Colorado. Colorado DOT's pavement type selection practices are examined in NCHRP Synthesis 424.

Characteristics of Proficient Agencies

Several characteristics differentiate agencies that are conversant with economic methods and are integral to the agency's makeup and approach to solving transportation problems and addressing needs:

◆ The influence of organizational champions and culture, with the support and participation of executive leadership;

◆ A level of knowledge, proficiency, and comfort with economic methods;

◆ Integration of economics into the business and decision-making processes, so that economic analyses are a part of routine business, not a distinct, somewhat isolated task;

◆ Creativity in developing alternative solutions;

◆ A willingness to experiment and innovate when available data and analytic methods do not fit a situation that requires a decision;

◆ The reliance of upper management on the results of economic analyses in making investment decisions;

◆ The availability of information technology to support not only the economic analysis but also important steps such as diagnosing a problem, defining realistic alternatives, and displaying results;

◆ Providing staff training in economic methods and tools and encouraging personnel to apply these capabilities in their daily work;

◆ Maintaining a healthy perspective on engineering economic analysis, viewing results as information, not as an automatic decision, that becomes part of the comprehensive understanding of a project solution; and

◆ Recognizing that economic outcomes are an integral part of gauging highway system performance.

Value of Economic Analyses

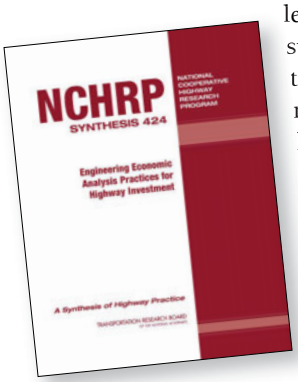
The case examples, together with reviews of the literature and interviews with agency personnel, identify the following benefits of economic analyses:

◆ The direct or tangible benefit consists of obtaining an economic result that shows the value or merit of a highway investment. This value may be in the benefits received by road users or in the costs avoided by road users and by the agency. Generally, economic performance—the benefits compared with the costs—is linked to the engineering or technical performance of the highway facility. Monetized benefits help in understanding the trade-offs between competing alternatives. The preparation of an economic analysis imposes a discipline that accounts for all costs and all benefits as comprehensively and as accurately as possible.

◆ The indirect or intangible benefit comes from encouraging a better decision-making process within the organization. This benefit provides an incentive to identify all realistic alternatives for solution; to a focus on the purpose of the proposed investment and to avoid "scope creep"—uncontrolled changes or growth in a project's scope; to avoid biases toward options, such as particular paving materials; and to support these objectives through clear agency guidance and communication, backed by analytical tools and effective data collection and processing.

Completing the Steps

NCHRP Synthesis 424, *Engineering Economic Analysis Practices for Highway Investments*, describes the ways that exemplary state DOTs and other transportation agencies complete the steps of engineering economic analysis: articulating the highway system need or problem to be investigated; defining alternative solutions to be assessed; quantifying the parameters of the analyses; setting economic and engineering criteria for decisions; introducing other noneconomic or nonquantitative factors that may affect the outcome; completing the analysis; and interpreting the results. The synthesis also includes lessons learned from the successful implementation of engineering economic analysis within a highway organization.



For more information on NCHRP Synthesis 424, visit www.trb.org/Publications/Blurbs/167096.aspx.

A Model for Identifying and Evaluating the Historic Significance of Post–World War II Housing

EMILY PETTIS AND CHRISTINA SLATTERY

Pettis is Senior Historian, Mead & Hunt, Inc., Madison, Wisconsin, and chair of the TRB Historic and Archaeological Preservation in Transportation Committee. Slattery leads the Cultural Resources Business Unit, Mead & Hunt.

The built environment along major transportation corridors typically includes subdivisions and neighborhoods of similar homes built from the mid-1940s through the 1970s. Following World War II, vast numbers of these homes were built in response to a significant housing shortage and population boom. Post–World War II residential development was a national trend—large urban areas, smaller cities, and formerly rural areas experienced significant growth and development.

These ubiquitous resources pose a challenge for transportation project planners. Many of the houses are now or soon will be more than 50 years old and may be eligible for listing in the National Register of Historic Places. According to Section 106 of the National Historic Preservation Act, agencies seeking federal dollars or permits must take into account the potential effects of a project on properties eligible for listing in the National Register. As a result, postwar residences increasingly are being considered as part of a transportation project's Section 106 compliance.

Relevance and Concerns

The postwar housing boom started shortly after World War II, and more than 40 million new homes were constructed between 1946 and 1975. As vast numbers of postwar residences meet the National Register's 50-year age guideline, state departments of transportation (DOTs), state historic preservation offices (SHPOs), and cultural resource professionals are struggling to evaluate the significance and integrity of these resources efficiently and consistently.

Photo: Mead & Hunt

Example of a 1960s split-level house in Omaha, Nebraska.

Photo: Wisconsin Historical Society, Image ID 66696

Many postwar subdivisions were modest residences set back along curvilinear streets, as in this Westport, Wisconsin, neighborhood circa 1960.

The increasing numbers of postwar properties eligible for the National Register in the next decade and beyond present a major challenge to decision makers. Most states use traditional survey methods and current National Register guidance to identify and evaluate historic resources. A major concern is that surveying and evaluating the large number of similar resources—postwar houses—according to long-established practices will increase project costs. An effective framework is needed for determining National Register eligibility in these instances.

In addition, a lack of contextual information often complicates the evaluation of individual postwar residences and neighborhoods. Project planners and reviewers have scant information for making decisions. A historic context for postwar residential development would aid in supporting consistent outcomes.

Developing Guidance

To solve this problem, the National Cooperative Highway Research Program (NCHRP) funded a project to develop national guidance for working with postwar residences. NCHRP Report 723, *A Model for Identifying and Evaluating the Historic Significance of Post–World War II Housing*, presents a national historic context and a survey and evaluation methodology for single-family postwar residences.[1] Mead & Hunt, with assistance from the Louis Berger Group, formulated and tested the context and methodology.

[1] www.trb.org/Main/Blurbs/167790.aspx.

Photo: Mead & Hunt

Unaltered Ranch house in Milwaukee, Wisconsin, displays many character-defining features.

The project objective was to develop a historic context for postwar housing and a methodology for identifying and evaluating the National Register eligibility of single-family postwar residences. The report includes three distinct components that provide a standard framework for transportation and cultural resource professionals to use in evaluating postwar housing judiciously and efficiently: the national historic context, the survey methodology, and the evaluation methodology.

National Historic Context

The national historic context supports an understanding of the social, economic, governmental, and political influences on the development of these resources nationwide. The context also considers the development of housing during the postwar period and covers national trends that influenced residential development.

This provides transportation and cultural resource professionals with a succinct history of postwar housing trends and influences. This general background, therefore, does not need to be developed for a specific transportation project that may affect postwar residences. Instead, professionals can focus on developing the local historic context and its relationship to the national trends.

Project historians conducted extensive research to address such topics as transportation trends; government programs and policies; social, economic, and cultural trends; subdivision planning and development; and advances in building materials and construction techniques. The report describes popular architectural forms and styles of the period in detail, such as the Minimal Traditional, Ranch, and Colonial Revival, including the evolution and the character-defining features of each style.

This illustrated discussion provides a clear and wide-ranging definition of the residential housing popular during the postwar period. Few architectural style guides cover the postwar period in detail, and NCHRP Report 723 may prove beneficial in providing a consistent terminology for use nationwide.

Survey Methodology

A methodology was developed to assist with surveying postwar single-family residences. Because of the sheer volume of these resources, applying the traditional survey methodologies that require a field survey of every building 40 or 50 years old was not practical or prudent. The task often requires the repetitive documentation of similar or identical houses.

For a project that may affect a large postwar subdivision, this house-by-house approach could result in a significant expenditure of time, resources, and budget. Therefore the project team developed a survey methodology that provides a streamlined and consistent approach to identify and evaluate postwar residences nationwide according to National Register criteria.

The approach surveys concentrations of similar postwar residences as a single grouping or potential district, instead of documenting individual resources.

Photo: Mead & Hunt

This collection of nearly identical Minimal Traditional homes in Detroit, Michigan, would benefit from documentation using the new survey methodology.

Photo: Mead & Hunt

Example of an unaltered Minimal Traditional house in St. Louis Park, Minnesota.

Appropriate to a neighborhood or subdivision in which postwar homes display similar forms, massing, and materials, the approach reduces survey efforts, which in turn reduces the associated project costs and schedule.

When the grouping approach is not applicable, the approach allows for a selective survey of individual residences that retain integrity and character-defining features. Although all properties within the survey area are reviewed, only those with the most potential for listing in the National Register are documented.

The report offers specific guidance on the popular architectural forms and styles of the postwar period, including illustrated examples of properties that meet and do not meet the selective survey criteria. Project team members tested this selective approach in several areas around the country to confirm the streamlining benefits and the appropriate consideration of intact examples of postwar residences.

Evaluation Methodology

The evaluation methodology guides the consistent application of the National Register criteria to postwar residences, for consideration of individual significance and as historic districts. The methodology also includes detailed and illustrated examples of common alterations that may compromise the integrity of individual residences and districts and result in a recommendation of not eligible.

Application of the methodology achieves consistent and streamlined National Register evaluations of postwar neighborhoods, subdivisions, and individual residences across geographic areas. In addition, the outcomes of Section 106 reviews become more predictable, so that transportation planners can provide timely project delivery. The guidance is illustrated with case studies of postwar residences and historic districts that have been listed in or determined eligible for the National Register.

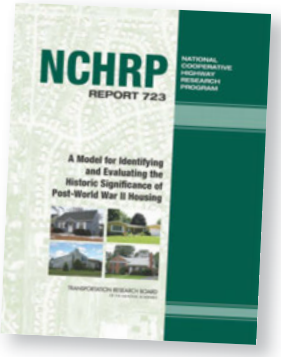
Practical Approach

The historic context outline and methodological tools developed through this NCHRP project provide first-of-its-kind national guidance for transportation projects that involve postwar residential housing. This practical approach helps ensure that the model context and survey methodology are useful to state DOTs, SHPOs, cultural resource professionals, and the Federal Highway Administration (FHWA).

Application of the recommended methodology will lead to more effective and efficient practices in addressing postwar housing during transportation project development. To quote FHWA Federal Preservation Officer MaryAnn Naber, a member of the NCHRP project panel, "Ultimately, the use of the national context and streamlined survey methodology is expected to lower project costs and help expedite schedules, assisting state DOTs and FHWA in fulfilling their missions to deliver transportation projects."

Another benefit of the project is that a consistent, credible approach to surveying and evaluating postwar residences can help change the perception that postwar houses are not important to understanding U.S. heritage. Although few postwar residences will be individually eligible for the National Register, the postwar period introduced a major residential building boom that transformed community planning and development, architectural standards, and social history. Postwar residences tell a unique story of these trends, both in the distinctive architectural styles and forms that developed in response to the technologies and societal preferences after World War II, and in the larger subdivisions that met the explosive demand.

NCHRP Report 723, *A Model for Identifying and Evaluating the Historic Significance of Post–World War II Housing*, includes the survey and evaluation methodology, the national historic context, and the model context outline. The report is available for download or purchase from the Transportation Research Board website at www.trb.org/Main/Blurbs/167790.aspx.



NCHRP Report 723 is available online at www.trb.org/Main/Blurbs/167790.aspx; to order a print copy from the TRB Bookstore, go to https://www.mytrb.org/store.

Photo: Wisconsin Historical Society, Image ID 4717

A promotional photograph of houses included in the 1955 Parade of Homes in Madison, Wisconsin. The postwar building boom transformed the American neighborhood as well as the architectural, planning, and transportation landscape.

Framework for Making Safe Transportation Decisions

Seven Principles for Prioritizing Safety

SUSAN B HERBEL AND NICOLE WALDHEIM

Herbel is Principal and Waldheim is Associate, Cambridge Systematics, Inc., Bethesda, Maryland.

More than 30,000 people are killed in crashes every year on the U.S. road system. This tragic loss of life costs the American economy well over $1 billion annually. Since 1998, federal legislation has required statewide and metropolitan transportation planning processes to address safety, and subsequent legislation, including the Moving Ahead for Progress in the 21st Century Act (MAP-21) of 2012, strengthened the role of safety in the planning process.

Nevertheless, the full integration of safety into the traditional transportation planning process has taken considerable time and effort, and the work is far from complete. National Cooperative Highway Research Program (NCHRP) Report 546, *Incorporating Safety into Long-Range Transportation Planning*, published in 2006, provided a point of departure, describing a basic process for safety integration.[1]

Phase 1 of NCHRP Project 8-76, Institutionalizing Safety in the Transportation Planning Processes: Techniques, Tactics, and Strategies, produced a framework for safety integration, published in 2011, with a focus on strategies for incorporating safety into every step of the planning process.[2] Figure 1 (page 51) depicts the transportation safety planning (TSP) framework.

Phase 2, Transportation Safety Planning Framework: Implementation, Testing, and Evaluation, is near completion and focuses on testing the TSP framework. Cambridge Systematics is working with seven states to understand how they consider safety in the planning process; what they see as the challenges to safety integration; and how they can move forward with safety integration in their unique planning environments. A guidebook, sharing the results of the Phase 2 research, will be available in early 2015.

[1] www.trb.org/Main/Blurbs/156716.aspx.

[2] http://onlinepubs.trb.org/onlinepubs/nchrp/docs/NCHRP08-76_PhaseI-FR.pdf.

Maryland state police conduct a road safety audit. NCHRP Project 8-76 is testing a framework for integrating safety into transportation planning.

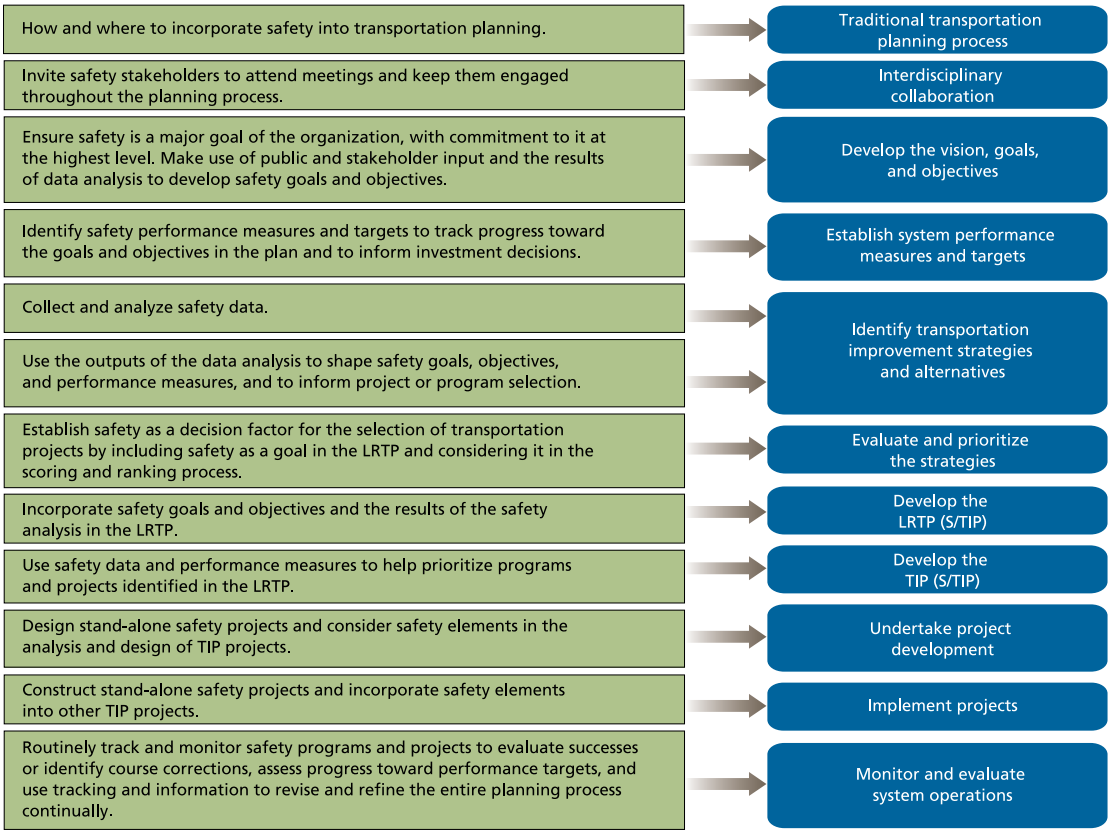


FIGURE 1 Framework for integrating safety in the transportation planning process. (LRTP = long-range transportation plan; TIP = transportation improvement program; S/TIP = statewide and metropolitan transportation improvement program.)

Research Methodology

To develop the TSP framework in Phase 1, the research team designed and implemented an approach for identifying tactics, tools, techniques, and strategies for institutionalizing safety in the traditional transportation planning process. The research included a literature review, practitioner outreach surveys to identify candidate agencies, 45 telephone interviews with agencies involved in transportation safety planning, in-person interviews in three states at the forefront of safety and planning integration, and a comprehensive review and input by an expert panel.

In Phase 2, researchers tested the framework to confirm its usefulness and validity in real-world settings. Transportation and safety planners from Louisiana, Maine, Arkansas, Nevada, Florida, Vermont, and Oregon participated in the research and developed action plans to implement the TSP framework; this helped the research team understand the opportunities and challenges within each planning task.

Seven Principles

The intent of the framework is to provide transportation planners at metropolitan planning organizations (MPOs) and state departments of transportation (DOTs) with ideas, strategies, and techniques for addressing safety or considering it in a more comprehensive and explicit manner. Although the concept of transportation safety planning is not new, the strategies and actions identified by the peer and lead states to incorporate safety throughout the planning process are innovative. Approaches to implementing the seven principles are presented below.

1. Establish multidisciplinary coordination with transportation and safety stakeholders.

The transportation planning process is a cooperative effort, designed to engage agencies, elected officials, operators, system users, citizens, and interested stakeholders in decisions about transportation policies, strategies, and investments. One of the first steps in developing a transportation plan, therefore, is to identify a cross section of individuals with some level of technical or policy-oriented knowledge of the subject matter. Safety experts and modal experts who address safety in their jobs can make key contributions to the consideration of safety in planning documents.

Photo: National Highway Traffic Safety Administration

Different transportation modes have different safety needs. A transportation plan should engage a cross section of experts, officials, agencies, system users, and other stakeholders.

Some of the opportunities to accomplish this include establishing a transportation safety committee; creating an ad hoc safety committee to meet during an update of the long-range transportation plan or during project selection; appointing safety representatives to established committees, such as a technical advisory committee or a bicycles-and-pedestrians committee; and identifying and including safety experts in discrete planning activities, such as corridor plans.

2. Incorporate safety into the vision, goals, and objectives.

Incorporating safety in the vision statement, goals, and objectives can lead to identifying and selecting safer transportation programs and projects. The vision sets the initial stage for prioritizing safety; the goals formalize and make the commitment prominent in the plan; and the objectives provide the goals with a structure and a focus on precise needs.

Safety goals and objectives in transportation plans can be identified or refined early in a planning process through a combination of sources: public involvement, multidisciplinary input, knowledge from MPO and state DOT staff, crash data, and reviews of other planning documents. MPOs and state DOTs, in particular, have recognized the value of coordinating the goals and objectives of state strategic highway safety plans (SHSPs) with transportation plans. Furthermore, MAP-21 requires this coordination.

Photo: Oregon DOT

A reporter speaks with Oregon DOT officials about work zone safety initiatives. Oregon participated in research on implementing the transportation safety planning framework.

3. Develop safety performance measures and targets.

Performance measures can track progress toward the vision, goals, and objectives in a plan and can serve as a basis for making investment decisions. A target is the numerical goal set by an agency. MAP-21 requires state DOTs and MPOs to track four safety performance measures, including the number and rate (per 100,000 vehicle miles of travel) of fatalities and serious injuries. Identifying and tracking measures require data; as a result, many state DOTs and MPOs are working together to identify consistent performance measures and to discuss available data, data collection, data access, and data analysis.

4. Collect and analyze crash data.

Data collection and analysis inform regional trends and challenges, which later are used to identify goals, objectives, policies, programs, and projects. The analysis focuses on understanding how a transportation system and its components function and consequently how improvements will alter the system's performance. Improving safety requires identifying unsafe locations, road characteristics, community features, modes, and behaviors. Data frequently needed to understand transportation safety issues include the total number of crashes, the crash frequency, the crash rates, the crash densities along roadways and intersections, roadway geometry, and the contributing crash factors.

5. Make safety a decision factor.
Prioritization is the process for evaluating and selecting individual transportation projects for inclusion in the transportation improvement program. DOTs and MPOs may use prioritization to allocate funds for safety-specific projects or to identify safety criteria to enhance the prioritization of safety in all transportation projects. The goals established in the long-range transportation plan serve in ranking, scoring, and selecting transportation projects, complemented by technical considerations.

Safety therefore should be a goal in the long-range transportation plan, with supporting objectives and policies. Technical criteria such as crash rates, crash severity, and crash totals should be identified to compare and score the safety of projects effectively. Key to success is collaborating with partner agencies early in the planning process to ensure that future projects include the appropriate safety elements when designed and constructed.

6. Monitor and evaluate transportation safety.
Monitoring and evaluation can occur at the network, corridor, goal, or project level to ensure programs and projects are on track and are implemented appropriately; to identify opportunities for course corrections to improve performance; and to provide feedback for improvements in the planning and programming process. Safety performance measures provide a reliable method for detecting and correcting problems, by allowing MPOs and state DOTs to monitor and evaluate the effectiveness of implementation and the safety impacts of improvements. At a minimum, states and MPOs should monitor the four performance measures required by MAP-21.

Other opportunities to approach and conduct monitoring and evaluation include creating a plan for monitoring and evaluation early in the planning process, to understand data availability, performance measures, and monitoring and evaluation responsibilities; building a tracking tool, such as an Excel spreadsheet, to simplify the tracking process; sharing the results with elected officials and stakeholders, possibly as an annual report; and using the results of before-and-after studies or road safety audits to inform future project and program selection.

MAP-21 requires state departments of transportation and metropolitan planning organizations to track performance measures, including road safety data.

Photo: AAA Foundation for Traffic Safety

Plans for specific issues, such as complete streets, transit, bicycles and pedestrians, and more, offer ways to address safety outside of strategic highway safety plans.

7. Include safety in planning programs and documents.
Many assume that the SHSP process will identify transportation safety goals, strategies, policies, objectives, and projects, but the SHSP is a strategic planning document, aimed at addressing the most critical, near-term safety issues. Several opportunities are available to address additional transportation safety issues outside the SHSP and to consider longer-term safety for motorized and nonmotorized users. One opportunity is to include a safety chapter in the long-range transportation plan as a guide for local agencies in considering safety in the context of transportation projects. Other opportunities include considering safety in stand-alone or modal plans to focus on specific issues, such as freight, bicycles and pedestrians, complete streets, transit, and corridors.

Next Steps

Every day, commuters expect their trips will be safe, whether by car, truck, public transportation, sidewalk, or bicycle. Although the general public makes this assumption, transportation planners cannot. To ensure safe transportation for all road users, planners should apply the seven steps: collaborate with safety professionals; identify goals and objectives; establish performance measures; identify available data and gaps; establish safety as a decision factor in setting priorities; monitor the safety benefits; and include safety in all planning activities.

Issues with Airport Organization and Reorganization

Finding the Perfect Organizational Structure for an Airport

KIMBERLY A. KENVILLE AND JAMES F. SMITH

Kenville is Professor and Graduate Program Director, Aviation, University of North Dakota, and Principal of Kim Kenville Consulting. Smith is principal, Smith-Woolwine Associates, Floyd, Virginia.

Managers from Colorado Springs Airport were among many who contributed insights on organizational structure, presented in ACRP Synthesis 40.

Airport managers face unprecedented political, environmental, and economic pressures. In the past decade, new challenges have included irregular operations, increased competition, changing regulatory issues, and economic pressures.

These external pressures have triggered changes in operations; in some cases, changes in business models and strategies have helped airports remain self-sustaining. Changing an organization's structure, however, requires sound leadership and high-level collaboration. Many airports are examining their internal organizational structures to rebalance workloads and identify outsourcing opportunities to improve efficiencies. Some are finding that a complete overhaul of their original organizational structure is warranted.

The Airport Cooperative Research Program (ACRP) undertook a synthesis study, which released ACRP Synthesis 40, *Issues with Airport Organization and Reorganization*.[1] The guiding principle from the research findings is that a well-understood and effective organizational structure can greatly assist an airport in meeting strategic, operations, and business goals and facilitate the delivery of core services.

PHOTO: MICHAEL SCHOENFELD, SALT LAKE CITY DEPARTMENT OF AIRPORTS

Case studies included small airports, as well as large, such as Salt Lake City International Airport.

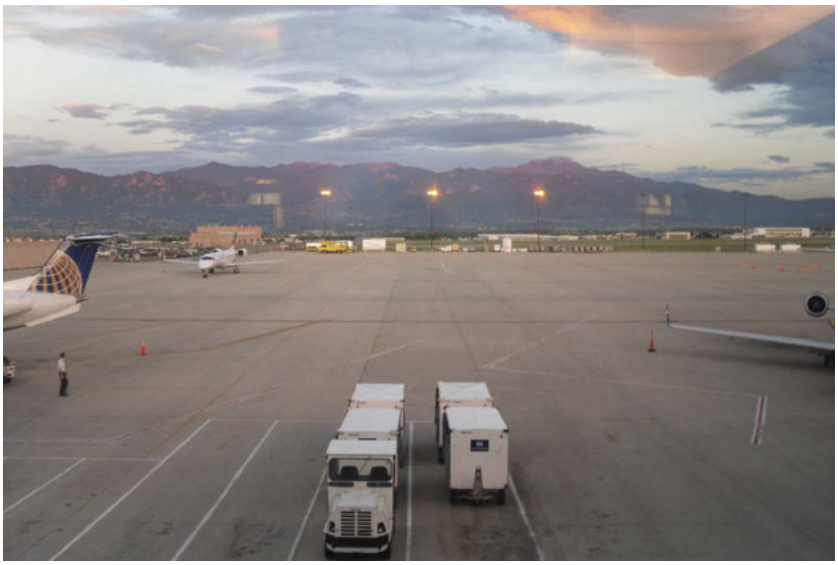


PHOTO: JAKE BARNARD, FLICKR

Study Methodology

The synthesis employed a mixed methodology to gain the most robust and useful information from airport managers. A quick first step was to request electronic copies of airport organizational charts; approximately 40 charts were received and catalogued. The majority of the organizational charts focused on functions.

After the review of the organizational charts, researchers designed a questionnaire based on the Three Sigma Corporation's indicators for change (see sidebar, page 55). Airport executives were asked to identify their type of governance structure, their type of organizational structure, the number of employees in their workforce, which employees or job functions were outsourced, and how they defined

[1] www.trb.org/Main/Blurbs/169008.aspx.

and determined organizational effectiveness and efficiency.

Twenty-two executives representing 36 airports completed the survey—a 100 percent response rate. The airports varied in size from 7 to 1,850 employees and represented each type of governance structure in each category of the Federal Aviation Administration's National Plan of Integrated Airport Systems.

After an analysis of the survey data, researchers selected five airports for a qualitative, in-depth interview. All five airports had experienced a recent significant change in organizational structure and were willing to share lessons learned from the change, along with advice to others initiating change in organizational structure and design. The five case study airports or airport systems were the Metropolitan Nashville Airport Authority, Tennessee; Louisville Regional Airport Authority, Kentucky; Salt Lake City International Airport, Utah; Rapid City Regional Airport, South Dakota; and the Colorado Springs Airport.

Indicators for Change

According to the Three Sigma Corporation, the following may indicate a need for an organizational redesign:[a]

- Change occurs in the strategy or strategic direction of the organization;
- New skills and capabilities are needed to meet current or expected operational requirements;
- Accountability for results is not clearly communicated and measureable, leading to subjective and biased performance appraisals;
- Parts of the organization are significantly over- or understaffed;
- Organizational communications are inconsistent, fragmented, and inefficient;
- Technology and innovation are changing workflow and production processes;
- Significant staffing increases or decreases are under consideration;
- Personnel retention and turnover are significant problems;
- Workforce productivity is stagnant or deteriorating; and
- Morale is deteriorating.

[a] www.threesigma.com/organizational_restructuring.htm.

Organizational Charts

Nearly all the airports employed a functional organizational structure, with jobs separated by departments—such as operations, maintenance, finance, administration, and development—functioning largely as independent silos. Represented graphically, these functions do not cross one another and have clear lines of authority. Larger airports generally exercised larger spans of control.

The organizational structures affected the number of full-time employees (FTEs). Nonhub and small hub airports that have municipal governance structures tended to purchase certain services such as accounting, legal, aircraft rescue and firefighting, and law enforcement, reducing the number of FTEs. This outsourcing allowed smaller airports more flexibility in human resources and budgets; the organizational

Photo: Port of San Diego

A K-9 officer and explosive detection canine perform a search at San Diego International Airport. Like many larger airport and port authorities, the San Diego Unified Port District has its own law enforcement authority; smaller airports use contractors.

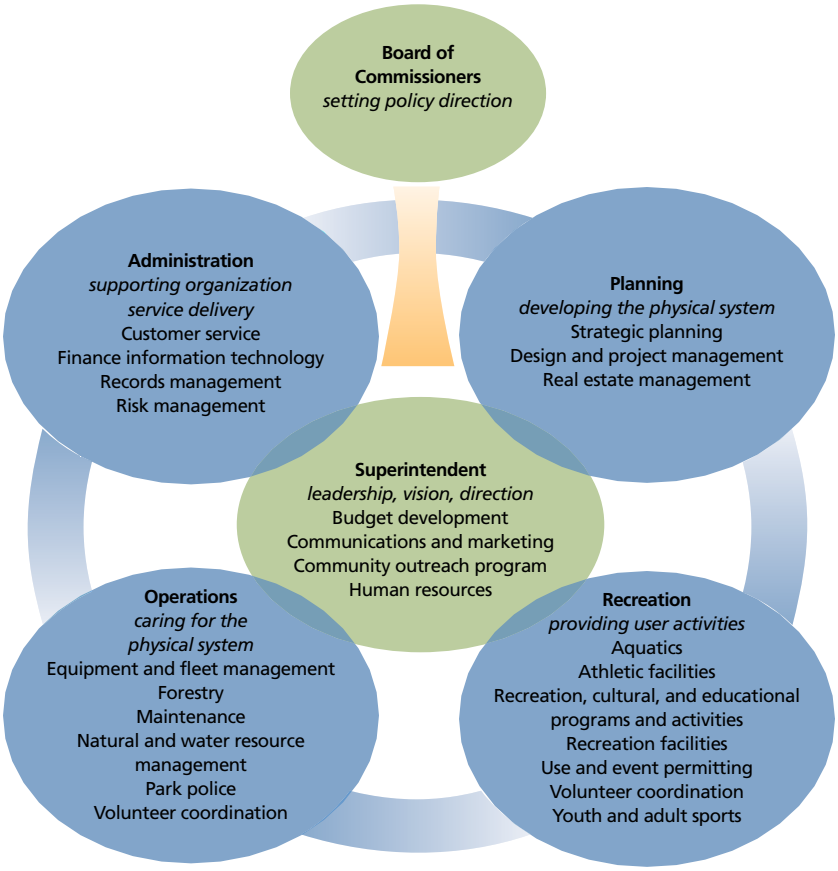


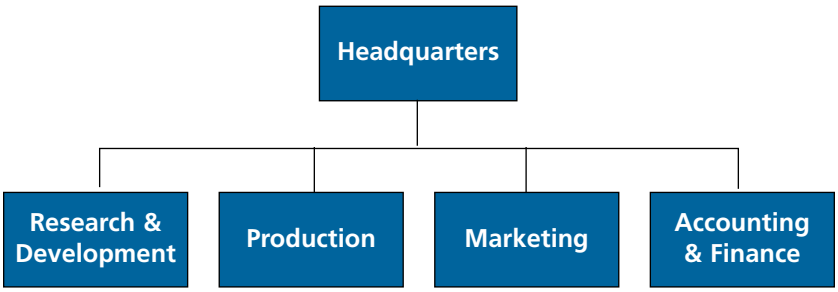
FIGURE 1 Team-based organizational chart: Minneapolis Parks Department.

charts were more concise and focused on operations and maintenance.

Conversely, authority-owned airports tended to assume all of the functional areas and therefore to have less outsourcing and a higher number of FTEs. The correlation between authority and number of FTEs prevailed regardless of the airport size.

Because most airports followed the functional model, the majority of organizational charts did not cross over at certain levels of finance, administration, customer service, and human resources. For example, the operations department interfaces with accounting on purchases or with human resources for the evaluation, hiring, or firing of employees. This universal element of day-to-day business practice was seldom represented clearly in the airports' organizational charts.

FIGURE 2 Functional organizational chart.



The typical organizational chart no longer suffices for most organizations. Many organizations are using teams and structures without boundaries, which is difficult to represent. For example, Figure 1 (left) depicts a team-based organizational structure; the circles represent lines of business, areas of work, or functions, but the connecting lines are less strong; the chart seems to convey that the circles must encompass one another to work together; on most functional organizational charts, these lines would connect at the next level (Figure 2, below left).

Additional Findings

Several issues emerged: a clear vision and strategic plan was critical in driving any organizational change—strategy should drive structure. Endorsement from the governing entity was essential; the primary role of the leadership was to involve key employees in determining the organizational structure that would best serve the new strategic business objectives. An overarching theme emerged from the case study interviews: initiating and implementing organizational change takes time; patience must prevail; and celebrating the small successes along the way is advisable.

Neither the literature nor the data address assessment metrics. At first, the assumption was that changes in an organization would be data driven; some of the changes are difficult to measure, however, or have no appropriate and accepted measurement. Airports often reported that no quantitative measurement was conducted before or after the change; instead, they relied on a qualitative assessment indicating that the change was an improvement for the organization.

Self-reported assessments like these, however, lack the validity of an established metric. ACRP Report 19A, *Resource Guide to Airport Performance Indicators*, is a valuable, practical guidebook that could be used more widely in the industry to establish a better understanding of how to measure and assess an airport's performance.[2]

Organizational Structures

The synthesis summarizes current practices in organizational design, indicators for change, assessment metrics, and other industry trends in organizational change, including the barriers to change. The report describes organizational structures that have evolved in the past 100 years of management science and reviews the advantages and disadvantages of each structure, yielding useful approaches for airport managers who face structural change in their orga-

[2] www.trb.org/Publications/Blurbs/165238.aspx.

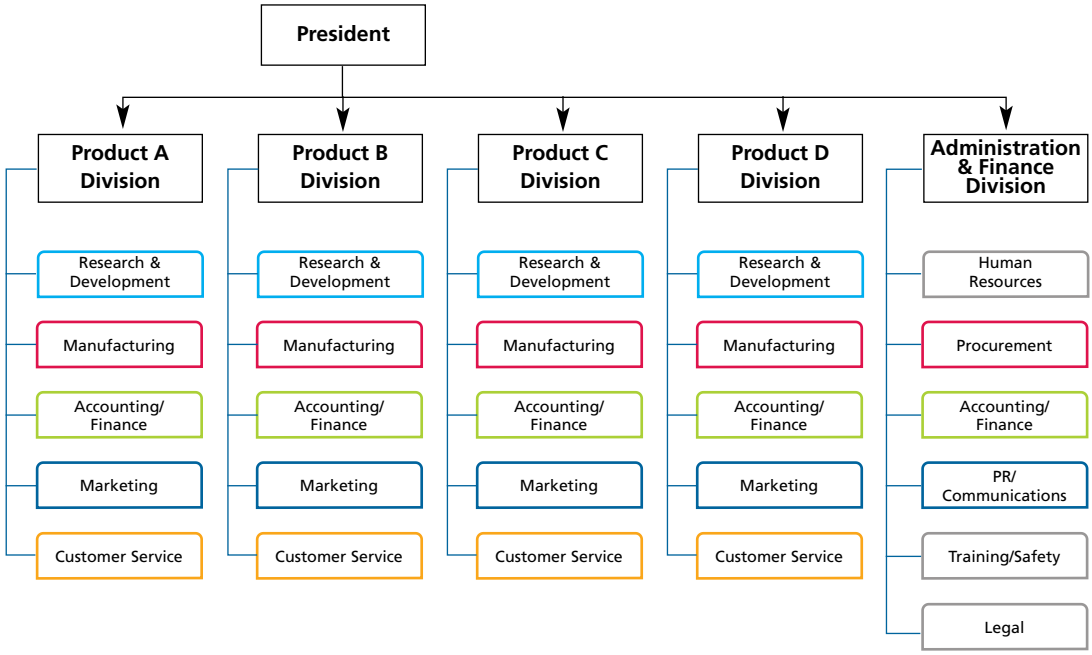


FIGURE 3 Sample divisional organizational chart.

nizations. The informal relationships within organizations and the impacts of change on organizational culture are also discussed.

The main types of organizational structures identified in the business literature range from conservative, centralized, and hierarchical to free-flowing, decentralized, and collaborative; in graphic representations of the structures, boxes and straight lines yield to circles and arrows. Each structure on the spectrum, from functional to division based to matrix, has advantages and disadvantages that airport managers can consider when restructuring.

These organizational structures are detailed in ACRP Synthesis 40. As organizations strive to represent graphically the connections needed to carry out core services, they are finding that conventional hierarchical structures often prohibit or confuse autonomy and teamwork both within and outside of the organization. Figures 2, 3, and 4 (page 56 and this page) represent organizational charts commonly found in the workplace.

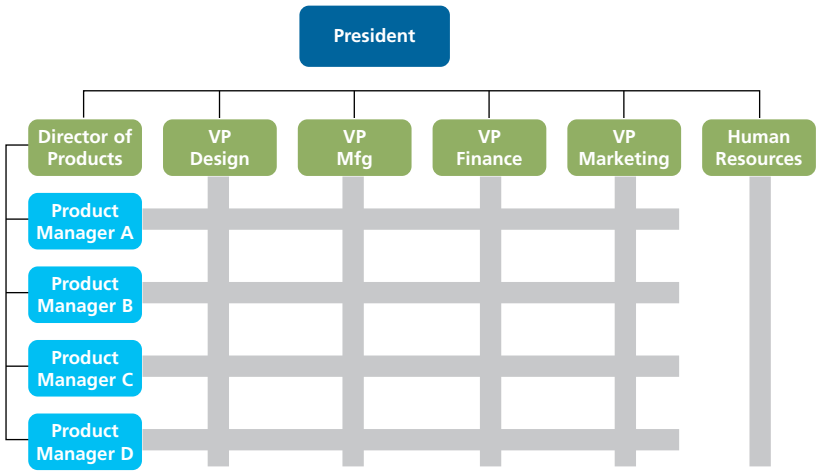
In summary, in the real world of airport management, a matrix-type structure is emerging (Figure 4), with departments interacting with other functional areas to achieve organizational flexibility. The disparity between conventional organizational charts and actual practice is driving much-needed change. The research indicates that an organization must establish a collaborative, cohesive culture, in which work groups function seamlessly.

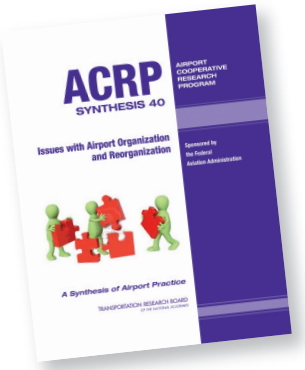
Flight Plan for Change

Drawing on findings from the organizational charts, the survey of airports, and the case study interviews, along with the literature on organizational design, structure, and strategy, researchers developed a flight plan for airport executives. Following are the steps critical for a cohesive organizational change; the process is not immediate and—as shown in some of the airport case studies—may require up to five years.

1. Review the airport's vision, mission and business strategy—its strategic objectives—and determine its core services.
2. Define what is triggering the need to change.
3. Determine what needs to be changed—or validate the current structure.
4. Gain support and endorsement from the governing entity to proceed.

FIGURE 4 Sample matrix organizational chart.





For more information on ACRP Synthesis 40, visit www.trb.org/Publications/Blurbs/169008.aspx.

5. Develop a strategic vision for the change with a realistic time frame. Case studies indicate that minor changes take approximately one year and major changes take approximately 3 to 5 years. Consult informally with airport managers.

6. Choose a metric for the assessment of conditions before and after the change. Describe the current organizational culture, to facilitate assessment after the change. For guidance in applying airport performance indicators, refer to ACRP Report 19A.

7. Assemble a team for the redesign. An external facilitator or organizational consultant may offer a fresh perspective; a realistic, objective assessment; and robust experience. Involving key staff from different levels of the organization can encourage organizationwide buy-in and expand awareness of the informal organizational structure. Two of the case studies indicated that employee teams can be used effectively in the change process, and the survey revealed that a yearly internal organizational analysis was common; both resources can help in determining the need for developing new processes and procedures. Inform and educate key staffers who are not on the design team about the communication processes, the informal organizational structure, the time frame for change, the expected outcomes, and organizational culture.

8. Review types of organizational structures with the design team (for example, see Figures 1–4).

9. Determine which organizational structure would be most suitable and identify changes to be developed and assignments to be divided among the employee groups. Review the literature, the critical considerations identified in the survey and case studies, and the administrative and the organizational barriers, formal and informal, to implementation.

10. Implement the change, focusing on the mission and vision; celebrate small successes.

11. Develop or redesign processes and procedures to facilitate organizational changes.

12. Continue training and education for staff.

13. Assess the culture and establish a feedback loop from employees.

14. Revisit the triggering variable and apply the chosen metric to evaluate the change.

Photo: Miami/Dade Aviation Department

Miami–Dade Aviation Director Emilio T. González meets with high-level officials to share information about major capital projects at Miami International Airport. Communication from airport leadership is key during reorganization and large projects.

Designing a New Strategy

ACRP Synthesis 40 provides airport managers with improved tools to help their organizations meet the changing needs of the airport industry. The synthesis examines relevant organizational design in the academic literature, along with current trends and practices in airport management. A discussion and synthesis of the literature with real-world experience, along with a flight plan for a successful strategy, aims to support airport leaders in aligning personnel and thriving in a rapidly changing environment.

Clearly, no "one size fits all" approach is applicable. Managers cannot simply copy and apply another airport's organizational chart. They need to create a strategy for their organization that optimally aligns the airport's core services and competencies and places employees to make a meaningful contribution to the organization.

Great pressures call for great measures. Airport managers can be proactive in the face of rapid change. A focused review of current practices, together with a thoughtful analysis of internal and external organizational issues, can help airport managers create organizations that will meet today's known challenges and be prepared for the unknown challenges of tomorrow.

Photo: Jimmy Emerson, Flickr

Rapid City Regional Airport in South Dakota was presented as a case study in ACRP Synthesis 40.

Preserving Georgia Pavements with Micromilling

DAVID M. JARED AND SHEILA HINES

Jared is Chief, Research and Development Branch, and Hines is State Bituminous Construction Engineer, Georgia Department of Transportation, Forest Park.

The Georgia Department of Transportation (DOT) has used open-graded friction course (OGFC) to maintain asphalt pavements on Interstate highways since the 1990s. This pervious friction course (PFC) is placed on the pavement surface to improve tire friction and surface drainage and to extend pavement life. In 2001, Georgia DOT introduced a different type of OGFC, known as porous European mix (PEM), now in use on most Interstate pavements.

Problem

Georgia's experience shows that PFCs provide good pavement performance for 10 to 12 years. When a PFC approaches the end of its service life, the underlying layer of dense-graded hot-mix asphalt or stone matrix asphalt (SMA) generally is still in good condition and could last for several more years.

Georgia DOT's rehabilitation practice is to mill and replace the PFC layer and the mixture beneath. This helps avoid (*a*) the poor bonding between PFC and milled surfaces and (*b*) the entrapment of water that penetrates through the PFC in the valleys created by milling. This procedure, however, is expensive; a cost-effective pavement maintenance procedure was needed, particularly as resources for pavement construction and maintenance diminish.

Solution

Georgia DOT initiated a research project to investigate micromilling for the removal of deteriorated OGFC. A team from the Georgia Institute of Technology and Auburn University conducted the research. The goal was to validate the stringent requirements that Georgia DOT had established for the surface texture and smoothness of the milled surface.

The requirements addressed the variations in surface texture and smoothness caused by the milling equipment. For surface texture, the requirements stipulated that the ridge and valley measurement of the mat surface should differ by no more than 1/16 in. (1.6 mm). The requirements also delineated the acceptance criteria and the contractor's liability if the criteria are not met. Georgia DOT specified a target smoothness index of 825 mm/km, not to exceed a correction index of 900 mm/km.

Micromilling operation.

I-75 Project

In 2007, the researchers investigated the micromilling of a deteriorated OGFC overlaid with PEM on I-75 near Macon; this was one of the first applications of PFC directly on top of a micromilled surface in the United States. Because micromilling equipment has more teeth at closer spacing than conventional milling equipment, micromilling produces a more uniform, smoother, and finer surface texture, which meets Georgia DOT's smoothness requirements for surface texture.

The placement of PEM on top of the milled surface without the addition of a new underlying layer of dense-graded mixture or of SMA has yielded significant cost savings. The researchers also investigated other technologies for surface texture quality assurance.

The study confirmed that the surface texture requirements established for the project were achievable and cost-effective with variable-depth

Variable-depth micromilled surface.

micromilling to ensure the complete removal of the PEM layer. The study also determined that the laser road profiler (LRP)—routinely used by Georgia DOT for quality acceptance of pavement smoothness—could be retrofitted with software that estimates surface texture parameters. These estimates would be suitable for use in the acceptance of surface texture quality and in the evaluation of pavement sections.

I-95 Project

In 2009, the micromilling and OGFC inlay on an I-95 project near Savannah was used to investigate the following:

◆ The applicability of micromilling for pavements with underlying layers different from those of the I-75 project,

◆ The viability of the measurements of surface texture and smoothness from the software-retrofitted LRP, and

◆ The stringency of the Georgia DOT surface texture requirements.

The study determined the following:

◆ Large cost savings can be realized by micromilling instead of conventional milling,

◆ The software-retrofitted LRP was capable of measuring both the surface texture and the smoothness of micromilled surfaces and therefore could be used as a tool for quality acceptance and performance measurement, and

◆ Variable-depth micromilling was necessary to ensure reasonable compliance with surface texture requirements, without sacrificing the milled surface texture or smoothness.

Application

The I-75 project achieved Georgia DOT's surface texture and smoothness requirements with variable-depth micromilling. The I-95 project, however, did not achieve the requirements; scabbing of the OGFC occurred—thin, weakly bonded layers remained in place—because a single milling depth had been specified. Georgia DOT approved a change order permitting variable-depth micromilling on the project and achieved the surface texture requirements. Variable-depth micromilling subsequently was used on a project on I-285 in metropolitan Atlanta.

Micromilling is a promising pavement preservation option for PFCs that have sound underlying pavement structures—that is, projects that have no load-related failures or failures associated with the underlying materials. The I-75 project area experienced and still shows reflective cracking from the underlying portland cement concrete; nonetheless, there are no indications of premature raveling or load-related failures.

Benefits

The research produced several findings that would benefit Georgia DOT and other highway agencies, including the following:

◆ Micromilling in conjunction with thin asphalt overlays is an effective pavement preservation treatment.

◆ Variable-depth micromilling provides the required surface texture without sacrificing milled surface texture and smoothness.

◆ The LRP can measure both surface texture and smoothness on micromilled surfaces and can serve as a tool for quality acceptance and performance measurement.

In addition, Georgia DOT has accrued cost savings from this preservation treatment. Replacing conventional milling with micromilling on the two Interstate projects saved an estimated $11 million—nearly 50 times the expenditures for the research. After 4 to 7 years in service, both projects have shown good performance.

For more information, contact Sheila Hines, State Bituminous Construction Engineer, Office of Materials and Testing, Georgia DOT, 15 Kennedy Drive, Forest Park, GA 30297; 404-608-4700; shines@dot.ga.gov.

EDITOR'S NOTE: Appreciation is expressed to Amir Hanna and G. P. Jayaprakash, Transportation Research Board, for their efforts in developing this article.

Suggestions for Research Pays Off topics are welcome. Contact G. P. Jayaprakash, Transportation Research Board, Keck 488, 500 Fifth Street, NW, Washington, DC 20001 (202-334-2956; gjayaprakash@nas.edu).

TRB Meetings

June

24–26 Innovative Technologies for a Resilient Marine Transportation System: 3rd Biennial Research and Development Conference
Washington, D.C.

29–July 2 North American Travel Monitoring Exposition and Conference (NATMEC): Improving Traffic Data Collection, Analysis, and Use
Chicago, Illinois

July

7 Geosynthetics in Roadway Design
Laramie, Wyoming

7–11 7th International Conference on Bridge Maintenance, Safety, and Management*
Shanghai, China

9–11 5th International Conference on Surface Transportation Financing: Innovation, Experimentation, and Exploration
Irvine, California

10 9th Strategic Highway Research Program Safety Symposium
Washington, D.C.

13–16 53rd Annual Workshop on Transportation Law
San Francisco, California

15–17 Automated Vehicles Symposium
San Francisco, California

15–18 9th International Conference on Short and Medium Span Bridges*
Calgary, Alberta, Canada

20–23 GeoHubei International Conference*
Hubei, China

20–24 Alternative Intersections and Interchanges Symposium
Salt Lake City, Utah

21–23 14th National Conference on Transportation Planning for Small and Medium–Sized Communities: Tools of the Trade
Burlington, Vermont

23–24 Workshop on the Value of Transportation Infrastructure
Washington, D.C.

August

3–8 Global Level Crossing Safety and Trespass Prevention Symposium*
Urbana–Champaign, Illinois

11–13 Istanbul Bridge Conference*
Istanbul, Turkey

11–13 Symposium Celebrating 50 Years of Traffic Flow Theory*
Portland, Oregon

18–22 NURail and Summerail Conference*
Altoona, Pennsylvania

25–27 15th Biennial Harbor Safety Committee and Area Maritime Security Committee Conference
Philadelphia, Pennsylvania

25–28 4th International Symposium on Naturalistic Driving Research
Blacksburg, Virginia

26–29 Transportation-Related Environmental Analysis Summer Conference
Nashville, Tennessee

September

15–17 Transportation and Federal Land Partnership Enhancing Access, Mobility, Sustainability, and Connections to the American Great Outdoors
Washington, D.C.

15–18 Pavement Evaluation 2014*
Blacksburg, Virginia

21–24 6th Biennial Northeast Transportation and Wildlife Conference*
Burlington, Vermont

25–27 2nd International Conference on Access Management*
Shanghai, China

29–Oct. 1 European Transport Conference*
Frankfurt, Germany

October

14–16 International Symposium on Pavement Life Cycle Assessment
Davis, California

26–29 21st National Conference on Rural Public and Intercity Bus Transportation: Setting Our Course for the Future*
Monterey, California

For additional information on TRB meetings, including calls for abstracts, meeting registration, and hotel reservations, visit www.TRB.org/calendar, call 202-334-2934, fax 202-334-2003, or e-mail TRBMeetings@nas.edu.

*TRB is cosponsor of the meeting.

Theodore K. Dahlburg

Delaware Valley Regional Planning Commission

A longtime fascination with the role of cities in transportation and culture propelled Theodore K. Dahlburg into a career in freight planning. As manager of the Office for Freight and Aviation Planning for the Delaware Valley Regional Planning Commission (DVRPC), Dahlburg integrates freight and aviation considerations into the commission's long-term plans and programs, promotes strategies to maximize the benefit of freight and aviation activity, and manages technical studies.

"We face critical challenges in urban freight transportation delivery systems and practices," Dahlburg observes, noting that for the first time in history, more than half of the planet's inhabitants reside in urban areas. He oversees the work of the DVRPC Freight Advisory Committee, established in response to the Intermodal Surface Transportation Efficiency Act of 1991 to engage the region's freight stakeholders. Through quarterly meetings and other events, the committee has gathered representatives from the trucking and railroad industries, ports, shippers, state departments of transportation, federal transportation agencies, and more. He also led a 2006 project to conduct a 24-hour scan of local freight operations, analyzing data from more than 50 transportation companies.

"Freight is being balanced with other community goals—air quality and complete streets, for example—and projects are being built that help freight move more safely and efficiently."

"It's immensely gratifying to see the tangible progress and difference the Freight Advisory Committee makes," Dahlburg notes. "Local planners now have greater awareness about freight operations and bottlenecks in their county or city. Freight is being balanced with other community goals—air quality and complete streets, for example—and projects are being built that help freight move more safely and efficiently."

After graduating with an art history degree from West Chester University in Pennsylvania, Dahlburg received a master's degree in city and regional planning at Rutgers University. In 1986, he joined the Delaware County Planning Department in Pennsylvania, where he conducted public transportation studies, briefed elected officials, and ranked highway projects. Eager for the opportunity to work in planning for the nation's sixth-largest metropolitan region, Dahlburg began working as a transportation planner at DVRPC, the Philadelphia area's metropolitan planning organization, two years later.

Early in his research career, Dahlburg documented the progress of a single shipping container—carrying unroasted coffee beans from Brazil to Canada—as it moved through the Philadelphia, Pennsylvania, region via ship, truck, and train. "This journey was a great eye-opener about the global economy and intermodalism," he recalls.

Dahlburg was chosen to lead DVRPC's new freight planning program in 1992. He worked to identify previously overlooked National Highway System connectors and to incorporate ports, airports, and intermodal rail terminals into planning. In 2012, he expanded his focus to aviation when the freight and aviation planning units were combined. Dahlburg currently oversees the development of the Delaware Valley Freight Transportation Mapping Application and Freight Data Platform—also known as PhillyFreightFinder—a web-based tool to promote awareness about the region's interconnected freight facilities and to provide a foundation for freight performance measures. A 2010 workshop on future freight flows has intensified efforts to coordinate long-term public- and private-sector goals.

"Freight transportation and economic development are powerfully linked, and jobs are of paramount importance to counties, cities, and municipalities in the region," Dahlburg comments. DVRPC has catalogued 44 major freight centers in the Delaware Valley region, an important step to understanding the needs and supply chains of local areas. Recently, he participated in City Logistics Research: A Transatlantic Perspective, a joint TRB–European Union symposium on European and North American logistics solutions.

Dahlburg is chair of the Urban Freight Transportation Committee, which he joined in 2010, and a member of the Freight Systems Group. He also was a member of the Intermodal Freight Transport Committee from 2001 to 2010. He served on the second Strategic Highway Research Program's Technical Expert Task Group on Integrating Freight Considerations into Collaborative Decision Making for Additions to Highway Capacity, as well as the National Cooperative Freight Research Program Project Panel on Capacity and Level-of-Service Analysis for Trucks.

"Limited funding for transportation improvements makes research critical," Dahlburg affirms. "Sound research also is what elected officials ultimately rely on to make the wisest and best decisions." He cites collaborative efforts between the Urban Freight Transportation Committee and other standing committees in developing such initiatives as Freight Day and promoting the adoption of innovative practices.

Robert Benton McGennis

HollyFrontier Refining & Marketing, LLC

Transportation research is the common thread that ties together the two parts of Bob McGennis' career: first, disseminating research results as a civil engineer in asphalt materials research, and, later, as a technical manager at HollyFrontier Refining & Marketing, LLC, translating research results into practice.

After he graduated from the University of Texas at Austin (UT Austin) with a bachelor's degree in civil engineering, McGennis worked for the Austin District of the Texas State Department of Highways and Public Transportation. The practice of basic civil engineering—hydraulic design, geometric design, and asphalt pavement design and construction—had a profound effect on his career. In 1980, McGennis received a job offer from Tom Kennedy, his former professor, to help investigate pavement performance problems on I-10 in southeast Texas. While working at UT Austin, McGennis pursued a master's degree in civil engineering, which he completed in 1981.

"The years of experience I have gained in evaluating transportation research data have better equipped me to understand my own experimental results and what they reveal."

"It was only a matter of time until I was introduced to the world of TRB," McGennis recalls. He joined the Flexible Pavement Construction and Rehabilitation Committee in 1984, and in 1989 became its chair. He served as chair of the Characteristics of Asphalt Materials Committee from 2004 to 2008 and of the Asphalt Materials Section from 2008 to 2014. Twice he has been a member of the Design and Construction Group Executive Board; recently, he led the Design and Construction Group subcommittee responsible for selecting the group paper awards.

"My TRB activities have been among the most rewarding of my career. Participation in TRB has afforded me the opportunity to work with and learn from the most respected individuals in the pavements and materials technical community," McGennis notes.

McGennis joined the Asphalt Institute in 1983 as a Texas district engineer, providing engineering and educational assistance to a range of asphalt users, from government agencies to private industries. After serving as central regional engineer and directing five district engineers covering 21 states, McGennis became director of Research and Engineering Services at the Asphalt Institute's headquarters in Lexington, Kentucky.

"It was an exciting time to be working in asphalt technology," McGennis comments. "The first Strategic Highway Research Program (SHRP) was nearing completion and its research products were ready to be implemented." The Federal Highway Administration (FHWA) selected the Asphalt Institute as the site of the National Asphalt Training Center (NATC), which aimed to train agency and industry personnel in the new Superpave® mix design system developed under SHRP, and McGennis directed the $1.2 million project. He guided efforts in asphalt binder and mixture training and conducted early implementation research for the system.

"We conducted the early ruggedness experiments for the Superpave gyratory compactor, a laboratory device that remains at the center of the system," McGennis recalls. "I was fortunate to lead the NATC team, an extraordinary group of technicians and engineers." He published many of his research results in the *Transportation Research Record: Journal of the Transportation Research Board*, including "Evaluation of Physical Properties of Fine Crumb Rubber-Modified Asphalt Binders" (1995), "Issues Pertaining to the Use of the Superpave Gyratory Compactor" (1996), "Evaluation of Materials from Northeast Texas Using Superpave Mix Design Technology" (1997), and "Comparative Analysis of Volumetric Properties for Superpave Gyratory Compactors" (2000).

In 1998, McGennis began working in Phoenix, Arizona, for HollyFrontier Refining and Marketing, an independent petroleum refiner. As Asphalt Technical Manager, he supervises the quality control testing activities of three accredited laboratories and develops formulations for various asphalt paving and emulsion products. He also provides engineering support for manufacturing operations, technical marketing, and user agencies.

"Participation in the transportation research community has made me better qualified to accomplish many of the day-to-day duties of my job. The years of experience I have gained in evaluating transportation research data have better equipped me to understand my own experimental results and what they reveal," McGennis notes, citing his experience and involvement with TRB as vital in sharing effective asphalt technologies. "I have discovered that if you provide practicing engineers with good information, they will make good decisions."

A registered professional engineer in Texas, Arizona, and New Mexico, McGennis is a life member and past president of the Association of Asphalt Paving Technologists. He also is a member of the FHWA Asphalt Binder Expert Task Group and the committee at Arizona State University that organizes the Arizona Pavement and Materials Conference.

New Space, New Opportunities for TRB Annual Meeting Exhibitors

MARK R. NORMAN AND RUSSELL W. HOUSTON

Norman is Director, Technical Activities, TRB. Houston is Assistant Executive Director, TRB, and manages Annual Meeting exhibits and marketing opportunities.

For the first time in almost 60 years, the TRB Annual Meeting will be moving to a new venue. TRB's 94th Annual Meeting will be held at the Walter E. Washington Convention Center in Washington, D.C., January 11–15, 2015. This is the third in a series of articles about the move.

Expanded Room for Exhibits

"Corridors to the Future: Transportation and Technology" is the theme for the 2015 TRB Annual Meeting. Consistent with the theme, the move to the Convention Center will provide attendees with an unparalleled opportunity to see first-hand innovative products and services from transportation businesses and organizations. No longer under constraints for space, the TRB Annual Meeting exhibit hall will expand impressively.

Enhancements for attendees and exhibitors will include the following:

- More available and more contiguous exhibit space,
- Accommodations for display vehicles and large exhibits,
- The vibrancy and energy of having all attendees under one roof,
- A modern facility with state-of-the-art technology,
- Improved lighting and higher ceilings for a more open and active atmosphere,
- Better, more visible signage for easier navigation, and
- Food and beverage options in the exhibit hall.

The exhibit hall is located adjacent to the popular "Meet the Author" poster sessions. The exhibits will open with a kickoff reception in the afternoon of Sunday, January 11, and will continue through Tuesday, January 13.

Booth sales are expected to open in June 2014 for TRB sustaining affiliates and for exhibitors with priority points. Booth sales will open in July for all companies and organizations. In recognition of the new venue, all companies and organizations exhibiting at the TRB 2015 Annual Meeting will be awarded double priority points.

Valued Advisers

The TRB Exhibitor Advisory Council has provided advice on the Annual Meeting Exhibits for several years, facilitating communication between exhibitors and TRB, reviewing exhibit-related policies, and representing the interests of the TRB Annual Meeting exhibitors. The members have contributed to the success of the Annual Meeting exhibits:

- Jason Watts, Marketing Manager, AgileAssets Inc.;
- Carol Fisher, Business Development Specialist, AMEC;
- Norman Hunt, President, CoVal Systems;
- Glen Weisbrod, President, EDR Group (TREDIS Software);
- Jami Harmon, Marketing Communications Manager, Geophysical Survey Systems, Inc.;
- Larry Bauer, Architectural Representative, SINAK Corporation;
- Julie Sikora, Journals Marketing Manager, Taylor and Francis; and
- Alex Gerodimos, President, TSS–Transportation Simulation Systems.

For more information on exhibiting at the TRB Annual Meeting, visit the TRB website at www.TRB.org, click on "TRB Annual Meeting," and go to "Exhibits and Marketing Opportunities."

Photo: Walter E. Washington Convention Center

The new, larger exhibit hall at the 2015 TRB Annual Meeting will be adjacent to the poster sessions and will feature better signage and state-of-the-art technology.

Real-Time Transit Information Reaps Rewards

GRAHAM CAYWOOD AND SHANA JOHNSON

TransitScreen, a transportation software and digital sign company, received top honors in the Six-Minute Pitch Transportation Start-Up Challenge at the TRB 93rd Annual Meeting in Washington, D.C., in January. TransitScreen, which specializes in real-time transit information displays, produces a live display of all transportation options at a specific location—bus, train, bikeshare, rideshare, and carshare.

TransitScreen technology was developed through a fellowship program with Mobility Lab in Arlington County, Virginia, a public research and development organization focused on advancing the practice of transportation demand management.

In the Six-Minute Pitch, four young transportation entrepreneurs propose a new transportation technology product or service—in six minutes or less—to a panel of industry entrepreneurs and investors. Presenters are judged on the commercial feasibility of their proposal and how their product or service brings transportation research into practice and meets critical transportation challenges.

Sponsored by the TRB Young Members Council, the competition was organized by 2013 winners Susan Paulus, Lakeside Engineers, and Robert Rodden, American Concrete Pavement Association. A panel of judges—Gabe Klein, Urban Land Institute; Sean O'Sullivan, Carma; and Rodden—provided immediate feedback on the market potential and business model of each proposal, as well as the incorporation of innovative technologies or techniques.

Caywood is Communications Director and cofounder of TransitScreen, Dallas–Fort Worth, Texas. Johnson is Senior Transportation Planner, Foursquare Integrated Transportation Planning, Inc., Rockville, Maryland, and served as moderator of the Six-Minute Pitch.

IMAGE: TRANSITSCREEN

A TransitScreen display for K and 15th Streets in Washington, D.C., includes information on bikeshare availability as well as approaching buses and Metro trains.

"TransitScreen is an outgrowth of the collaborative consumption economy. The world is changing," noted Klein, former transportation commissioner for the City of Chicago and former director of the District of Columbia Department of Transportation, in a radio interview with the Washington, D.C., National Public Radio affiliate.[1] He added that TransitScreen would be useful outside Metro stations, which typically lack electronic data about nearby modes, as well as inside stations, so that travelers exiting a train can review their modal connections.

In April, TransitScreen launched SmartWalk, a digital display of real-time transit information to be projected on sidewalks or walls that incorporates traditional signs and information about local landmarks, directions, distances, and opening and closing times.[2]

[1] http://wamu.org/news/14/04/21/taking_transit_ information_off_mobile_devices_and_onto_public_displays.
[2] http://www.fastcodesign.com/3028960/slicker-city/smartwalk-turns-any-public-surface-into-a-subway-tracker.

PROMOTING SAFETY— Charlie Williams II, Center for Offshore Safety, discusses safety culture at the first meeting of the Committee on Offshore Oil and Gas Industry Safety Culture Framing Study. The committee gathered April 29–30 at the National Academies' Keck Center in Washington, D.C., to identify the essential characteristics of a strong safety culture; industry barriers to achieving this culture and ways to overcome the barriers; and effective measurement and assessment strategies. The study, a project of TRB and the National Research Council's Division of Behavioral and Social Sciences and Education, is expected to be completed in late 2015.

IN MEMORIAM

John A. Clements 1930–2014

John A. Clements, former commissioner of the New Hampshire Department of Transportation (DOT), died April 2014 in Croydon, New Hampshire. He was 83.

Clements served as DOT commissioner for more than a decade and under three governors: Meldrim Thomson, Jr.; Hugh Gallen; and John Sununu. An advocate for transportation research, Clements served as chair of the TRB Executive Committee in 1985. He also was a member of the 1981 National Research Council Technical Review Panel for Truck Size and Weight, the committee that developed the National Cooperative Highway Research Program's 1994 strategic plan, and many other TRB committees and panels.

Clements served as the Federal Highway Administration's Associate Administrator for Research and Development and as Director General of the Pan American Highway Institute. He also represented the United States in several international transportation research organizations. Past president of the American Association of State Highway and Transportation Officials, Clements sat on the board of directors of the America Public Works Association and the American Road and Transportation Builders Association. In 1986, he received the George S. Bartlett Award for his outstanding contributions to highway progress. He was a longtime member of the Road Gang in Washington, D.C.

Clements was born in 1930 in Hyannis, Massachusetts, and received a bachelor's degree from Yale University. He served as a U.S. Navy explosive ordnance disposal officer during the Korean War. He held many private-sector positions throughout his career as well—president, Highway Users Federation; vice president of firearms manufacturing, Sturm, Ruger & Co. Inc.; vice president, New Hampshire Ball Bearings; vice president, Parsons Brinckerhoff; and chair, New Hampshire Business and Industry Association.

COOPERATIVE RESEARCH PROGRAMS NEWS

Potential Strategic Plan for Cooperative Rail Research


Research Results Digest 1

The first Research Results Digest of the National Cooperative Rail Research Program (NCRRP) defines a potential strategic plan and research agenda for the program if additional funding is forthcoming. One of many active rail research programs in the country, NCRRP has focused on matters of policy, economics, and institutions, and the report assumes that this will continue.

The plan and agenda presented are based on a review of recent rail research and on the results of interviews with more than 60 railroad stakeholders who were asked to identify key opportunities and problems facing the industry. Areas in which research is needed to produce cost-effective results include the following:

- Assuring safe and efficient management of railroad capacity, particularly in the case of shared rights of way;
- Facilitating and accelerating railroad project delivery;
- Developing the railroad workforce;
- Promoting innovation in funding and financing rail projects and operations;
- Increasing the ridership on regional and commuter passenger services;
- Promoting and facilitating freight rail services to reduce highway congestion, save energy, and reduce environmental impacts;
- Developing and deploying strategies and technologies for enhancing safety; and
- Developing and deploying advanced methods and materials for railroad design, rehabilitation, and maintenance.

2014; 15 pp.; TRB affiliates, $15.75; nonaffiliates, $21. Subscriber categories: railroads; passenger transportation.

PHOTO: NHTSA

Child safety seats reduce traffic deaths by more than 70 percent for infants and by more than 50 percent for toddlers.

Children's Traffic Safety Shows Few Improvements

Children 14 years of age and younger accounted for 1,168 traffic fatalities in the United States in 2012—or 3 percent of the nation's total 33,561 fatalities. This number represents a 3 percent increase from 2011, according to the National Highway Traffic Safety Administration (NHTSA). Traffic-related injuries of children 14 years of age and younger totaled 169,000, a slight decrease from the previous year.

Children comprise 19 percent of the total U.S. resident population; data from the National Center for Health Statistics show that in 2009 motor vehicle crashes were the leading cause of death for children age 4 and between the ages of 11 and 14. Twenty percent of the children killed in traffic accidents in 2012 were passengers in a vehicle with an alcohol-impaired driver.

From 2003 to 2012, the number of child fatalities decreased by 45 percent, according to NHTSA. The largest decrease was seen in the 8- to 14-year-old group, with 53 percent fewer fatalities than in 2003. Although traffic deaths in the 1- to 3-year-old group have decreased since 2003, they increased between 2011 and 2012.

More than one-fifth of the children killed in traffic who were under age 14 were pedestrians. Since 2003, child pedestrian deaths have dropped by 34 percent to a total of 389 in 2012. The number of children killed in bicycle and tricycle accidents also declined, from 130 in 2003 to 58 in 2012.

Forty percent of children fatally injured in crashes were not wearing car restraints such as seat belts, lap belts, or child safety seats. According to NHTSA, research has shown that child safety seats reduce fatal injury by 71 percent for infants under 1 year old and by 54 percent for toddlers ages 1 to 4.

For more information, see www-nrd.nhtsa.dot.gov/Pubs/812011.pdf.

Racial Bias Found in Driving Behavior

An experiment testing drivers' behavior toward pedestrians of different races at street crossings showed that, on average, twice as many cars drove past black pedestrians, who waited 32 percent longer to cross than white pedestrians.

The controlled field test was conducted by the Oregon Transportation Research and Education Consortium over five days in fall 2013 at an unsignalized midblock marked crosswalk in downtown Portland. Six trained research team associates—three white males and three black males, similar in age and build and wearing identical outfits—each crossed the street at the crosswalk 15 times.

Trained observers recorded the number of cars that drove by or stopped and noted the time that passed before a driver yielded. All trials took place in clear, mild weather during off-peak hours with free-flowing traffic. If pedestrians not involved with the experiment arrived in the crosswalk, the data were recorded but were not included in the analysis.

Ninety pedestrian trials involving 168 driver subjects showed that 52 percent of the time, the first car to approach the crosswalk stopped. The average number of cars to pass by before one stopped was 1.49 for all the test subjects; the average wait until a car yielded was 8.57 seconds. But for the black pedestrians, an average of 2.02 drivers passed by without stopping, and the average wait to cross was 9.79 seconds. For white pedestrians, .98 drivers passed by, and the average wait time was 7.40 seconds.

For the full report, visit http://ppms.otrec.us/media/project_files/TRF_Crosswalkpaper_Final.pdf.

Tracking the Status of Virginia's Historic Bridges

In 2001, the Virginia Center for Transportation Innovation and Research (VCTIR) produced a plan for the management and treatment of 54 public bridges in Virginia that were eligible or listed on the National Register of Historic Places. For a formal update, VCTIR collected information on the current status of the 54 bridges, including major maintenance or rehabilitation, damage, deterioration, or demolition since 2001.

In the intervening decade, 37 bridges were repaired or rehabilitated, three were closed to public access, three were demolished, one was damaged by flooding, and one was dismantled and stored. Twelve bridges had not undergone any major changes. Six bridges were placed on the National Register: Wolf

Humpback Bridge, a National Historic Landmark in Virginia.

Photo: Wikimedia Commons

(continued from page 67)

Creek Bridge in Rocky Gap, Appomattox River Bridge, Clarkton Bridge in Charlotte County, Crab Run footbridge in Highland County, Overall Bridge in Page County, and Hibbs Bridge in Mountville.

Humpback Bridge, a wooden, trussed-arch covered pedestrian bridge over Dunlap Creek near Covington, was designated a National Historic Landmark in 2012. Built in 1857, it is the only remaining example of a trussed-arch covered bridge in the country.

For the full report, visit www.virginiadot.org/vtrc/main/online_reports/pdf/14-r9.pdf.

INTERNATIONAL NEWS

Surveys Document Gender-Based Travel Differences in India

Women in Indian cities travel shorter distances than their male counterparts, depend on lower-cost modes of travel, and link their trips for multiple purposes, according to data presented by the International Transport Forum (ITF) of the Organisation for Economic Co-operation and Development. Household surveys were performed in Delhi, India's capital and home to 16.4 million people, and in Vishakhapattanam, a southern Indian city with a population of 1.7 million. The Delhi surveys focused on low-income settlements.

According to the data, walking is the primary mode of transportation for the vast majority of low-income women in Delhi—whether the women are employed (86 percent) or unemployed (87 percent). Thirteen percent of employed women and 8 percent of unemployed women report that they use buses as their primary mode of transportation—by contrast, nearly 30 percent of employed, low-income men in Delhi ride the bus. Bicycle use is negligible among the Delhi women surveyed.

Walking is the main mode of transportation for 71 percent of female travelers in Vishakhapattanam. Thirteen percent of women ride the bus and 5 percent use motorized two-wheelers—for men, these figures are 21 and 23 percent, with 35 percent of men walking. Trip distances for most women tend to be 3 miles or less, with 71 percent of all trips 1 mile or less.

Photo: Shawn Allen

A bus outside Delhi, India. Among the city's low-income employed, nearly a third of men but less than 15 percent of women ride buses.

Although men travel longer distances, travel times for men and women are similar, since men more frequently use motorized transportation. Across all income groups, women cite religious and education trips as their primary purposes for travel; for most men, work is the primary trip purpose, according to the surveys.

For the full report, visit www.internationaltransportforum.org/jtrc/DiscussionPapers/DP201404.pdf.

Road Safety Improvements Do Not Extend to Vulnerable Users

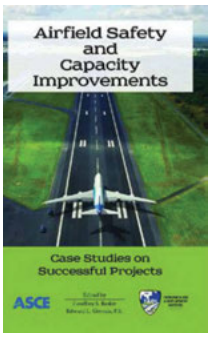
Road safety policies do not necessarily improve the protection of vulnerable road users, although the number of road fatalities fell by 1.7 percent between 2011 and 2012 in the 31 countries covered by the International Road Traffic and Accident Database (IRTAD), an ITF analysis concludes.

Between 2000 and 2012, annual road deaths have declined by nearly 40 percent, with 45,000 fewer per year in the 31 countries. Approximately 1.3 million traffic fatalities occur annually, mostly in emerging economies. Since 2009, however, road deaths among pedestrians, cyclists, and motorcyclists have plateaued and, in some cases, have increased. Larger numbers of elderly road users in many IRTAD countries also have led to an increase in the share of fatalities among road users age 65 and older. The share of deaths in this age group exceeded 30 percent for European IRTAD countries in 2012; in Japan, the share of traffic fatalities among the elderly was approximately 55 percent.

In 2012, Denmark, Norway, Sweden, the United Kingdom, and Iceland reduced their annual traffic fatalities to three or fewer per 100,000 people. The countries that experienced traffic fatalities of more than 10 per 100,000 people in 2012 included the United States, Korea, Chile, Jamaica, Argentina, Colombia, Cambodia, and Malaysia, which reported 23.6 deaths per 100,000 people.

For more information, visit www.internationaltransportforum.org/Press/PDFs/2014-05-21-IRTAD.pdf.

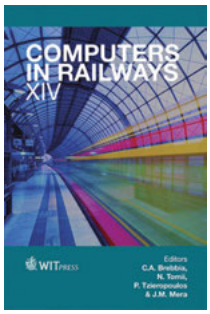
Airfield Safety and Capacity Improvements: Case Studies on Successful Projects



Edited by Geoffrey S. Baskir and Edward L. Gervais. American Society of Civil Engineers (ASCE), 2013; 104 pp.; ASCE members, $45; nonmembers, $60; 978-07-8441-256-5.

Presented in this volume are six case studies on planning, engineering, and managing major construction projects at active airports. Challenges addressed by airports in the United States and overseas include access to and from airport operating areas, logistics, staging, short-term lighting and signs, airline–airport communications, and more.

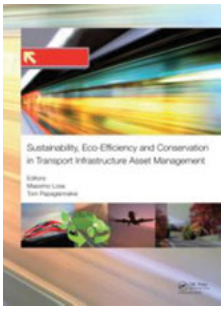
Computers in Railways XIV: Railway Engineering Design and Optimization



Edited by C. A. Brebbia, N. Tomii, P. Tzieropoulos, and J. M. Mera. WIT Press, 2014; 940 pp.; $808; 978-18-4564-766-7.

This book comprises the proceedings of an international conference on railway engineering design and optimization and encourages the use of advanced systems in business management, design, manufacture and operation of railways and other emerging passenger, freight, and transit systems. Topics covered include train control systems, computer techniques and simulations, timetable planning, and more.

Sustainability, Ecoefficiency, and Conservation in Transportation Infrastructure Asset Management

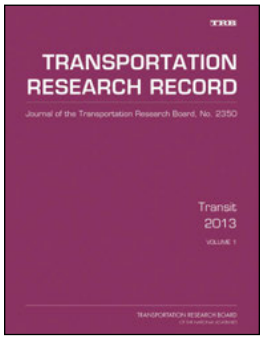


Edited by Massimo Losa and Tom Papagiannakis. CRC Press, 2014; 800 pp.; $339; 978-11-3800-147-3.

Efficient planning and the design, construction, and maintenance of transportation facilities and infrastructure assets are explored in this volume. Paper topics include advanced modeling tools, emerging technologies and equipment, ecofriendly design and materials, reuse or recycling of resources, case studies, and more.

The titles in this section are not TRB publications. To order, contact the publisher listed.

TRB PUBLICATIONS



Transit 2013, Volume 1
Transportation Research Record 2350

New rail hubs along a high-speed rail corridor in California, the promotion of public transport and nonmotorized transport, disaggregate ridership elasticity, airport railways ridership, and a framework for innovative public spaces are among the topics explored in this volume.

2013; 142 pp.; TRB affiliates, $53.25; nonaffiliates, $71. Subscriber category: public transportation.

Transit 2013, Volume 2
Transportation Research Record 2351

Authors present research on transit fleet resource allocation, benchmarking disaggregate customer satisfaction scores of bus operators, intraurban rail access, dynamic system optimal routing, pedestrian route choice of vertical facilities in subway stations, doing business around transit corridors, and more.

2013; 170 pp.; TRB affiliates, $56.25; nonaffiliates, $75. Subscriber category: public transportation.

Transit 2013, Volume 3
Transportation Research Record 2352

Examined in this volume are the implementation costs of electric transit bus systems, where to implement bus signal priority in mixed-mode operations, a transit assignment model incorporating bus dwell time, planning dial-a-ride services, general-public demand-responsive transit, and more.

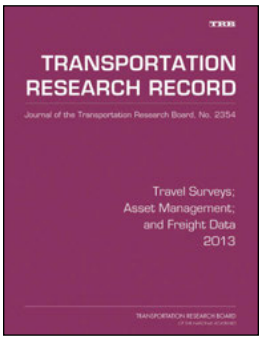
2013; 154 pp.; TRB affiliates, $56.25; nonaffiliates, $75. Subscriber category: public transportation.

Transit 2013, Volume 4
Transportation Research Record 2353

Among the subjects presented in this volume are accelerated transit operations, disruption recovery in passenger railways, automatic data for applied railway management, measurement of subway service performance, and factors that influence urban streetcar ridership in the United States.

2013; 106 pp.; TRB affiliates, $48.75; nonaffiliates, $65. Subscriber category: public transportation.

TRB PUBLICATIONS *(continued)*



Travel Surveys; Asset Management; and Freight Data 2013
Transportation Research Record 2354

Quantification of key errors in household travel surveys, the effects of question type on transit rider expressions of policy preferences, the development of a smartphone-based travel survey, and route choice characteristics for truckers are among the subjects presented in this volume.

2013; 132 pp.; TRB affiliates, $53.25; nonaffiliates, $71. Subscriber categories: administration and management; freight transportation.

Traffic Signal Systems 2013, Volume 1
Transportation Research Record 2355

Authors present research on cycle length, optimizing traffic signal timing, estimating queue lengths at signalized intersections, exit lanes for left-turn traffic, controller upgrade decision making, and more.

2013; 104 pp.; TRB affiliates, $47.25; nonaffiliates, $63. Subscriber categories: operations and traffic management; safety and human factors; pedestrians and bicyclists.

Traffic Signal Systems 2013, Volume 2
Transportation Research Record 2356

Adaptive signal control in Germany, a coordinated optimization model for transit priority control under arterial progression, and a statistical study of the impact of adaptive traffic signal control on traffic and transit performance are some of the topics examined in this volume.

2013; 126 pp.; TRB affiliates, $48.75; nonaffiliates, $65. Subscriber categories: operations and traffic management; safety and human factors; pedestrians and bicyclists.

Performance Indicators, Sustainability, and Socioeconomic Factors 2013
Transportation Research Record 2357

Subjects investigated in this volume include the Greenroads rating system, environmental justice for minority and low-income populations, transit-oriented development and household transportation costs, and germane time use.

2013; 133 pp.; TRB affiliates, $53.25; nonaffiliates, $71. Subscriber categories: policy; environment; society.

The TRR Journal Online website provides electronic access to the full text of approxiately 14,000 peer-reviewed papers that have been published as part of the Transportation Research Record: Journal of the Transportation Research Board *(TRR Journal) series since 1996. The site includes the latest in search technologies and is updated as new TRR Journal papers become available. To explore the TRR Online service, visit www.TRB. org/TRROnline.*

Highway Design 2013
Transportation Research Record 2358

The papers in this volume cover such topics as the safety impacts of design exceptions on nonfreeway segments, an evaluation of wheat straw wattles in ditch check installations, and green infrastructure design for pavement systems.

2013; 87 pp.; TRB affiliates, $47.25; nonaffiliates, $63. Subscriber categories: design; hydraulics and hydrology.

Carsharing; Demand Management; and Parking 2013
Transportation Research Record 2359

Addressed in this volume are parking patrol surveys, smart parking systems, parking utilization in neighborhood shopping centers on transit routes, dynamic ridesharing systems, travel behavior of carsharing members, and the effect of carshares on travel behavior.

2013; 84 pp.; TRB affiliates, $45.75; nonaffiliates, $61. Subscriber categories: public transportation; administration and management; policy.

Maintenance and Preservation 2013, Volume 1; Including 2013 Thomas B. Deen Distinguished Lecture
Transportation Research Record 2360

"A Holistic Approach to Transportation Infrastructure Maintenance and Preservation," the 2013 Thomas B. Deen Distinguished Lecture by John P. Broomfield, is included in this volume, along with papers on bridge preservation by action type, modeling hurricane hazards and damage on Florida bridges, and other topics.

2013; 83 pp.; TRB affiliates, $45.75; nonaffiliates, $61. Subscriber categories: maintenance and preservation; bridges and other structures.

Maintenance and Preservation 2013, Volume 2
Transportation Research Record 2361

A cross-asset resource allocation framework for achieving performance sustainability, public opinions about roadway assets, and chloride deicer corrosion on highway maintenance equipment are among the topics presented in this volume.

2013; 113 pp.; TRB affiliates, $48.75; nonaffiliates,

TRB PUBLICATIONS *(continued)*

$65. Subscriber categories: maintenance and preservation; operations and traffic management; safety and human factors.

Renewable Energy Guide for Highway Maintenance Facilities
NCHRP Report 751

Offered in this volume is guidance for the application of renewable energy technologies to the heating and cooling, lighting, and electrical power requirements of highway maintenance facilities.

2013; 239 pp.; TRB affiliates, $57; nonaffiliates, $76. Subscriber categories: highways; energy; maintenance and preservation.

Improved Mix Design, Evaluation, and Materials Management Practices for Hot-Mix Asphalt with High Reclaimed Asphalt Pavement Content
NCHRP Report 752

Described in this volume are proposed revisions to the American Association of State Highway and Transportation Officials (AASHTO) R 35, Superpave Volumetric Design for Hot-Mix Asphalt, and AASHTO M 323, Superpave Volumetric Mix Design, to accommodate the design of asphalt mixtures with high reclaimed asphalt pavement contents.

2013; 152 pp.; TRB affiliates, $51; nonaffiliates, $68. Subscriber categories: highways; construction; materials.

Highway Safety Research Agenda: Infrastructure and Operations
NCHRP Report 756

Proposed in this volume is an agenda of prioritized safety research needs in highway infrastructure and operations, with options for directing research to areas that can benefit the most. A CD-ROM is included with the print publication and is available for download.

2013; 92 pp.; TRB affiliates, $51; nonaffiliates, $68. Subscriber categories: highways; research; safety and human factors.

Long-Term Performance of Epoxy Adhesive Anchor Systems
NCHRP Report 757

This report describes guidelines and specifications for standard test methods, design, and quality assurance and construction in the use of adhesive anchor systems in transportation structures.

2013; 268 pp.; TRB affiliates, $60; nonaffiliates, $80. Subscriber categories: bridges and other structures; construction; materials.

Trip Generation Rates for Transportation Impact Analyses of Infill Developments
NCHRP Report 758

Presented in this volume is a procedure for analyzing potential vehicular trip generation impacts in urban and urbanizing locales.

2013; 45 pp.; TRB affiliates, $33; nonaffiliates, $44. Subscriber categories: highways; economics; planning and forecasting.

State Department of Transportation Fleet Replacement Management Practices
NCHRP Synthesis 452

With a discussion of the perceived strengths and weaknesses of various management and financing methods, this synthesis explores the current state of the practice in fleet replacement management and financing methods by state departments of transportation.

2014; 42 pp.; TRB affiliates, $33; nonaffiliates, $44. Subscriber categories: administration and management; highways.

State Bridge Load Posting Processes and Practices
NCHRP Synthesis 453

This volume compiles U.S. state government practices regarding highway bridges and culverts restricted to vehicle weights below legal loads, or load-posted structures—identifying the structures, evaluating safe load capacities, and implementing the restrictions.

2014; 136 pp.; TRB affiliates, $51; nonaffiliates, $68. Subscriber categories: bridges and other structures; highways.

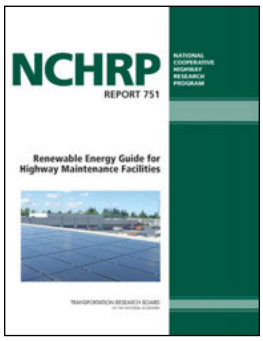
Measuring PM Emissions from Aircraft Auxiliary Power Units, Tires, and Brakes
ACRP Report 97

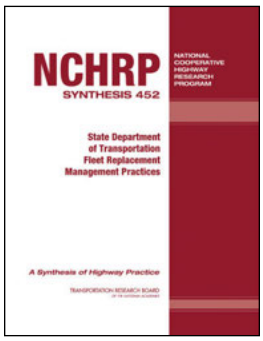
Examined in this volume are the results of a comprehensive test program designed to measure particulate matter emissions from auxiliary power units and from tires and brakes during the landing phase of operation of in-service commercial aircraft.

2013; 43 pp.; TRB affiliates, $33; nonaffiliates, $44. Subscriber categories: aviation; environment.

Understanding Airline and Passenger Choice in Multi-Airport Regions
ACRP Report 98

This report addresses the business models airlines use to establish service in regions with multiple airports and explores how passengers select an airport within a multiairport region.





To order TRB titles described in Bookshelf, visit the TRB online Bookstore, at www.TRB.org/bookstore/, or contact the Business Office at 202-334-3213.

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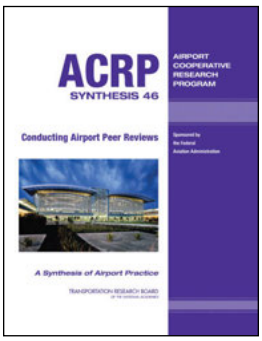

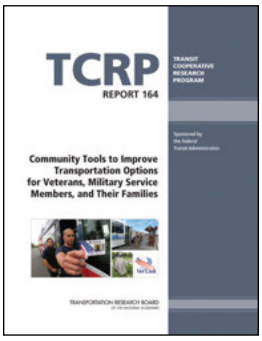

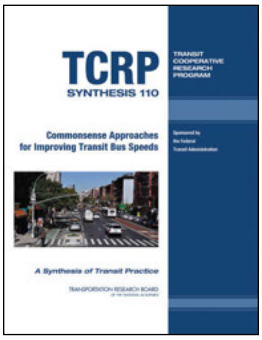

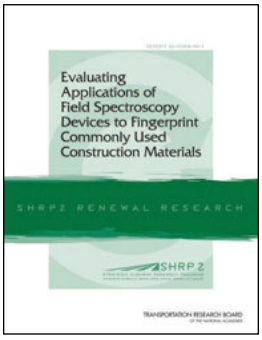

2013; 100 pp.; TRB affiliates, $43.50; nonaffiliates, $58. Subscriber categories: aviation; passenger transportation; planning and forecasting.

Guidance for Treatment of Airport Stormwater Containing Deicers
ACRP Report 99

Presented in this volume is a process to help airports identify, select, and implement technologies to treat stormwater that has been affected by deicing materials, as well as suggestions for designing, operating, and maintaining the technologies.

2013; 322 pp.; TRB affiliates, $63; TRB nonaffiliates, $84. Subscriber categories: aviation; environment.

Recycling Best Practices: Guidebook for Advancing Recycling from Aircraft Cabins
ACRP Report 100

This report describes procedures for recycling airport, airline, and flight kitchen waste and includes action plans designed to improve recycling and reduce waste disposal costs for airports.

2013; 78 pp.; TRB affiliates, $41.25; nonaffiliates, $55. Subscriber categories: aviation; administration and management; education and training; environment; maintenance and preservation.

Conducting Airport Peer Reviews
ACRP Synthesis 46

This volume presents the range of peer review approaches used by airport sponsors, identifies similar efforts outside the airport industry, and documents effective practices and challenges in conducting peer reviews.

2013; 40 pp.; TRB affiliates, $33; nonaffiliates, $44. Subscriber categories: administration and management; aviation.

Repairing and Maintaining Airport Parking Structures While in Use
ACRP Synthesis 47

Provided is information on developing and implementing successful maintenance and repair strategies for in-use airport parking structures while creating the least impact on an airport's patrons, revenue stream, and facility operations.

2013; 46 pp.; TRB affiliates, $34.50; nonaffiliates, $46. Subscriber categories: aviation; terminals and facilities.

Community Tools to Improve Transportation Options for Veterans, Military Service Members, and Their Families
TCRP Report 164

By building on the concepts of transportation coordination and mobility management, this volume explores ways to enhance transportation options for veterans, military service members, and their families and provides guidance and tools to assess the transportation needs of these groups.

2014; 228 pp.; TRB affiliates, $56.25; nonaffiliates, $75. Subscriber category: public transportation.

Commonsense Approaches for Improving Transit Bus Speeds
TCRP Synthesis 110

This synthesis examines the approaches transit agencies have taken to increase average bus speeds and identifies metrics such as changes in travel speed, operating cost, and ridership.

2014; 156 pp.; TRB affiliates, $51; nonaffiliates, $68. Subscriber categories: economics; public transportation; operations and traffic management.

Evaluating Applications of Field Spectroscopy Devices to Fingerprint Commonly Used Construction Materials
SHRP 2 Report S2-R06B-RR-1

Documented in this volume are evaluation results of practical, portable spectroscopic equipment for in situ analysis of a range of commonly used construction materials.

2013; 253 pp.; TRB affiliates, $39; nonaffiliates, $52. Also available as e-book. Subscriber categories: construction; highways; materials.

A Multivariate Analysis of Crash and Naturalistic Driving Data in Relation to Highway Factors
SHRP 2 Report S2-S01C-RW-1

In the second phase of the second Strategic Highway Research Program Safety Project S01C, a multivariate analysis was conducted on crash and naturalistic driving data in relation to highway factors. A geographic information system framework was used to fuse multiple information sources in analyzing road departure crash risk.

2013; 64 pp. Subscriber categories: highways; safety and human factors. Available at http://onlinepubs.trb.org/onlinepubs/shrp2/SHRP2_S2-S01C-RW-1.pdf.

INFORMATION FOR CONTRIBUTORS TO

TR NEWS

TR News welcomes the submission of manuscripts for possible publication in the categories listed below. All manuscripts submitted are subject to review by the Editorial Board and other reviewers to determine suitability for *TR News*; authors will be advised of acceptance of articles with or without revision. All manuscripts accepted for publication are subject to editing for conciseness and appropriate language and style. Authors receive a copy of the edited manuscript for review. Original artwork is returned only on request.

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◆ All manuscripts should be supplied in 12-point type, double-spaced, in Microsoft Word, on a CD or as an e-mail attachment.

◆ Submit original artwork if possible. Glossy, high-quality black-and-white photographs, color photographs, and slides are acceptable. Digital continuous-tone images must be submitted as TIFF or JPEG files and must be at least 3 in. by 5 in. with a resolution of 300 dpi. A caption should be supplied for each graphic element.

◆ Use the units of measurement from the research described and provide conversions in parentheses, as appropriate. The International System of Units (SI), the updated version of the metric system, is preferred. In the text, the SI units should be followed, when appropriate, by the U.S. customary equivalent units in parentheses. In figures and tables, the base unit conversions should be provided in a footnote.

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