NUMBER 313

JANUARY–FEBRUARY 2018

TR NEWS

Marine Transportation and the Environment

Trends and Issues

Plus:

Findings from the State Partnership Visits

Public Health Response to Major Marine Oil Spills

Insights for Civil Space Success

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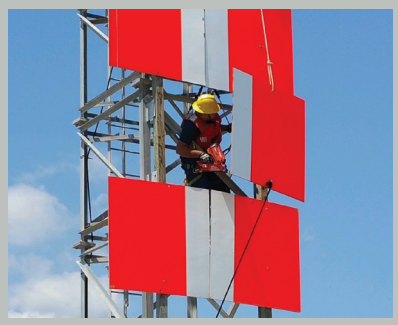

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COVER: Warming seas have opened up the Arctic Circle to travel. Authors examine regulatory frameworks and innovations to mitigate the environmental impact of increased marine transportation. (Photo: Chris Parker, Flickr)

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.

***TR News* is produced by the Transportation Research Board Publications Office**
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TR News (ISSN 0738-6826) is issued bimonthly by the Transportation Research Board, 500 Fifth Street, NW, Washington, DC 20001. Internet address: www.TRB.org.

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Subscriptions: North America: 1 year $75; single issue $19. Overseas: 1 year $100; single issue $19 plus shipping. Inquiries or communications concerning new subscriptions, subscription problems, or single-copy sales should be addressed to the Business Office at the address below, or telephone 202-334-3216, fax 202-334-2519. Periodicals postage paid at Washington, D.C.

Postmaster: Send changes of address to TR News, Transportation Research Board, 500 Fifth Street, NW, Washington, DC 20001.

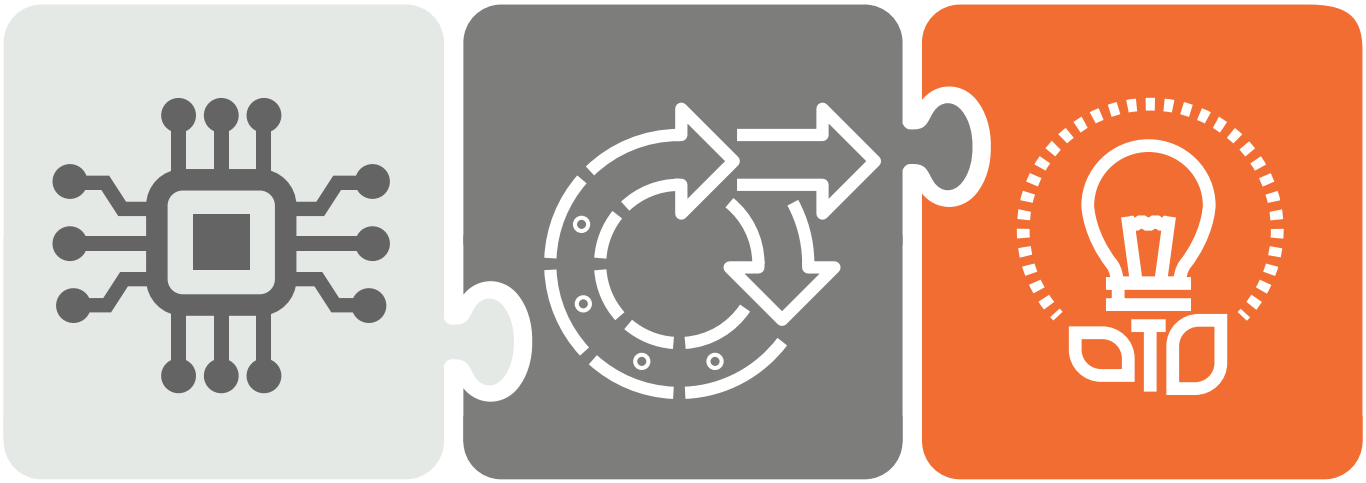
ALSO IN THIS ISSUE:

COMING NEXT ISSUE

Already in use in the construction industry, 3-D printing technology can change the way transportation infrastructure is designed, constructed, and maintained. Author Mohammad Khan examines the history and progress of 3-D printing and automated construction and the applications of these technologies to transportation. Also presented are insights from the development of Hyperloop One, a commercial travel prototype consisting of a levitation system; propulsion, power, and electronics systems; controls; vacuum structures; and an autonomous pod—as well as a vision for the future of intercity travel. Other articles offer an overview of the work of the Gulf Research Program of the National Academies of Sciences, Engineering, and Medicine, and a look at the 2018 TranspoCamp event, an "unconference" that convenes researchers and practitioners interested in urban transportation and technology. The March–April *TR News* also includes photos from the TRB 97th Annual Meeting in January.

PHOTO: KAREN FEBEY

TranspoCamp facilitates onsite development of session topics based on interest from attendees. The January 2018 event, which immediately preceded the 2018 TRB Annual Meeting in Washington, D.C., included such topics as accessibility, shared mobility, autonomous vehicles, and safety.



PREPARING FOR THE FUTURE, BUILDING RESILIENCE

FINDINGS FROM THE TRANSPORTATION RESEARCH BOARD'S 2017 STATE PARTNERSHIP VISITS PROGRAM

The Technical Activities Division of the Transportation Research Board (TRB) conducts the State Partnership Visits Program, in which TRB staff visit state departments of transportation (DOTs), university transportation centers, transit and other modal agencies, and private industry. The purpose of these visits is to exchange information on what TRB is doing to foster transportation research, as well as on what the states are researching and how they are implementing completed research. Founded in 1945, the partnership visits program has a rich tradition of strengthening the bond between TRB and its state sponsors.

TRB recruits staff from all facets of the transportation field. Senior program officers are chosen based on their education and experience in one or more areas of interest to the TRB community. Besides engineers, TRB staff includes planners, writers, historians, attorneys, economists, mathematicians, geologists, geographers, and political scientists. Most staff officers have professional experience in their field of expertise in the public or private sector or both. They bring detailed knowledge of their chosen field to TRB, including knowledge of current issues and trends that might affect state DOTs.

The Partnership Visits Program's annual cycle begins with a questionnaire, sent to DOTs in each state and in the District of Columbia. Agencies are asked what areas of transportation they would like to focus on during the visit; TRB staff members are selected based on their experience in these focus areas, as well as on their recent state visit history. Each TRB staff member is assigned two or three states each year and develops visit plans with the DOT's state representative to TRB. Staff members are rotated among states to avoid repetition; indeed, it has been said that if one works at TRB for about 20 years, they will have an opportunity to visit every state in the country.

State visits last one or two days and typically consist of face-to-face meetings with upper management; discussions with DOT staff involved in various topic areas; exchanges of issues and ideas; and, often, a visit to DOT facilities or sites of ongoing projects. Technical Activities Division staff members have contributed to the following summary of the issues covered in the 2017 state visits.

PHOTO: COAST GUARD NEWS, FLICKR

U.S. Coast Guard crews repair navigational aids after Hurricane Harvey. Preparing infrastructure to withstand extreme weather continues to pose a challenge for transportation agencies.

Planning

The field of planning faces a crossroads: establishing performance goals that guide current transportation plan development and making preparations to accommodate a rapidly changing transportation future. State DOTs, transit agencies, and metropolitan planning organizations are developing performance-based plans, performance measures, and targets in accordance with federal law and regulations. Several critical deadlines for establishing performance targets occur in early 2018 and are therefore a predominant focus. Agencies recognize the benefits of performance-based planning and management in creating efficient transportation project planning and delivery.

Another area of focus among planning agencies is preparing for future automation in transportation, particularly for connected and automated vehicles (CAVs). As it becomes more commonplace for online applications to dispatch mobility services and for drones to deliver everything from packages to pizza, many transportation agencies envision a largely automated future.

The transformation of automation often is visualized in phases—from CAV 1, or some automation in vehicles, to CAV 5, or fully engaged automation with no driver assistance. The question no longer is whether transformation will occur, it is when the various phases will take place—and, more importantly, what the government's role is in preparing for them.

Although state DOTs are enthusiastic about the benefits of transformational technologies, practitioners and members of the academic community have many unanswered questions as to how governments should prepare for the arrival of the technologies. Issues prompting research include the impacts of automation on land use and the potential for sprawl; workforce impacts; and equity of access, particularly for low-income and other underserved populations.

For many planning organizations, one last area of focus is planning for resiliency. The ability of infrastructure to withstand the devastation of extreme weather events is a vexing concern for many states and large metropolitan areas. Planning for emergencies requires collaboration among a variety of public-sector agencies. Technology can provide a critical communications link between organizations and the public they serve.

Data

Technology advances are increasingly important to state DOTs—technology was the most-requested area of expertise for the 2017 state visits. Because quality data are expensive and time-consuming to maintain, many states are developing data business plans to guide their investments both in data collection and in staff costs to manage the data.

The correlation of different data sources is a vital concern, as is developing a better understanding of how data are used in policy decisions. Both the timeliness of data and the use of understandable formats are key factors in the successful deployment of transportation data.

Big data and data analytics are emerging issues for many states. The new governor of Iowa, Kim Reynolds, has made data analytics a statewide priority and has asked Iowa DOT to lead that effort. Recruiting and maintaining DOT staff with data-management capabilities remains a challenge.

Aviation

The potential for changes to the management of the U.S. air traffic control system, and the implications of these changes, continue to cause heated debate throughout the aviation community. State DOTs, which own many airports, are trying to better understand how general-aviation airports may be affected and what role they and other stakeholders will play if air traffic control management shifts from public to private.

Photo: Tomas del Coro, Flickr

Shifts in air traffic control from the public to private sector is a topic of debate in the aviation industry.

States also are absorbing more roles and responsibilities for unmanned aircraft system operations and are seeking innovative ways to use the technology to help support various services, including inspection, maintenance, and mapping—while managing the challenges of ensuring and enforcing safe operations in the vicinity of airports and populated communities.

Freight

As state DOTs look for innovative approaches to enable efficient freight mobility, many are incorporating plans to research, test, and implement various technology solutions as part of state freight strategic plans. Alabama DOT has identified a list of eleven available technologies in its statewide freight plan that best serve freight mobility—among them adaptive signals, vehicle detection systems, and weigh-in-motion equipment.

Idaho DOT also is exploring freight-enabling technology, with a pilot that will outfit several intersections with the ability to leverage vehicle-to-infrastructure technologies—for example, the use of radar technologies to capture information on types and levels of traffic, particularly freight traffic. Practices such as delayed-yellow timing when trucks are identified can reduce red-light violations, helping to mitigate congestion and increase safety. The Idaho Statewide Freight Plan also contains several projects to extend weigh-in-motion capabilities by upgrading technology in both mobile enforcement units and fixed pavement locations.

Texas DOT's Freight Advanced Traveler Information System (FRATIS) demonstration project is being deployed in the Dallas–Fort Worth area and along the I-35 corridor. To optimize truck drayage operations, FRATIS facilitates the real-time sharing of information between terminal operations, vehicle dispatchers, and truckers, and provides information on terminal queue times, optimal routing, construction, traffic delays, and weather.

Ports and Waterways

Although the popular notion is that most U.S. seaports are gearing up for the age of the megaship and for surges of containers, many small- and medium-sized ports are leveraging their particular state and regional markets to vary their portfolios and to thrive as niche ports for certain commodities.

At the Port of Mobile, Alabama, the volatility of the coal market has prompted the maintenance of

Photo: Idaho DOT

Idaho's weigh-in-motion technology captures and records the weight of vehicles traveling at normal traffic speed, allowing trucks to bypass weigh stations.

Photo: Corey Templeton, Flickr

The Eimskip cargo ship *Skogafoss* departs Portland Harbor, Maine. Through tailored facilities and business processes, the Port of Portland has developed strong regional supply chain relationships with Eimskip and with local retailers like L.L. Bean.

a diverse portfolio, ranging from steel and forest products to bulk liquids and frozen poultry. Using an automated handling system at its purpose-built Pinto Island Terminal, the port has the unique capacity to transload finished steel slabs directly from ships to barges. This one-of-a-kind facility was developed specifically to serve an Alabama steel mill located roughly 50 miles from the port. The port's ability to react to this regional economic development opportunity was key to the steel mill's decision to locate in Alabama.

Similarly, at the Port of Portland, the Maine Port Authority has established regional supply chain relationships with Maine-based outdoor outfitter L.L. Bean as well as with Iceland-based carrier Eimskip, which handles refrigerated products such as imports of frozen fish from Northern Europe and exports of frozen Maine lobsters. In both instances, by tailoring its facilities, operations, and business processes to provide more efficient service for these niche product supply chains, the Port of Portland was able to lure business from other East Coast ports.

Rail

Shipments of crude oil by rail continued to decline in 2017, as petroleum market price fluctuations and pipeline construction placed downward pressure on this form of traffic. Traditionally a traffic staple for the railroads, coal production continued its decade-long drop—although there are signs that the rate of decline may be slowing. The loss of rail traffic in these markets has been partially offset by increases in intermodal, automotive, and merchandise traffic. Service issues continue to plague the industry as the large railroads try to cut costs and as calls for new economic regulation continue.

The upcoming year will pose challenges, with the upcoming deadline for implementation of positive train control (PTC). Although railroads and transit agencies have spent millions of dollars to prepare for the deadline, accidents that might have been prevented by PTC continue to occur. The mandate for electronically controlled pneumatic brakes on certain trains was rescinded after studies found that

Photo: Clint, Flickr

Loss of rail traffic from declines in coal production has occurred along with the challenges of cost-cutting and new regulations.

the benefits of the technology do not outweigh the costs and disruption associated with it.

In many parts of the country, state-supported passenger service continues to be successful—service is expanding and new equipment is being acquired. Amtrak welcomed new leadership in 2017 and ridership remains strong. Planning and construction for new intercity services—some of them high-speed—continued in Florida, Texas, and California.

Public Transportation

State DOTs are evaluating ways to take advantage of transportation network companies (TNCs) and are discussing the evolution and potential impact of TNC regulation. States also must determine the best way to engage with TNCs and are considering the relationship between TNCs and public transportation. The District of Columbia DOT curbside management program is weighing "transportation hubs"—consolidating bus stops, bikeshare stations, and taxi and TNC pick-up and drop-off locations.

State DOTs also are examining possible CAV impacts on the transportation network and continuing to invest in public transportation. In Oklahoma, transit is a major consideration in city revitalization and in facilitating accessible and livable communities. As part of a downtown revitalization project, Oklahoma City is installing a new streetcar system and also has begun to study the potential of automated streetcars. The District of Columbia DOT is exploring an innovative, data-driven transit planning process to prioritize infrastructure and route-level improvements.

Several TRB committee members were invited to participate in a research peer exchange with Florida DOT that focused on emerging technologies, automated vehicles, and big data. Participants included staff from TRB, the American Association of State Highway and Transportation Officials, the Federal Highway Administration, the Federal Transit Administration, state DOTs, universities, and private-sector firms. The theme of the peer exchange was to discuss state DOT research roadmaps in the context of national activities and emerging technologies, exploring how a state program can be aware and relevant in a fast-paced national environment.

Florida is home to at least six CAV test beds in Florida, with an estimated 11 more across the country. The City of Gainesville, Florida DOT, and the University of Florida have launched a joint endeavor to manage an advanced traffic-control test bed in Gainesville—one that accommodates automated vehicles in the traffic mix. In conjunction with the University of Florida and Florida DOT, the Hillsborough Area Regional Transit Authority will begin testing an automated shuttle bus this year. The City of Jacksonville is modifying its fixed-guideway people-mover to provide access to other automated vehicles.

Photo: Washington Area Bicyclist Association, Flickr

District of Columbia DOT is considering installing transportation hubs, with bus stops, bikeshare stations, and taxi services all accessible in one location.

Environment, Energy, and Climate Change

Recent declines in staffing levels are prompting state DOTs to evaluate how best to meet environmental goals and requirements. Now that states can assume the responsibility for National Environmental Policy Act review and approval processes under SAFETEA-LU and MAP-21, many state DOT environmental departments are learning from the experience of early adopters as they evaluate ways to meet the increasing demand for streamlined business practices.

Technological tools also are being explored further—not only to examine the future environmental impacts of transportation projects, but also to analyze existing impacts more effectively and potentially to reduce them. From drones and lidar used in monitoring to analyzing impacts with geographic information systems and other improved modeling tools to facilitating the use of alternative power sources such as solar, electricity, and hydrogen, states are talking collectively about the challenges and opportunities posed by these new and improving technologies in the field of environmental mitigation.

Legal

Attorneys representing state DOTs handle myriad legal matters that range from routine to extraordinarily complex in subject areas including environmental law; eminent domain; permitting; contracts, from routine procurements to multimillion-dollar construction projects; civil rights; statutory and regulatory drafting; and driver and vehicle issues.

Oregon DOT employees relocate fresh creek mussels in advance of a bridge project. State DOTs must evaluate the environmental impacts of transportation projects.

Photo: Oregon DOT

In keeping with the priorities of their clients, state DOT attorneys are engaged in the adoption and integration of transformational technologies into state transportation systems by helping states delineate their legal authority and that of the federal government—and the gray areas in between. Of particular concern are data privacy and security issues associated with connected and autonomous technologies and liability issues associated with potential tort actions involving CAVs, unmanned aerial vehicles, and associated infrastructure.

States and local governments continue to deploy innovative project delivery methods, including public–private partnerships, to help meet critical infrastructure needs. These innovative financing options often pose challenging policy and legal issues to be resolved by DOT attorneys—particularly in states in which user fees or tolls are disfavored or in which constitutional restrictions on debt exclude such options as availability payments.

Critical infrastructure needs, new technologies, and innovative project delivery methods can raise legal issues on the environmental front. The organizational stresses associated with a need for expedited NEPA processes challenge DOT attorneys to find ways both to address their clients' needs and to preserve the integrity of the applicable laws and regulations.

Highway Design

To reduce run-off-the-road crashes and other incidents, states are working to increase the effectiveness of roadside safety design countermeasures like high-friction surface treatments on roadway curves; innovative bridge rail and cable median barriers; and protection for vulnerable facility users like pedestrians, bicyclists, and motorcyclists.

Other simple and effective design countermeasures—for example, pavement edge drop-off treatments in Iowa and centerline rumble strips in Louisiana—also are finding widespread application throughout the country. Centerline rumble strip countermeasure data from Louisiana indicate an approximately 40-percent reduction in cross-centerline crashes, with a three-year study showing a nearly ten-to-one benefit–cost ratio.

Financial constraints continue to challenge design engineers to develop cost-effective designs that meet the demands of infrastructure replacement, rehabilitation, or both. Fiber-reinforced polymers (FRP) are finding application in many pavement and bridge projects; this may include FRP-reinforcing bar or dowel joints in reinforced concrete pavements or lightweight FRP structural elements in bridges.

In a majority of U.S. states, between 5 and 9 percent—or more—of bridges are rated as structurally deficient. In West Virginia, bridge decks have been designed with FRP to reduce the load and thereby increase design efficiency; West Virginia DOT also has rehabilitated many bridges using FRP wraps on substructure elements.

Highway Construction and Materials

Under e-construction initiatives, state DOT workforces have been equipped with mobile devices to

PHOTO: VIRGINIA DOT

The use of centerline rumble strips has resulted in a significant reduction in cross-centerline crashes. Positive results in Louisiana further support the increased application of this countermeasure for improved safety.

update construction drawings electronically and to inspect projects faster. Research is verifying the match-up of 3-D drawings and the accuracy of electronic grade control; some exploratory projects use only 3-D models as contract documents.

Data and functionality enhancements for e-ticketing systems help improve materials production and placement. Also being researched are emerging technologies, such as sensors that link construction vehicles and worker safety gear for proximity warning.

Alternative project delivery methods increasingly are used instead of design–bid–build in complex projects with critical schedules—for example, Georgia DOT's Major Mobility Investment Program to reduce long-term corridor congestion.

To improve and increase the use of recycled materials, agencies are incorporating engineering properties into specifications and pavement design procedures, including base mixes made from nearly 100-percent recycled asphalt pavement (RAP) with foamed asphalt binder or recycled concrete as an aggregate. When contractors follow state DOT–developed guidance that stipulates adjustments to RAP proportions for performance, conventional asphalt mixes of up to 30-percent RAP have been produced.

Internally cured concrete, which experiences less shrinkage and cracking because of better cement hydration, is being implemented in trials with local agencies. High-performance concrete mix designs replace some cement with such alternative materials as silica fume, slag, limestone, and fly ash for added durability and sustainability.

Material quality tests are being updated for ground tire rubber in asphalt binder creep and recovery and concrete resistivity testing for newer cements.

Geotechnical Engineering

Geotechnical resilience in the face of extreme weather events continues to challenge the transportation community, with expansive soils considered a common cause of pavement distress in many states. Louisiana Department of Transportation and Development is examining the effects of severe drought on compacted expansive clays, researchers in Texas looked at stabilizing expansive clays in pavement applications using geosynthetics, and Oklahoma DOT is investigating the performance of moisture barriers in pavement construction on top of expansive soils.

Heavy rainfall increases soil moisture and slope stability problems. Minnesota DOT published local guidance on slope stabilization and repair solutions to address the increased need for stabilization caused by intensified climatic events, and Texas is developing failure prediction and rehabilitation techniques for embankment slopes.

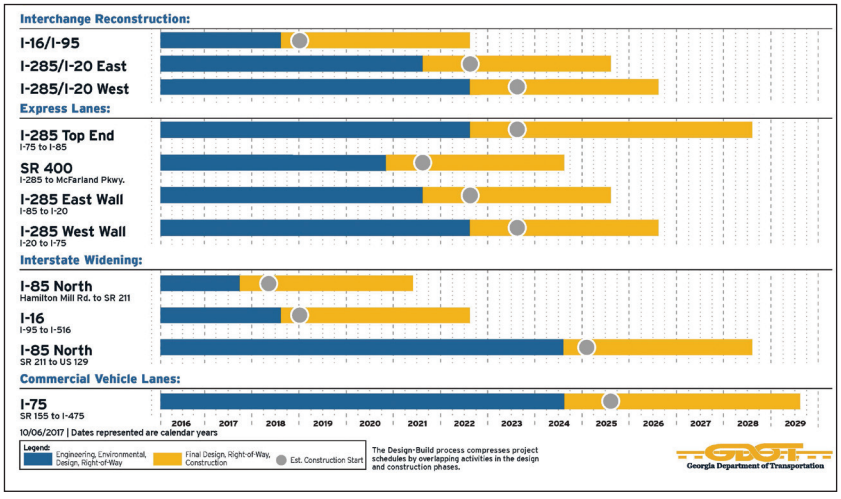
PHOTO: UTAH DOT

Equipped with a lidar camera, this Utah DOT data-collection vehicle collects high-definition, 3-D representations of surrounding areas.

Advances in technology continue to benefit states. Kansas DOT is developing the use of 3-D subsurface modeling in road design to reduce costs, save time, and facilitate more-informed decisions. Several states are taking advantage of high-resolution remote sensing technologies—for example, lidar, photogrammetry, or GB-InSAR—not only for design and construction but also to help identify backslope instability. Combined with probabilistic tools, these technologies may lead to useful forecasting models.

Washington, Oregon, Ohio, and other states have implemented slope hazard rating and management systems, and states such as Alaska, Montana, Idaho, and Colorado are recognizing the advantages of developing an asset management program that includes geotechnical assets and hazards. Colorado DOT's program includes all earth-retaining structures, slopes, embankments, and roadway subgrades, and Montana DOT recently upgraded its rock slope assessment program. Identifying, quantifying, and communicating risk is a challenge.

GRAPHIC: GEORGIA DOT



A timeline of Georgia DOT's Major Mobility Investment Program.

Photo: Oregon DOT

Sensors, GPS, and other onboard technologies have increased the efficiency of winter maintenance operations, optimizing plow routes and managing materials applied to icy roads.

Highway Maintenance and Preservation

Maintenance practices continue to take advantage of evolving technology. Since the mid-1990s, equipment operations and winter maintenance services have led the effort to incorporate technology. By equipping trucks with GPS, cellular technology, and other onboard sensors, several states have reduced costs and have increased the efficiency of winter maintenance operations.

Data-based decisions have helped several state transportation agencies optimize both their snowplow routes and the amount of materials applied to treat snow and ice on roadways.

In some far-flung locations, state DOTs use remote sensors to measure bridge deck temperatures to determine when the surface will freeze, thus necessitating closure of the bridge to traffic.

The development of automated vehicle technology—from assisted-driver systems to fully automated systems—is changing the way states consider infrastructure and services.

Photo: Chevrolet

Highway Operations

The development of CAVs again dominates the field of highway operations, commanding the attention of state DOTs across the country. So far, more than 40 states either have enacted legislation related to automated vehicles or are considering such legislation.

The development of these CAV technologies has progressed from research and development to advanced engineering. Automated vehicles are expected to be deployed in one form or another within one or two years.

Although fully self-driving cars are still three to seven years away, driver-assisted systems are available, along with vehicles equipped with sensors, cameras, and other safety devices. PricewaterhouseCoopers estimates that $230 billion is spent each year recovering losses caused by distracted driving; driver-assist technology could significantly reduce or end that loss.

It is too early to determine the exact form that transportation will take in a future of automated vehicles and technological advancements, but demonstration projects under way in many parts of the country incorporate CAV into cars, taxis, trucks, buses, highway maintenance vehicles, bicycles, and pedestrian facilities.

Some experts predict major land use changes in cities; for example, the need for parking reduced by the availability of automated vehicles and the development of mobility as a service. Public agencies are beginning to explore the impacts of CAVs on their infrastructure and services.

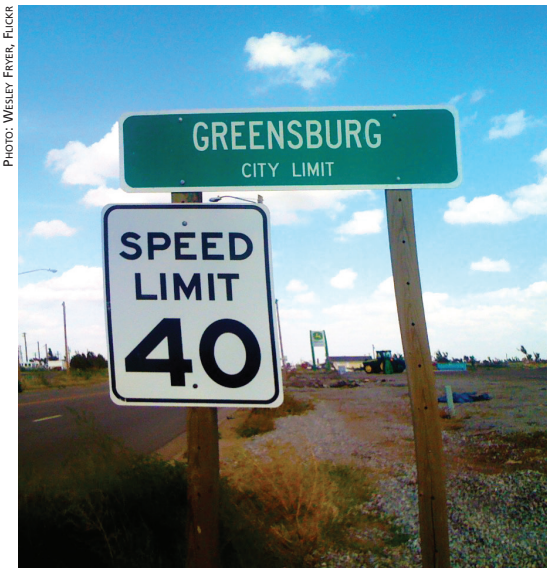
Safety

Another significant rise in motor vehicle–related fatalities occurred in 2016. According to the National Highway Traffic Safety Administration, the number of vehicle miles traveled (VMT) on U.S. roads increased by 2.2 percent, but the fatality rate per 100 million VMT increased by 2.6 percent from the previous year. Motorcyclist and pedestrian fatalities accounted for more than a third of the year-to-year increase. Driver error continues to be a factor in the vast majority of fatalities; infrastructure safety investment remains critical to eliminating and reducing the severity of motor vehicle crashes.

Kansas DOT is conducting research on the effects of speed limits on motor vehicle crashes and is examining details for categorizing pedestrian fatalities, such as when a crash involves a driver outside a broken-down vehicle. The organization of staff and programs to address emerging issues related to intelligent transportation systems is another focus for Kansas DOT.

The robust highway trust fund in New Jersey offers opportunities for the state DOT to implement a variety of programs. The agency emphasizes *Highway Safety Manual* methods for safety project selection and is working to advance safety projects on locally owned roads through outreach, peer exchanges, and technical support. Pedestrian and bicycle safety is a focus of the prioritization of complete-streets efforts in New Jersey as well.

Photo: Wesley Fryer, Flickr



Speed limit sign in Greensburg, Kansas. Kansas DOT's research includes the effects of speed limits on crashes and better ways to categorize fatalities.

Dedication and Perseverance

The 2017 State Partnership Visits Program revealed the hard work and dedication by state DOT staff members as well as their efforts to perform their duties under challenging circumstances, such as constrained budgets, extreme weather events, and rapidly changing technology. TRB hopes that the information exchanged in these visits can serve to help dedicated public servants perform their difficult jobs more easily and effectively.

Photos: Dough Miller, Flickr (*left*); Steven Harrell, Flickr (*right*)

About 500 car crashes per year in Maine involve moose.

Did You Know?

- The Pennsylvania Turnpike was built partly on a railroad line that was begun but never completed—this includes some of the tunnels still in use today.
- Maine experiences about 500 moose crashes each year. The peak month for moose strikes is June.
- Three state DOT headquarters are not located in the state capital cities. Can you name them? (*Answer below.*)
- At 11,158 feet above sea level, the highest point on the Interstate Highway System is the Eisenhower Tunnel on I-70, 60 miles west of Denver, Colorado. The lowest point is on I-8 in El Centro, California, at 52 feet below sea level.
- The national average fuel mileage for tractor trailers has remained steady over the past 10 years at just under six miles per gallon.
- China surpassed Japan in 2009 as the largest producer of passenger cars. The top five producers of passenger cars in 2015 (in descending order) were China, Japan, Germany, the United States, and India.
- There were 701 recreational boating fatalities in the United States in 2016. That same year, all types of aviation in the United States recorded 412 fatalities.
- The 1.4 million miles of unpaved roads in the United States comprise about a third of the country's 4.2 million road miles.

Answer: Connecticut DOT in Newington, Iowa DOT in Ames, and Maryland DOT in Hanover.

PHOTO: JUSTIN CONNAHER, FLICKR

Marine Transportation and the Environment

Trends and Issues

C. JAMES KRUSE, LENA M. DeSANTIS, SCOTT J. EATON, AND RICHARD BILLINGS

Kruse is Director, Center for Ports and Waterways, Texas A&M Transportation Institute, Houston, and Chair, TRB Standing Committee on Marine Environment. DeSantis is Environmental Planner, Anchor QEA, LLC, Woodcliff Lake, New Jersey. Eaton is Assistant Professor of Engineering, Maine Maritime Academy, Castine. Billings is Senior Project Manager, Eastern Research Group, Inc., Morrisville, North Carolina.

Commercial marine transportation is the most energy-efficient and cost-effective method of transporting goods and people globally (*1*). Domestic ports and their supporting infrastructure are critical for efficient global trade, economic competitiveness, and reduced urban congestion.

A range of environmental impacts, however, accompanies these benefits. For example, vessel and port operations affect regional air and water quality; ballast exchange can lead to the spread of invasive species; competition for market share is expanding port operations and is pushing vessel traffic into new Arctic routes; and the cruise market is sending out larger ships—literally floating cities—that are entering vulnerable ecosystems.

The global nature of trade and vessel transport presents unique regulatory hurdles and requires innovative, yet cost-effective, technologies and practices to curb the environmental impacts. The Transportation Research Board (TRB) Standing Committee on Marine Environment has identified the pressing environmental issues and has explored several of the emerging technologies and regulatory frameworks that can mitigate the effects of legacy fleet operations and can ensure strong environmental stewardship in the next-generation fleet.

(*Above*): The Port of Anchorage, Alaska. As new Arctic routes open to maritime traffic, emerging environmental issues are met with innovative solutions.

PHOTO: BBMEXPLORER.COM

Marine ecosystems are especially sensitive to the environmental impacts of waterborne transportation.

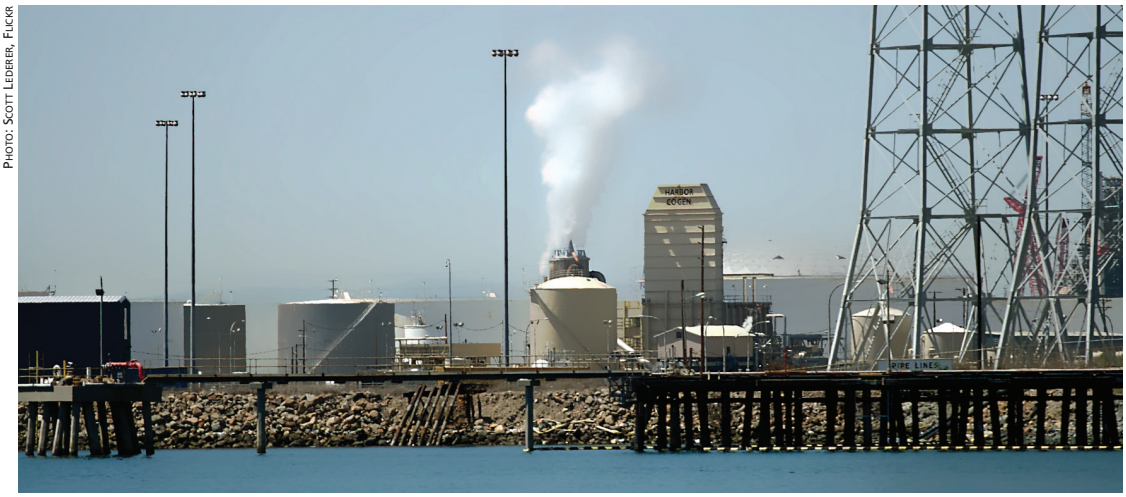


Photo: Scott Lederer, Flickr

Antipollution policies implemented by the Port of Long Beach, California, reduced diesel truck pollution by 80 percent in four years.

Air Pollution

Air pollution represents the most prominent and targeted source of environmental impacts from marine transportation. Marine vessels and port equipment are a significant source of the air pollutants that affect environmental health and climate change.

Most air pollution from port activities comes from the operation of the diesel engines that power ships, cargo-handling equipment, drayage trucks, and locomotives. Collectively, these diesel engines emit significant amounts of sulfur oxides, nitrogen oxides, volatile organic compounds, particulate matter, and carbon dioxide.

The combination of fine particulates and hazardous air pollutants can affect human health, causing a range of respiratory ailments including asthma, bronchitis, and lung cancer, as well as cardiovascular disease and premature death. These effects are magnified in lower-income and working-class communities adjacent to ports and rail yards. Emissions of sulfur oxides, volatile organic compounds, and nitrogen oxides have larger-scale deleterious effects on air quality and the environment by contributing to regional smog and ozone formation.

International shipping produces approximately 2.4 percent of global greenhouse gas emissions, and the share is expected to increase with the demands for global trade (2). Vessel emissions of carbon dioxide also affect water quality by reducing the ocean's pH—a phenomenon known as ocean acidification. Vessel emissions of nitrogen further contribute to ocean acidification.

Ocean acidification harms marine organisms that have calcareous exoskeletons, such as corals, mollusks, and crustaceans. Some of these species—particularly corals—are important in forming habitats; others have recreational or commercial significance.

Alternative technologies for marine fuels and energy sources have the potential to improve the environmental footprint of waterborne commerce. Innovations are supplying new policies, products, and methods to reduce emissions. These innovations include the following:

- National and international standards for conventional marine fuels,
- Fuel concepts,
- Exhaust remediation technology,
- Shore-to-ship alternative powering techniques,
- Improved in-port vessel scheduling, and
- Ocean-based renewable energy.

Controlling Sulfur

The International Maritime Organization (IMO) and the U.S. Environmental Protection Agency have issued standards for fuel sulfur. Designed to reduce regional and global emissions of particulate matter and sulfur oxide, the standards are evolving but have

Photo: Chris Parker, Flickr

The *MS Midnatsol* is one of a growing number of cruise ships that take tourists across the Arctic Circle.

PHOTO: ENI.COM

The Eni's Green Refinery project at Port Marghera in Venice produces biofuels from organic raw materials.

served as key drivers. In conjunction with the designation of emission control areas, the standards have reduced emissions of sulfur oxide, nitrogen oxide, and particulate matter, largely through the combustion of light marine gas oils with a low sulfur content—however, the costs are higher.

In response, the fuel oil market is introducing low-sulfur heavy fuels that can hold down costs but satisfy the fuel regulations. These new fuel formulations are expected to become the conventional fuel globally by 2020 (*3*).

Alternative Fuels

Despite this regulatory success, additional power options are needed for vessels to meet all air quality concerns. These options include liquefied natural gas (LNG) as a marine fuel, biofuels, exhaust gas scrubbers, hydrogen, and shore-to-ship power—also called cold ironing or alternative maritime power—the provision of electrical plug-in power for vessels in port.

Vegetable-based and cellulosic-based biofuels are compatible with current fleet operations and can reduce sulfur oxide, particulate matter, and greenhouse gases, although the limited availability of these fuels and the uncertainties about powertrain maintenance and cost continue to hamper adoption. These technologies are considered most effective as regional solutions, because cost and supply are tied directly to a region's economic constraints.

Fuel processing technologies are maturing rapidly, and several integrated biorefineries have emerged. Large-scale introduction of second- and third-generation biofuels to the marine market, however, will not occur until well into the future.

Exhaust scrubbers, particularly using salt water, may allow for continued use of conventional high-sulfur fuels. But in reducing emissions of sulfur dioxide, the exhaust scrubbers could cause water pollution; moreover, the devices could require significant vessel capital and lay-up times for retrofitting. In addition, the technology requires new methods and materials to comply with pending requirements to control emissions of nitrogen oxide.

Cold ironing is increasingly available at domestic ports; the infrastructure costs are balanced by the benefits. Military bases, several California ports, and cruise terminals in Seattle and New York have implemented cold ironing. The systems greatly reduce a vessel's dockside emissions—even when the accounting includes emissions from the shoreside power plant supplying the electricity—because the production of electricity is more efficient than diesel combustion in the ship's main engine. Cold ironing has led to marked improvements in local air quality but has no effect, of course, on emissions once the vessel is under way.

A Port of Seattle, Washington, employee uses cold ironing—or shore-to-ship power—to fuel a cruise ship while its engines are turned off.

PHOTO: DON WILSON, PORT OF SEATTLE

Liquefied Natural Gas

LNG continues to gain attention because of competitive energy pricing, the potential for rapid global implementation, and a low rate of combustion emissions in comparison with conventional marine fuels. Lloyd's Register estimates that LNG could reach an 11 percent share of marine fuel usage by 2030 (*4*). The use of natural gas as a transport fuel has grown steadily in the past decade, with 47 registered LNG-powered vessels in operation in 2014 and 200 now in operation or on order (*5*).

The deployment of LNG-powered vessels and the construction of new infrastructure for LNG refueling and import have been steady since 2006. Three manufacturers—Rolls Royce, Wärtsilä, and MAN—

have developed LNG engine technologies for marine applications. Spark-ignited, lean-burn engines allow the gas to be mixed with an excess of air before passing through the intake valves, so that the fuel combusts more completely, improving efficiency and limiting stack emissions of methane, a greenhouse gas 25 times more potent than carbon dioxide. Dual-fuel diesel engines, which can run on LNG or petroleum distillates, are attractive for vessels operating at ports yet to complete the infrastructure for LNG.

The support infrastructure for LNG continues to evolve to meet demand. Norway has developed a system of small-scale LNG production and storage facilities to supply ferries and other working ships. New LNG shipbuilding contracts around the world are aligned with the installation of bunkering facilities to store and provide the fuel.

In the longer term, several governments are planning for expanded use of LNG in the maritime sector. For example, the European Commission has launched an ambitious plan for 139 LNG refueling facilities to serve seagoing and inland vessels starting in 2020. China has established incentives for the construction of LNG vessels, and 110 vessels are in planning or production.

Nevertheless, LNG is still in the fledgling stages as a marine fuel. Forecasts indicate that the growth of LNG-powered ships is unlikely to play a major role in the shipping market in the next decade. Moreover, concerns remain about safe handling and about methane slip—the release of noncombusted methane into the atmosphere.

PHOTO: SHELL

Shell's floating LNG facility *Prelude* can transport LNG directly to carriers at sea.

Other options for reducing fossil fuel combustion in the marine sector include wind and solar sources to supplement on board energy demand. Kite technology, for example, can tap into winds at high altitudes to reduce propulsion power demand. Also promising is the reintroduction of Flettner rotors, vertical spinning cylinders that rely on the Magnus effect[1] to generate electricity for propulsion engines. Photovoltaic systems in development may provide cheap renewable electricity for ships, although a variety of technical issues now limit use (*6*).

[1] The Magnus effect occurs when a spinning object drags air faster around one side, creating a difference in pressure that causes the object to move in the direction of the lower-pressure side.

PHOTO: DAVID MERRETT, FLICKR

Flettner rotors, like those on the ship *Alcyone*, augment traditional engines to generate electricity.

PHOTO: UNCLIMATECHANGE, FLICKR

The *National Geographic Explorer* takes travelers into areas of the Arctic that previously were impassable. Melting of sea ice has opened the area to unprecedented travel.

FIGURE 1 Melting Arctic sea ice has enabled increased cargo vessel and cruise line navigation in an environmentally sensitive region. (Image: The Arctic Institute)

Changing Trade Routes

Few places on earth capture the human imagination and present nature's unadulterated beauty like the Arctic. Human industrial activity, however, has introduced profound environmental changes to the region.

Marine transportation takes several forms in the Arctic. Regional systems of tugs and barges provide local transport for the delivery of essential supplies to communities. Fishing is an important industry and provides subsistence to indigenous communities. But increasingly, larger vessels engaged in oil exploration, new trade routes, and tourism are straining the region's environmental balance. In addition, the area is sensitive to climate change, which exacerbates the effects of localized pollution.

Melting Ice Cap

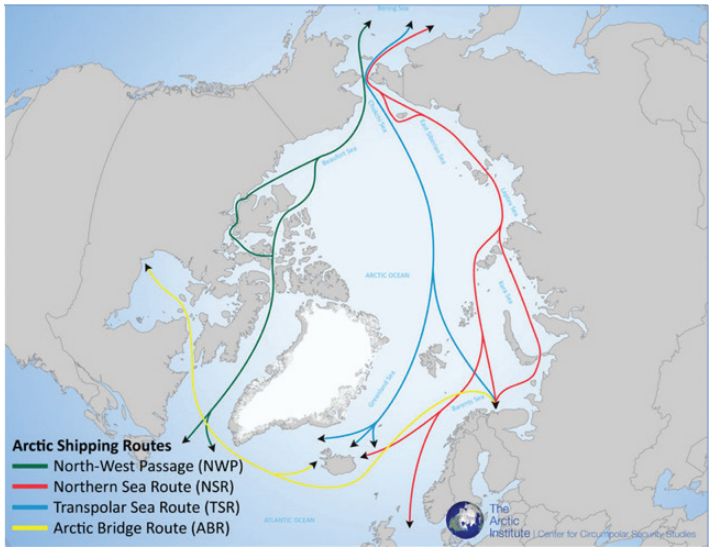
The U.S. Geological Survey estimates that the Arctic contains 22 percent of all undiscovered oil and gas resources (7). Exploration and recovery require a variety of marine vessels at the sites and for transportation to markets. Large and small cruise ships also visit the Arctic (see Figure 1, below left). The melting of sea ice will increase vessel traffic and open the Arctic to commerce and recreational activities not previously possible, increasing the concern about the region's environmental health.

The Arctic ice cap is approximately 40 percent smaller than it was in 1979 (see Figure 2, below right). Continued shrinkage would allow for the development of Arctic shipping lanes between Asia and Europe that could reduce travel distances by 5,200 miles, cutting transit time by an estimated 30 percent. This would create the greatest restructuring of global shipping routes since the opening of the Panama Canal in 1914.

Northern Passages

Possible routes include the Northern Sea Route, which transits Russian Arctic waters, and the Northwest Passage, which transits territorial waters of the United States and Canada. Both routes are open only for several weeks during the summer but offer a commercially viable alternative to the Panama and Suez Canals.

The number of vessels passing through the Bering Strait, the entry or exit point for both passages, grew from 220 in 2008 to 480 in 2012—an increase of more than 100 percent (8). Tanker vessels had the highest growth rate, with tugs and other cargo vessels the second and third largest categories of movements, respectively.



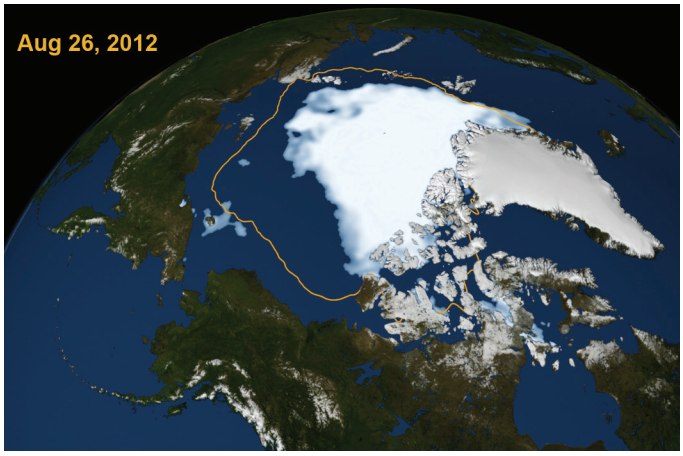


FIGURE 2 Satellite image of the Arctic ice cap, August 26, 2012, superimposed with border line (*orange*) indicating edge of ice cap in 1979.

Photo: Cheryl Strahl, Flickr

Pollutants make their way into the air and water of the Arctic, affecting local wildlife.

Passage through the Northern Sea Route is limited but is increasing. The route's ice fields and shallow straits challenge navigation, raising concerns about a potential increase in the incident rate and limited access for emergency and environmental response.

The Northwest Passage is even more challenging. IMO continues to evolve Annex 10, International Code for Ships Operating in Polar Waters, to stay at the forefront in assessing and mitigating the potential hazards from vessel traffic and in enforcing the regulations.

The first large commercial vessel, *MS Nordic Orion*, transited the Northwest Passage in 2013, and the expectation is that vessels will be able to move through this area without the aid of an icebreaker by 2050. The passage also could facilitate the movement of crude oil from the Alaskan North Slope to U.S. East Coast refineries.

Expected Traffic

Limited exploratory drilling has been permitted offshore of the Alaskan North Slope, with plans to increase the activities and eventually to develop and operate offshore oil and gas production platforms. A range of vessels will service this industry, including survey ships, drilling rigs, support vessels, crew boats, spill response vessels, offshore tugboats for the construction of gravity-based offshore platforms or artificial gravel islands, and pipe-laying vessels.

In addition, the opening of Arctic waters could increase cruise ship traffic. Crystal Cruises completed a 32-day journey across the Northwest Passage this year and has taken bookings for a cruise from Anchorage, Alaska, to New York City.

The shorter Arctic routes will reduce vessel fuel consumption and emissions substantially. Nevertheless, local air quality issues may offset the global benefits. For example, because of their physical–chemical properties, persistent organic pollutants can be transferred readily to the Arctic via air and water currents and can accumulate in the fatty tissues of the local wildlife. Increased vessel traffic in the Arctic also will facilitate the concentration of hazardous air pollutants in northern latitudes.

Photo: U.S. Coast Guard

U.S. Coast Guard Cutter *Healy* rescues a sailboat trapped in Arctic ice. Although new routes have opened in the Northwest Passage, ice and shallow waters still create challenges.

Smokestack emissions also pose a unique threat to the Arctic. Researchers have found that the black soot from ship smokestacks settles on polar ice sheets and lowers its albedo—that is, its reflection of light and radiation—and accelerates melting.

Protecting Biodiversity

Vessels also act as vectors for the introduction of invasive, nonnative species to new areas. These species often can outcompete native species and can reduce biodiversity dramatically, impairing the resilience of coastal and marine ecosystems. The short-term and long-term economic and environmental effects include the following:

Photo: Marco Verch, Flickr

Black soot from passing ships accumulates on polar ice.

PHOTO: VIV LYNCH, FLICKR

Invasive species, like the zebra mussel, attach to marine vessels and spread to nonnative environments, where they damage infrastructure and local habitats.

◆ Species extinction—the loss of any species has far-reaching effects; in particular, some Arctic species of marine life have pharmaceutical applications;

◆ Damage to infrastructure—similar to the problems caused by the spread of zebra mussels in the Great Lakes and elsewhere; and

◆ Loss of recreational and commercial fishing opportunities.

The IMO Annex 10, Part II-A, outlines measures to prevent pollution and preserve the environment in the polar region. Research is needed to enhance the effectiveness of the IMO code of regulations and to determine the need for additional measures.

Vessel Discharges

Oil and chemical spills remain a dominant issue in maritime transportation. Although accounting for approximately 10 percent of the total oils contributed to the ocean, spills have high public visibility. Improved understanding of programs to prevent oil spills and of the options for clean-up can facilitate linkages between governance, policy, and scientific knowledge.

Vessel discharges and upland maritime support operations introduce pollution from toxins, nutrients, bacteria, pathogens, pharmaceuticals, and plastics directly into waterways. For example, EPA estimates that a single 3,000-person cruise ship discharges 150,000 gallons of sewage a week.

Vessels, vessel support operations, and port operations also directly and indirectly pollute waterways through a variety of sources that include the following:

◆ Gray or used water, bilge water or excess fluids in the hull, black or sewage water, and ballast water from onboard tanks;

◆ Antifouling paints and their leachates;

◆ Hazardous materials;

◆ Garbage and other wastes; and

PHOTO: MICHAEL EDENFIELD, FLICKR

In 2004, the Malaysian cargo ship *M/V Selendang Ayu* ran aground and spilled 336,000 gallons of oil into the Bering Sea. Oil spills continue to be a predominant, high-visibility issue in maritime transportation.

◆ Aerial deposition of smokestack emissions into aquatic habitats.

A host of wastewater treatment options that systematically meet water discharge regulations is available for vessels. Typically, vessel operations include two or three systems working together to achieve compliance. The most common approach couples the physical filtration of biomass solids with chemical disinfection. Ultraviolet treatment, coagulation, thermal, deoxygenation, acoustic, and electric pulse systems are among the other options.

Although effective, the regulations for ballast and wastewater handling continue to evolve and are becoming increasingly stringent. Research and development efforts are working to identify ways to trim the cost, to lower the complexity, and to decrease the impacts of a vessel's footprint while reducing the harmful impacts of discharges.

IMO has proposed performance standards for ballast water management, following an implementation schedule based on a vessel's ballast water capacity and on its status as new or already in operation. Although IMO adopted the standards in 2004, ratification was slow, and the convention did not enter into force until September 2017. This is the first global standard for ballast water—it establishes a long-awaited framework for improving global water quality.

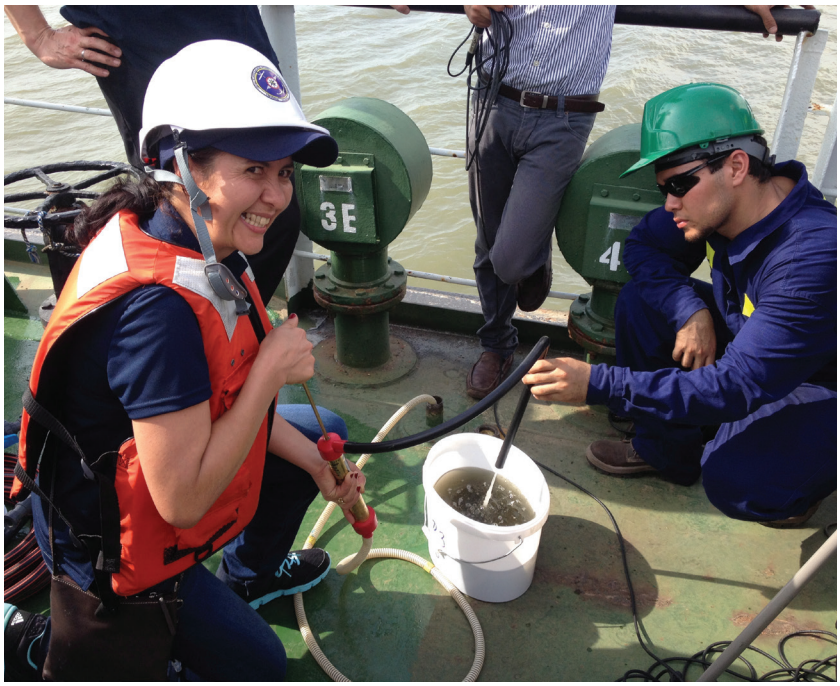


Photo: International Maritime Organization, Flickr

An IMO ballast water workshop teaches participants how to hand-pump ballast water for sampling.

Noise

In his 1953 book, Jacques Cousteau called the ocean The Silent World. Although intended as an artful expression, the title accurately characterizes aquatic biology and ecosystems. Oceans are among the quietest places on earth, despite the vast richness of the biological diversity.

Human-generated sound, however, has been increasing in the marine environment. Marine shipping is one of the major sources of underwater sound and has been linked directly to aquatic life stress and death. Commercial shipping is the major contributor to low-frequency noise—5 to 500 Hz—in the world's oceans (*9*). Ship noise is continuous and can exceed 200 decibels, and the emissions can travel over large geographic areas, especially in the higher latitudes, such as the Arctic.

The following activities also contribute to increases in underwater sound:

◆ Energy exploration and production, including the development of offshore renewable sources such as wind power;

Photo: U.S. Army Corps of Engineers

Homer Harbor, Alaska, is dredged each year to keep the basin depth safe for marine vessels. The noise, however, contributes to sound that disturbs sea life.

PHOTO: MICHAEL PADILLA, SANDIA NATIONAL LABORATORY

HYDROGEN FERRY—Hydrogen fuel cells produce power by controlling the reaction of hydrogen and oxygen to create electricity and water. This process produces zero toxic air emissions or greenhouse gases. The technology, however, has a poor power-to-weight ratio compared with conventional diesel engines and requires new vessel engineering designs. Significant capital investment in the refueling infrastructure is needed to increase the availability of hydrogen fuel. The U.S. Maritime Administration, Sandia National Laboratories, and Red and White Fleet are collaborating in the development of fuel cell–powered ferry designs for operations in San Francisco Bay.

◆ Port infrastructure improvements, such as dredging; and

◆ Structure demolition and replacement.

The effects of sound vary according to the intensity, frequency, and duration. Effects are species-specific and range from behavioral responses, such as avoidance, to injury and death. The effects are most severe for species susceptible to barotrauma—physical damage caused by differences in internal and external pressure—which can occur in certain fish, and for species that rely on sound to communicate and to find prey and mates, such as marine mammals. Federal regulations—for example, in the Endangered Species Act and the Marine Mammal Protection Act—protect many of these species in U.S. waters.

Advancing the Research

The TRB Standing Committee on Marine Environment is compiling research needs statements (RNS) focusing on these and closely associated topics, several of which were recently posted to the TRB RNS database.[2] The postings will enable the committee to solicit research funding. The committee maintains a detailed research needs statement that explores each topic in detail; for further information, please e-mail the committee chair at j-kruse@tamu.edu.

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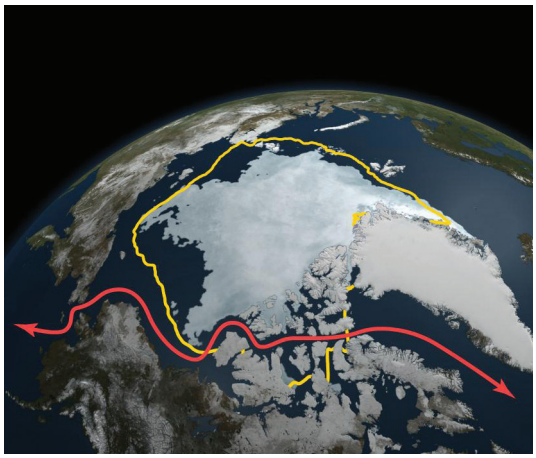

PHOTO: SCIENTIFIC VISUALIZATION STUDIO, NASA

A NASA visualization of the extent of Arctic ice. The red line shows the emerging Northwest Passage.

PHOTO: NOAA

NASEM WORKSHOP SUMMARY

Preparing for a Rapid Response to Major Marine Oil Spills

Protecting and Assessing the Health and Well-Being of Communities

CLAIRE GIAMMARIA, ANNA NICHOLSON, AND JUSTIN SNAIR

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Every disaster affects community health. Oil spills have potential individual and public health consequences that include mental and behavioral dimensions for responders and for the affected communities. If oil spill preparedness, response, and recovery can address short- and long-term health concerns, many communities would be better prepared and more resilient after a spill.

The Gulf Research Program and the Health and Medicine Division of the National Academies of Sciences, Engineering, and Medicine held a stand-alone workshop, Preparing for a Rapid Response to Major Offshore Oil Spills: A Workshop on Research Needs to Protect the Health and Well-Being of Communities, on August 2–3, 2017. The workshop explored research needs and opportunities for improving public health preparedness, response, and protection related to oil spills; considered ways to work within and to complement the established framework for oil spill response, to improve protection of community health and well-being; and fostered connections between public health workers, oil spill

Oil spills, like the 2004 spill that occurred when the *M/V Selendang Ayu* ran aground off the coast of Alaska, can affect not only complex ecosystems but also regional economies and ways of life.

Photo: Coast Guard News, Flickr

U.S. Coast Guard crews conduct oil spill response training with local agencies in New York. The federal government works with state and local governments to coordinate response management.

practitioners, disaster researchers, and leaders from affected communities. The workshop speakers and participants represented the range of stakeholders.

Response Framework

Two federal laws guide oil spill response—the Oil Pollution Act of 1990 and the Robert T. Stafford Act of 1988. Roger Laferriere, National Institutes of Health, explained that the Oil Pollution Act streamlined and strengthened the U.S. Environmental Protection Agency's (EPA's) ability to prevent and respond to catastrophic oil spills. The Stafford Act established the National Response Framework and the National Disaster Recovery Framework to provide federal assistance to state and local governments for alleviating the suffering and damage caused by national emergencies and disasters.

Rear Admiral Peter Gautier, U.S. Coast Guard (USCG), noted that the Incident Command System (ICS) of the National Incident Management System provides a top-down, structured, and established process for a unified command to coordinate response management. The unified command includes the responsible parties—or "spillers"—who pay for cleanup, restoration, the assessment of damages to natural resources, and economic and third-party claims, according to Yvonne Addassi, Office of Spill Prevention and Response, California Department of Fish and Wildlife. Laferriere pointed out that the ICS lacks a community health component, which could be incorporated in responses to future spills.

Community Health Impacts

Several speakers highlighted the interconnected effects of spills on individuals, families, networks, communities, and entire regions. David Abramson, New York University, observed that in contrast to natural disasters, which typically damage physical infrastructure, oil spills threaten complex ecosystems that support regional economies and ways of life.

Liesel Ritchie of the Natural Hazards Center at the University of Colorado, Boulder, reported that in both the *Exxon Valdez* and *Deepwater Horizon* spills, the strongest predictors of stress were concerns about family health, economic futures, and economic loss, as well as individual and group connections to the threatened renewable resources.

Keith Nicholls, University of South Alabama, illustrated the links between oil spill stressors and an array of economic, psychological, sociological, and physical impacts. For instance, the loss of a job

Photo: Coast Guard News, Flickr

The 2014 *Deepwater Horizon* oil spill in the Gulf of Mexico threatened regional, water-based economies.

Photo: Deepwater Horizon Response, Flickr

A member of the Federal Drug Administration meets with fishermen to discuss the impact of the *Deepwater Horizon* oil spill on their industry.

PHOTO: GEOFF LIVINGSTON, FLICKR

Vietnamese-speaking fishing families await information and government aid after the *Deepwater Horizon* oil spill. To build trust, it is critical to address specific community needs related to culture, language, and education level.

because of an oil spill can have impacts that extend beyond the loss of income and affect individual health through fear, anxiety, depression, and high blood pressure.

Sharon Croisant, University of Texas at Galveston, noted that disasters disproportionately affect vulnerable groups that already lack access to health care and other resources. She stated, moreover, that mental health impacts are often manifested over the long term.

John Tarpley, Office of Response and Restoration at the National Oceanic and Atmospheric Administration, described the Scientific Support Coordinator Program, which develops contingency plans, runs exercises and training, and responds to an average of 150 spills per year. In the past 30 years, oil spill responses have incorporated new aspects, he observed, but the time has come to expand the focus from the health and safety of workers and responders to the impacts on the public. He noted that EPA's National Response System, which addresses a range of oil and hazardous substance releases, is flexible and adaptable and can expand and contract to meet needs.

Many participants emphasized the importance of preparedness before oil spill events. Tarpley emphasized the need to have the science and procedures in place before a response. Duane Gill, Oklahoma State University, added that engaging communities before an oil spill is important so that "when an event occurs, we are in the community, we know what is going on in the community, and we are prepared to ameliorate the negative impacts of an event."

Potential Challenges

The workshop discussion identified and characterized four groups of challenges to incorporating the protection of community health and well-being into oil spill response:

1. **Complex and long-term impacts.** Oil spill responders "come in and try to solve what [they] have to solve, but once [they] are done, [they] leave," said Thomas Dardar, Jr., Principal Chief of the United Houma Nation. Gill explained that when a community's social, cultural, and economic existence centers on renewable resources, spills that affect those resources have huge and lasting impacts. Nicholls noted that preexisting conditions, such as poverty, unemployment, and declining social capital, make communities less resilient to disasters.

2. **Communicating and engaging at a local level.** Participants identified language, literacy, and the limited reach of communications as some of the challenges in effectively connecting with and engaging communities. Dardar said that responders' messages often are full of jargon that is not translated appropriately. Linda Birnbaum, National Institute of Environmental Health Sciences (NIEHS) at the National Institutes of Health, observed that effectively communicating about risk can be difficult because of low levels of environmental and health literacy among the general public.

3. **Gaps in knowledge for prevention and mitigation strategies**. Nicole Lurie, former Assistant Secretary for Preparedness and Response, U.S. Department of Health and Human Services, noted that after 40 major oil spills, critical information gaps persist about how to prevent and mitigate the physical, mental, and behavioral health impacts. Several participants highlighted the need for baseline data to inform preparedness planning and to help track the impacts of an event.

PHOTO: GEOFF LIVINGSTON, FLICKR

A sixth-generation Louisiana fisherman waits to hear information about how the *Deepwater Horizon* oil spill will affect his livelihood.

PHOTO: NATIONAL ACADEMIES

Participants of the Preparing for a Rapid Response to a Major Offshore Oil Spills workshop examined the complex effects of oil spills on communities.

Photo: Louisiana Governor's Office

Then-Governor of Louisiana Bobby Jindal discusses the impact of the *Deepwater Horizon* oil spill on the seafood industry with local restaurant owners, fishermen, oyster harvesters, and seafood processors.

4. Competing priorities and sustainability. Jonathan Waldron, Blank Rome, LLP, and Captain Joseph Loring, USCG Office of Marine Environmental Response Policy, summarized stakeholders and their roles as follows:

- Responders and responsible parties focus on immediate safety,
- Communities focus on local concerns and ensure that needs are understood, and
- Public health actors address safety, hazard detection, food source safety, and mental health effects.

Many participants suggested that involving a broader range of groups in preparedness and planning would help in aligning perspectives.

Potential Opportunities

Several participants acknowledged that a culture change would be necessary on many levels to expand the scope of oil spill response. The suggested opportunities can be grouped into four categories:

1. Aligning policies, funding, and systems. To effect a change of culture, Laferriere called for a national recognition that oil spills are community health incidents. Several workshop participants noted other opportunities within the current policy structure—for example, to improve and sustain preparedness between major spills, many underscored the need to align with social justice, community health, and disaster recovery and resilience efforts.

2. Improving communications and building trust. Ann Hayward Walker, Scientific and Environmental Associates, said preparedness efforts should leverage social capital structures to build lines of direct, open, and reciprocal communication through trusted messengers, community networks, and public health organizations. Walker observed that community associations and networks of nongovernmental organizations could help to disseminate information and to address community concerns in real time during a response. Thao Vu, Mississippi Coalition for Vietnamese-American Fisher Folks and Families, pointed out the need for messaging and materials that are appropriately packaged for communities' languages, cultural sensitivities, levels of education, and practical concerns.

3. Including communities in planning and response efforts. Walker said the response sector should reframe community engagement as part of planning and response efforts. She said outreach through area planning committees can acknowledge and make accommodations for underlying power imbalances. Local knowledge and community engagement are equally valuable in response efforts, and many participants suggested that knowledge of community concerns and values should inform operational decisions. Eric Baumgartner, formerly of the Louisiana Public Health Institute, suggested that local health or resilience officers could be assigned

Jamie Arleo, Florida Department of Environmental Protection, surveys the Gulf of Mexico and gathers data for recovery efforts.

Photo: Deepwater Horizon Response, Flickr

Photo: U.S. Coast Guard

Crews prepare to assess damage to the Mississippi River after an oil spill. Quick risk assessments—and prior research to assist—are vital.

Photo: MPCA Photos, Flickr

Oil spill health impacts—including mental and behavioral impacts—affect responders and communities.

to preparedness efforts to map community systems and resources, to inform response, and to engender community confidence.

4. Improved understanding of oil spill science, impacts, and mitigation strategies. During an emergency, risk assessment decisions must be made quickly without time for consensus, stated Bernard Goldstein, University of Pittsburgh—therefore, laying a foundation of good science is a necessity. Dale Sandler, NIEHS, emphasized that research must be part of the response process. Aubrey Miller, NIEHS, suggested that collaboration across sectors was needed to collect data and to identify platforms for the development of protocols, tools, and methodologies related to human health and resiliency. Ritchie pointed out that what is known about oil spills is grounded in a large and longstanding body of research on the societal dimensions of hazards and disasters, and she cautioned that research should build on what is known and should focus on specific, unanswered questions.

Addressing Health Impacts

Oil spills have potential health and public health consequences, including mental and behavioral dimensions, for responders and for affected communities. Nevertheless, neither the command structure nor the compensation structure account well for responding to these health aspects of oil spills, as several workshop participants noted.

Participants also expressed concerns about the limited use of science-based decision making in oil spill responses and about the ways available for stakeholders to work with affected communities to prepare, prevent, and respond to oil spills. Although addressing the health effects of oil spills may encounter wide-ranging challenges, the opportunities are many for improving the long-term vitality of the communities that could be affected—and that already have been affected—by oil spills.

Acknowledgments and Resources

The Gulf Research Program of the National Academies of Sciences, Engineering, and Medicine asked the Health and Medicine Division to convene the stand-alone workshop summarized in this article. The Board on Health Sciences Policy in the Health and Medicine Division oversaw the workshop as part of its mission to strengthen the preparedness, resilience, and sustainability of communities.

The workshop proceedings-in-brief is available at https://www.nap.edu/catalog/24924/preparing-for-a-rapid-response-to-major-marine-oil-spills. To learn more about the work of the Board on Health Sciences Policy, see www.nationalacademies.org/hmd/About-HMD/Leadership-Staff/HMD-Staff-Leadership-Boards/Board-on-Health-Sciences-Policy.aspx. More information about the Gulf Research Program is available at www.nationalacademies.org/gulf/index.html.

Planning Committee for Preparing for a Rapid Response to Major Marine Oil Spills: A Workshop on Research Needs to Protect the Health and Well-Being of Communities

Ann Hayward Walker, Scientific and Environmental Associates, *Chair*
David Abramson, New York University
Yvonne Najah Addassi, Office of Spill Prevention and Response, California Department of Fish and Wildlife
Sharon Croisant, University of Texas at Galveston
Elizabeth (Terry) Fontham, Louisiana State University
Duane Gill, Center for the Study of Disasters and Extreme Events, Oklahoma State University
Larissa Graham, Mississippi–Alabama Sea Grant Consortium

PHOTO: PENN STATE, FLICKR

Public–Private Partnerships in Civil Space

Insights from a National Academies Workshop

DWAYNE DAY AND MICHAEL MOLONEY

The authors are with the Space Studies Board and the Aeronautics and Space Engineering Board, Division of Engineering and Physical Sciences, National Academies of Sciences, Engineering, and Medicine, Washington, D.C. Day is Senior Program Officer and Moloney is Director for Space and Aeronautics.

The role of public–private partnerships in space policy was one of four main topics explored in a stand-alone workshop, America's Future in Civil Space, convened in May 2017 by the Space Studies Board and the Aeronautics and Space Engineering Board of the Division on Engineering and Physical Sciences, National Academies of Sciences, Engineering, and Medicine. The discussions and presentations—which also focused on U.S. space policy, international cooperation in space, and the sustainability of outer space activities[1]—examined the role that the evolving commercial space sector could play in fulfilling national space goals and the role of the government in facilitating the evolution and success of new actors and modes of working with the commercial sector. (For a list of workshop planning committee members, see page 29.)

[1] https://doi.org/10.17226/24921.

(*Above*): SpaceX's *Dragon* is used by the National Aeronautics and Space Administration (NASA) to deliver cargo to the International Space Station (ISS).

PHOTO: PENN STATE, FLICKR

The joint efforts of NASA and the commercial company SpaceX demonstrates how public–private partnerships can advance and develop ideas.

Public–private partnerships have been in use in the United States since the earliest days of the nation and have advanced space-related goals for decades, noted Mary Lynne Dittmar, a member of the Space Studies Board. The partnerships have proved instrumental in driving industry forward, injecting innovation, remaking or opening markets, and driving down costs. Nevertheless, the arrangements are not a panacea, and the successes have depended on balancing government and industry roles and on balancing discretion and risk.

Historical Overview

Roger Launius, former chief historian for NASA and formerly with the National Air and Space Museum, presented several case studies of public–private partnerships as models for adaptation to the needs of the space program. These included the Transcontinental Railroad and the incentivized development of commercial aviation.

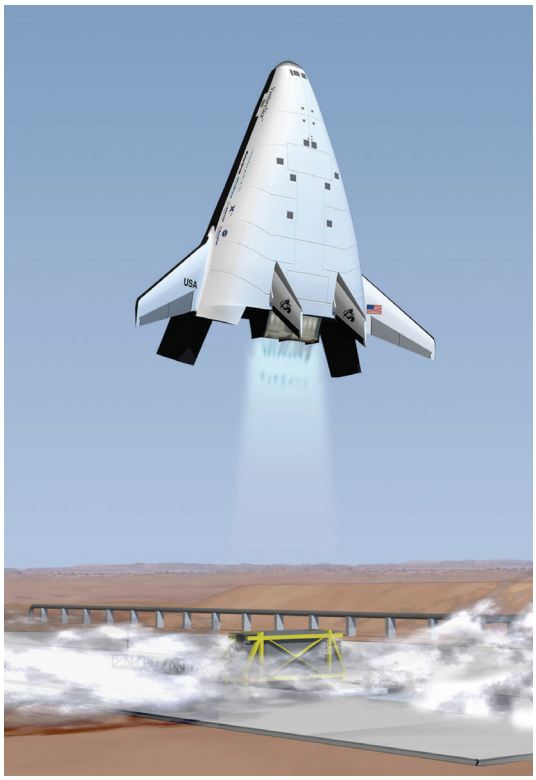
Launius noted that in the 1920s, Congress could have established a national government–run airline for postal delivery and for passenger travel. Instead, Congress created a favorable climate for private investment, including a subsidy system, which persisted for 40 years. Although commercial aviation experienced early setbacks, Congress wanted to disperse aeronautics research across the nation and to commercialize the aviation sector, Launius pointed out.

John Donahue, Harvard University, defined a partnership between government and industry as a construct of rules, procedures, and incentives to induce private actors to advance public goals. The United States has a long history with such partnerships—the Lewis and Clark Expedition, for example, was one of the earliest American public–private partnerships. The Transcontinental Railroad was another; although expensive and not perfect, the project may have raised the rate of growth of the U.S. economy significantly in the decades that followed.

PHOTO: BILL WHITTAKER, WIKIMEDIA

In the early days of airmail, the United States chose not to establish a government-run airline and instead opted to work with private investors.

PHOTO: NASA



In the *Delta Clipper* Experimental Program, NASA partnered with McDonnell Douglas to develop a reusable spacecraft.

Donahue pointed to several failures in public–private partnerships that left problems for the government to clean up—for example, the savings and loan crisis of the late 1980s. For this reason, he emphasized that such partnerships need well-defined rules, procedures, and incentives to ensure that private entities act in the national interest and achieve the public good in space.

Dan Dumbacher, Purdue University and formerly with NASA, discussed historical examples and lessons learned from past NASA partnerships with private industry on vehicle development programs. Regulations on cooperating with industry had not been established in the early and mid-1990s, when NASA undertook the Delta Clipper Experimental Program to develop an unmanned prototype of a reusable single-stage-to-orbit launch vehicle. But regulations were in place in the later 1990s, when the X-33 Program began developing an unmanned suborbital spaceplane—the regulations allowed the adoption of a fixed-price contract approach.

The lessons from this and from other programs led to the development of an acquisition approach for commercial cargo services to the International Space Station (ISS). Dumbacher reported that in his experience at NASA, officials always considered both the value and the risk of public–private partnerships for government and for private industry.

PHOTO: CLIPPERARCTIC, FLICKR

The Boeing 707 jet airliner. NASA's research in aircraft fuel burn helped advance aviation efficiency.

Advancing Aeronautics

Aeronautics and Space Engineering Board Chair Alan Epstein of Pratt & Whitney offered insights from public–private partnerships in aviation. After World War II, the Army, Navy, and industry sought to shut down the National Advisory Committee for Aeronautics, NASA's predecessor. The attempt failed, he noted, but some ambivalence has persisted about NASA's role in aeronautics.

Historically, NASA and aviation evolved together to form what Epstein termed a symbiotic relationship. Although the aviation industry invests far more than NASA in research and development, NASA has provided value by pushing new ideas, which often have gestation periods longer than the usual span of industrial investments. Epstein pointed to the tremendous advancements since the days of the Boeing 707 jet airliner—such as an 80 percent improvement in fuel burn for large aircraft—that are the results of NASA research. The history of commercial aviation in the United States shows that industry and government can work well together over time.

PHOTO: NASA

Test engineer Samantha O'Flaherty sets up an X-Plane design model in NASA's Langley Research Center.

Innovation Is Key

Epstein observed that innovation in industry today is occurring at an ever-accelerated rate, and this creates challenges in establishing partnerships. NASA, the sparkplug for new ideas from universities and industry, also is learning how to work at this fast pace of innovation.

For example, the NASA X-Plane Program is developing experimental aircraft and rockets to test and evaluate new technologies and aerodynamic concepts. Terming this the most exciting aeronautics program in decades, Epstein noted that the approach may be the only way to develop a commercial aircraft that does not look like a Boeing 707.

Bill Gerstenmaier, Associate Administrator for NASA's Human Exploration and Operations Mission Directorate, said that public–private partnerships are necessary, regardless of the difficulties. Although

Additional Resources

To read the entire report, *America's Future in Civil Space: Proceedings of a Workshop—In Brief*, see https://doi.org/10.17226/24921.

The webcast of the entire workshop is posted at https://vimeo.com/album/4596049.

More information about the work of the Space Studies Board can be found at http://sites.nationalacademies.org/SSB/index.htm, and more information about the work of the Aeronautics and Space Engineering Board can be found at http://sites.nationalacademies.org/DEPS/ASEB/index.htm.

PHOTO: NASA

In 2017, SpaceX's Falcon carried 6,000 pounds of science research, supplies, and hardware to ISS.

NASA is trying to establish more public–private partnerships, the efforts raise challenges in work culture—the agency has to recognize that outside partners can be the sources of innovation.

Vint Cerf of Google observed that the government continually reinvents public–private partnerships and ways to stimulate private industry. The challenge therefore is to figure out how to reinvent the nation's goals in space. Epstein pointed out that new entrants in the aerospace industry have a much higher tolerance for risk and that NASA may have to tolerate more risk.

The Business Case

One participant noted that private industry is good at finding the value proposition—that is, the promise of the value to be delivered—for its own activities; for this reason, NASA should make public–private partnerships a priority. Donahue pointed out, however, that the value proposition for industry may not always consider the long-term public interest.

Epstein added that in space-related endeavors, identifying the point at which an investment boost can realize a self-sustaining, profitable outcome can be difficult. The question then becomes how long to subsidize a program, considering the length of time required to establish a new industry.

One possibility, Epstein said, is to adopt an approach based in part on the Defense Advanced Research Projects Agency model—in other words, a plan that allows a short-term investment, after which the project must "sink or swim." Donahue remarked that the craft of partnerships involves a thoughtful selection of partners and the establishment of incentives—by considering what private partners would do in their own interest, the government can leverage private efforts closer to a public purpose.

Cerf pointed out that past successes involved a nascent value in the fundamental proposition of the partnership, but that incentives were necessary to demonstrate the value before the private sector would engage fully. Cerf noted that the question must be what is the business case—launching into space clearly is one example, but NASA should look at other activities that that would be of interest to private partners.

Incentives and Public Good

Summary discussions at the workshop noted that a variety of historical models can inform the U.S. approach to public–private partnerships in civil space. Industry and government agencies working together can promote innovation and can leverage their assets to advance their own interests and to benefit the common good.

Moving forward with such innovation requires identifying the right motivation for partnering with private industry. In addition, government policies and incentives need to be established that would bring industry to contribute to the public good that is at the core of the nation's civil space program.

Planning Committee for America's Future in Civil Space: A Workshop

Lester L. Lyles, The Lyles Group, *Cochair*
David N. Spergel, Princeton University, *Cochair*
Jeff M. Bingham, Retired, U.S. Senate
Eileen M. Collins, Space Presentations, LLC
Mary Lynne Dittmar, Dittmar Associates, Inc.
Alan H. Epstein, Pratt & Whitney
Fiona A. Harrison, California Institute of Technology
Mark J. Lewis, Science and Technology Policy Institute, Institute for Defense Analyses
John M. Olson, Polaris Industries
Barbara Sherwood Lollar, University of Toronto

Photo: Washington State DOT

NEW NCHRP RESEARCH REPORT

Quantifying the Effects of Preservation Treatments on Pavement Performance

JAMES M. BRYCE, GONZALO R. RADA, AND AMIR N. HANNA

Bryce is Senior Consultant, and Rada is Senior Principal Engineer, Amec Foster Wheeler Environment and Infrastructure, Inc., Beltsville, Maryland. Hanna is Senior Program Officer, National Cooperative Highway Research Program, Transportation Research Board, Washington, D.C.

For highway agencies, preservation is essential in maintaining and improving the functional condition of a pavement at a relatively low cost. Pavement preservation may not affect the structural, load-carrying capacity of a pavement but serves many other purposes, such as sealing the surface to reduce the infiltration of moisture into the pavement structure or patching cracks to correct localized surface defects.

The Fixing America's Surface Transportation Act—like its predecessor, the Moving Ahead for Progress in the 21st Century Act—recognizes preservation as vital for maintaining pavements in a state of good repair (*1*). In general, although preservation is recognized as a cost-effective practice in pavement management, guidance is limited on the use of data-driven approaches to evaluate the effectiveness of preservation and on ways to incorporate preservation into pavement management decision making.

(*Above*): Although it is critical to preserve the country's millions of miles of pavement, until recently, guidance on selecting and applying performance measurements has been limited.

Accurate Assessments

Pavement preservation is in broad use across many state departments of transportation (DOTs), but the benefits of preservation activities are primarily anecdotal, highlighting the need for more accurate assessments. As a result, the National Cooperative Highway Research Program (NCHRP) undertook Project 14-33, Pavement Performance Measures That Consider the Contributions of Preservation Treatments.[1]

The project results, forthcoming in NCHRP Research Report 858, *Quantifying the Effects of Preserva-*

[1] https://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=3655.

tion Treatments on Pavement Performance, offer guidance to state DOTs on selecting and applying an appropriate set of performance measures for evaluating the effectiveness of pavement preservation (2). The research report demonstrates the use of selected performance measures in conjunction with other data collected by state DOTs and develops models for incorporating preservation into pavement management decision making.

Critical Questions

Incorporating preservation into the pavement management decision process allows state DOTs to address several critical questions:

◆ Does the preservation treatment contribute to improved performance and to more cost-effective management in comparison with not using the preservation treatment?

◆ What are the best times and the best locations to apply preservation within the pavement network?

◆ What level of funding should investment strategies consider for preservation activities in the pavement network?

Answering these questions involves three steps:

1. Select a set of performance measures.
2. Use the performance measures to assess the effects of preservation on pavement performance.
3. Incorporate the performance measures from Step 1 and the models from Step 2 into the state DOT's business practice.

Key Concepts

Figure 1 (below) illustrates the expected effect of preservation according to a performance measure that decreases as the pavement condition worsens. The figure represents some important concepts:

◆ Preservation should be performed on pavements that are in good condition.

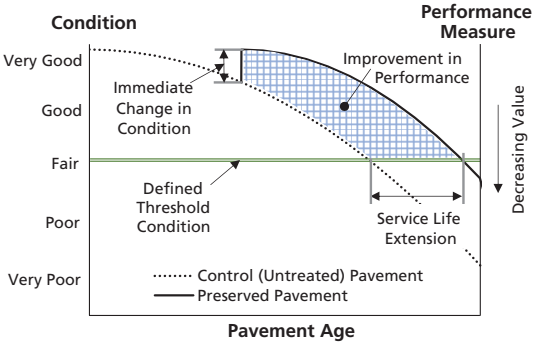


FIGURE 1 Pavement performance with and without preservation treatments.

PHOTO: GRAND CANYON NATIONAL PARK, FLICKR

In pavement management plans, DOTs must address the potential benefits of preservation treatments, best times and locations for the treatments, and funding strategies.

◆ Preservation should have two main effects: an immediate change in condition and a long-term change in performance.

The two main effects depend on the preservation treatment and on the performance measures chosen; moreover, the effects may not occur with every performance measure and treatment combination.

For example, the application of a chip seal may not produce an immediate change in the pavement's international roughness index (IRI) but may improve the pavement's performance by reducing the rate of increase in the IRI (3). Many other measures can show the effects of preservation—for example, the extension of service life or a comparison of the annualized costs of the treated and the untreated pavement over time.

Metrics and Goals

Performance measures serve two primary purposes:

1. Communicating the current condition of a pavement or pavement network and

PHOTO: R. GARY HICKS, CALIFORNIA PAVEMENT PRESERVATION CENTER

Application of a fog seal.

Photo: Washington DOT

Cracking in wheelpaths is one of the metrics collected to determine the scope of pavement work.

2. Providing a basis for the decisions about achieving specific goals for the pavement network.

The literature offers several definitions of pavement performance. The NCHRP project combined the various definitions and criteria; the researchers determined that pavement performance measures quantify the degree to which specific performance goals are achieved. Implicit in this definition is that performance measures must communicate the current condition of the pavement, must have a direct link to the pavement management decision processes, and must be connected with the broader asset management goals defined by the state DOT.

TABLE 1 Examples of Measures, Their Functions, and Their Advantages and Limitations

Measure	What It Captures	Primary Benefits and Limitations
International Roughness Index (IRI)	Pavement smoothness as perceived by the traveling public	**Benefit:** Standardized measure collected by most state DOTs **Limitation:** Preservation is not generally designed to address IRI
Transverse cracking	Cracking caused by environmental/climactic factors	**Benefit:** Captures distress typically addressed by preservation **Limitation:** Not standardized or collected by all state DOTs
Equivalent Uniform Annual Cost	The effects of preservation in terms of the annual expected costs to maintain a pavement	**Benefit:** Expresses effects of preservation in financial terms **Limitation:** Requires detailed cost history and cost projections
Composite measures (e.g., pavement condition rating)	A combination of the extent and severity of multiple distresses on a bound scale	**Benefit:** Expresses effects of preservation for many distresses in a single measure **Limitation:** Preservation affects individual distresses differently; combining the distresses may mask some effects; not standard across state DOTs

In 2017, the *Federal Register* published rules for reporting national pavement performance measures (*4*). The rules define the metrics and offer guidance on collecting and submitting the measurements to the Federal Highway Administration (FHWA).

The metrics for submittal to FHWA are the following:

- Pavement smoothness in terms of the IRI,
- Percent cracking in the wheelpath,
- Rutting in asphalt pavements, and
- Faulting in jointed portland cement concrete pavements.

These metrics allow the calculation of the percentage of a pavement network in poor or good condition.

Standardizing Metrics

A review of practices at state DOTs revealed that several use composite performance measures that combine the severity and the extent of pavement distresses, but each of these composite indexes is unique to the agency. Some use economic performance measures, such as the Equivalent Uniform Annual Cost, to capture the changes in costs associated with preservation. Table 1 (below left) presents a sample of these measures.

The NCHRP project reviewed these performance measures, and the researchers have recommended that state DOTs adopt the same individual distress metrics required by the national rules as performance measures for assessing the effectiveness of preservation. Most DOTs use these measures in day-to-day decision making—after all, gathering and submitting the metrics to FHWA are required for all applicable pavements. An analysis of the data collected from several state DOTs demonstrated that these measures capture the effects of preservation.

Preservation Effects

Pavement preservation can produce two distinct effects:

- An immediate effect that occurs with the application of the treatment and
- A long-term effect that occurs as changes in performance after the treatment.

Two sets of models therefore should be developed for each combination of preservation type and performance measure. The first set of analyses would address the immediate effect of preservation on the pavement condition. The second set would capture the change in performance as a result of the preservation application.

Immediate Effects

Figure 2 (below left) draws on data from the Long-Term Pavement Performance (LTPP) Specific Pavement Study (SPS) 3 experiment to show two cases that illustrate immediate changes in condition following the application of (*a*) thin overlays and (*b*) chip seals. The data demonstrate that a reduction in the IRI is expected after the application of the thin overlay and that no change in the IRI is expected after the application of the chip seal.

The expected change after the overlay is related to the IRI before the overlay, as the figure demonstrates. The variability in the data, however, is significant, and this may mask some relationships; caution should be taken to use the appropriate statistics to account for the variability.

Long-Term Effects

After the immediate changes are estimated, the long-term effects of preservation need to be evaluated. Many possible approaches are available, but care should be taken to ensure that a large enough number of projects is evaluated to draw statistically significant conclusions.

Following are two example approaches for capturing the long-term effects of preservation on pavement performance:

◆ If a full set of condition data is available for a pavement, starting with construction or another significant rehabilitation, for a period long enough to include the application of a preservation treatment and the deterioration to a poor condition, then the effect of preservation can be estimated directly from the performance before and after the preservation application. Nevertheless, most state DOTs are not likely to have collected the same performance measures with the same data collection protocols for the selected pavement segments over such a long period.

◆ The effects of preservation can be estimated by comparing the deterioration of a set of preservation projects with that of another set of projects that have the same characteristics—for example, projects not included in the preservation program because of budget limitations.

PHOTO: SNOHOMISH COUNTY PUBLIC WORKS, FLICKR

With various processes of preserving pavement available, DOTs need accurate data to determine which methods work best for each project.

Example Assessments

The second approach assesses the effect of the treatment by comparing the performance of a treated segment to that of a segment that did not receive preservation—that is, a control segment. Figure 3*a* (below right) applies data from a treated and a control site in the LTPP SPS 3 experiment to illustrate this approach. The linear regression model was fit to the IRI as a function of time; this was repeated for each treatment and control segment for 28 experimental sites.

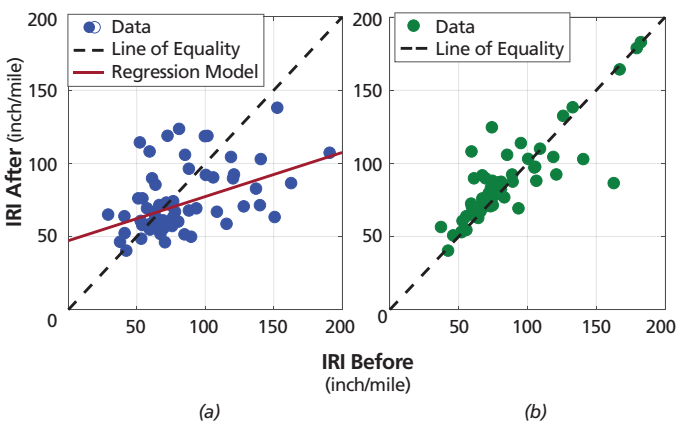


FIGURE 2 Examples of immediate changes in pavement condition with (*a*) thin overlay and (*b*) chip seal.

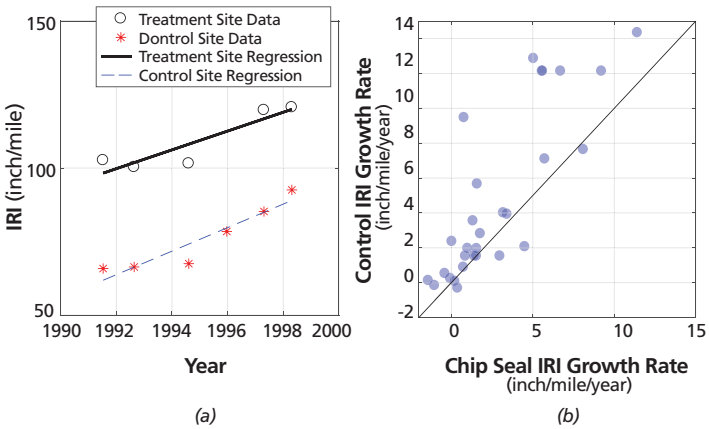


FIGURE 3 Examples of long-term changes in pavement condition, LTPP SPS 3 experiment: (*a*) data from a treated and control site; and (*b*) results for chip seal at 28 sites.

Photo: Minnesota DOT

Models must account for extreme weather variances and other factors that influence a change in pavement performance.

The slope of the model provides an estimate of the IRI growth rate with and without the application of a chip seal. Figure 3*b* shows the results for the 28 sites, all of which had at least four IRI measurements before another maintenance or rehabilitation was applied to the preservation or control segments. The results indicate that applying the chip seal reduces the IRI growth rate by approximately 20 percent—that is, the control segment growth rates are higher on average by 20 percent.

The immediate and long-term effects were evaluated for several preservation treatments; Table 2 (below) shows the results for some common treatments. The check marks in Table 2 represent the performance measures expected to be affected by the application of a specific preservation treatment, based on a detailed analysis of state DOT and LTPP data.

The dash marks in Table 2 represent those cases with no evidence of an effect. The analysis revealed variability in the data sources, indicating that some effects may vary from state to state; Table 2 represents averages from the results of the research.

Other Factors

A number of factors in addition to the application of preservation may influence a change in performance—for example, the traffic or the climate. Therefore, the models to describe the changes in performance need to account for factors directly and indirectly related to pavement condition.

These models can be extended to assess the best time for applying a preservation treatment. NCHRP is addressing this topic in the ongoing Project 14-38, Guide for Timing of Asphalt-Surfaced Pavements Preservation.[2]

Evaluating the effects of preservation on pave-

[2] https://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=4045.

TABLE 2 Examples of the Effects of Preservation Treatments on Performance Measures

	IRI		Rutting		Transverse Cracking		Fatigue Cracking	
	Immediate	Long Term[a]	Immediate	Long Term[a]	Immediate	Long Term[a]	Immediate	Long Term[a]
Thin overlay	✔	✔	✔	–	✔	✔	✔	–
Chip seal	–	✔	–	–	✔	✔	✔	–
Slurry seal	–	✔	–	–	✔	–	✔	–

[a] Refers specifically to change in the rate of deterioration.
✔ Treatment affects performance.
– No effect measured as a result of treatment.

TABLE 3 Examples of Data Issues and Their Effects on Performance Models

Potential Issue	Addressing the Potential Issue
Data inadequacy	Several sources can be leveraged, such as the LTPP and data from neighboring state DOTs that use similar treatments.
Poor data quality and data variability	The effects of poor data quality can be mitigated with more advanced statistical methodologies, such as robust or censored regression.
Changes in data collection technology	Changes in data collection technology can be addressed using statistical techniques. An example is using weighted regression—data collected with different equipment are weighted to reflect the confidence in the measurements.

ments can encounter several issues, as presented in Table 3 (page 34). NCHRP Research Report 858 addresses these issues and offers suggestions for ways to overcome the complications.

Support for Decision Making

The selected set of performance measures and the models developed to describe the effects of preservation can be used to support pavement management decision making. For example, the models can be used with treatment costs to predict the best timing to apply a specific preservation treatment.

Figure 4 (at right) illustrates the process that can be used to predict the best timing for a preservation treatment; NCHRP Project 14-38 is pursuing this approach for asphalt pavements. The performance measures and the models for preservation effects also can support decisions about pavement and asset management, such as the development of investment strategies that include preservation, and can help with other decision making.

Research is under way to develop models, algorithms, best practices, and other necessary procedures to include preservation in state DOT business processes, but more research will be needed. For example, data quality is a significant issue for modeling the effects of preservation, and therefore research that leads to improved data quality is a necessity. Also, inconsistent definitions of cracking have limited state-to-state comparisons of the effects of preservation on cracking. Standardized cracking definitions would allow the comparison and combination of data from many state DOTs.

Advancing the Models

The NCHRP Project 14-33 research has shown that data are available to support the development of models to incorporate preservation into state DOT business practices; however, the statistical methods required to develop the models are more advanced than those found in the literature. Nevertheless, incorporating preservation into DOT decision processes is promising. The availability of data from annual collection cycles on many pavement networks is increasing, making possible the development of reliable models to support preservation decision processes.

Data-driven approaches support the move away from anecdote, which historically has described the effects of preservation. Instead of general estimates of values for extended service life from preservation derived from anecdote, agencies can begin to develop models to describe the effects of preservation and to implement those models in decision support systems.

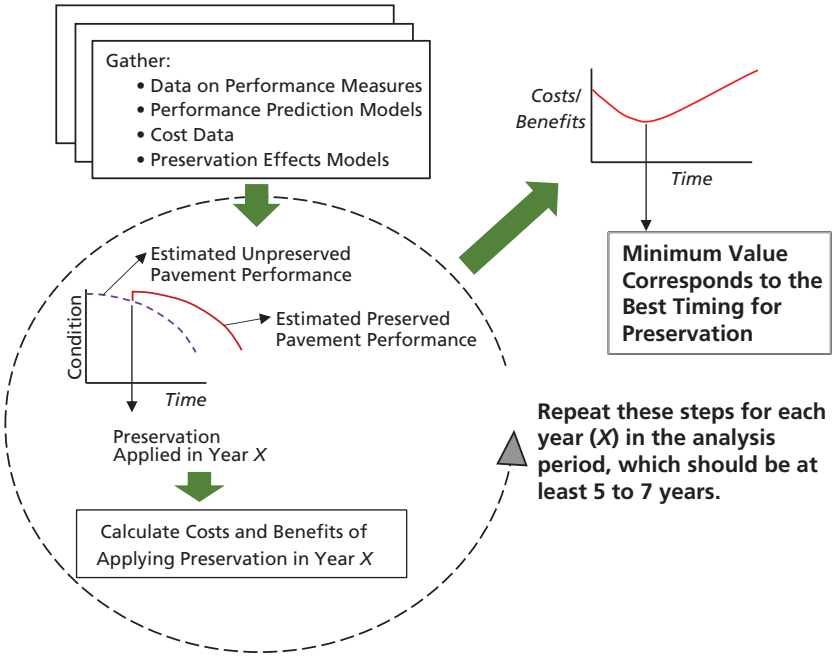


FIGURE 4 Basic approach for selecting preservation timing.

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2. Rada, G., J. Bryce, B. Visintine, G. Hicks, and D. Cheng. *NCHRP Report 858: Quantifying the Effects of Preservation Treatments on Pavement Performance*. Transportation Research Board, Washington, D.C., forthcoming.
3. Mamlouk, M., and M. Dosa. Verification of Effectiveness of Chip Seal as a Pavement Preventive Maintenance Treatment Using LTPP Data. *International Journal of Pavement Engineering*, Vol. 15, No. 10, 2014, pp. 879–888.
4. National Performance Management Measures: Assessing Pavement Condition for National Highway Performance Program and Bridge Condition for National Highway Performance Program. *Code of Federal Regulations*, 23 CFR, Part 490, 2017.

Inconsistent definitions of cracking make it challenging to conduct state-to-state comparisons of the effects of pavement preservation.

PHOTO: WASHINGTON DOT

Brian J. Gardner

Federal Highway Administration

As leader of the Systems Planning and Analysis Team in the Federal Highway Administration (FHWA) Office of Planning, Brian J. Gardner has collaborated with the Transportation Research Board (TRB), Argonne National Laboratory, and other research organizations to facilitate new methods and technologies in transportation modeling.

In 1990, after receiving bachelor's and master's degrees in civil engineering from North Carolina State University, Gardner joined FHWA as a transportation engineer. He became program manager at FHWA in 1999, responsible for transportation planning modeling and simulation research.

Gardner guided the deployment program for TRansportation ANalysis SIMulation System (TRANSIMS), which analyzes regional changes in travel patterns and mobility impacts of such large-scale events as evacuations and facility closures. In

"We used practices from successful open-source projects to mitigate technology transition issues."

one of the deployment case studies, researchers built a TRANSIMS model for the Detroit metropolitan area in southeast Michigan, which used a day-by-day evolutionary approach to examine how freeway segment closures affected mobility, travel patterns, and departure times. Using the TRANSIMS model, researchers could analyze travel reliability and travel pattern changes attributable to the facility closure.

In 2009, Gardner became Systems Planning and Analysis Team leader at FHWA, guiding the group responsible for policy, technical assistance, and research related to travel forecasting and analysis.

In collaboration with the FHWA's Exploratory Advanced Research Program, Gardner advanced conceptual frameworks for federated simulation and agent models of urban transport systems. These simulation approaches emphasized integration of land uses, traveler behaviors, and dynamic networks. The agent frameworks and tools were further developed under the second Strategic Highway Research Program (SHRP 2) in partnership with the Maryland State Highway Administration and the University of Maryland.

One of his most challenging projects was launching a deployment program for technology developed in a uniquely isolated research environment.

"Over the course of the program, we used practices from successful open-source projects to mitigate some of the technology transition issues," he comments.

The deployment program also relied on third-party verification to build capacity within the consulting community and peer reviews of deployment projects to familiarize researchers, consultants, and agency staff with the technology. This experience helped inform subsequent efforts on evaluating and communicating technology readiness.

Gardner worked with researchers at Argonne National Laboratory in Illinois to develop the open-source, agent-based, urban systems simulation suite POLARIS. This modeling capability features dynamic, agent-based representation of travelers, network performance, information flows, and control systems where daily travel decisions—departure time scheduling, destination choices, route choices, pretrip planning, and en-route replanning—can be modeled together. POLARIS currently is used in research for energy and mobility issues related to vehicle fleet changes and automation scenarios.

Gardner served on the TRB Standing Committee on Transportation Planning Applications from 1998 to 2007. He is a member of the Standing Committee on Transportation Demand Forecasting and of the Special Committee for Travel Forecasting Resources. He was highly active in SHRP 2, serving on expert task groups and task forces on understanding highway users and the factors affecting travel demand, especially congestion and pricing; incorporating reliability performance measures into planning and operations modeling tools; and establishing partnerships to develop an integrated, advanced travel demand model and a fine-grained, time-sensitive network. He also served as the FHWA implementation lead for the projects that comprised SHRP 2 TravelWorks and EconWorks.

Gardner also worked with TRB to create the Travel Forecasting Resource (TFResource) on travel demand modeling. TRB *Special Report 288, Metropolitan Travel Forecasting: Current Practice and Future Direction*, examined the state of the practice in metropolitan travel forecasting and identified many ways to improve travel demand forecasting, such as a national handbook or online resource to provide information to travel demand forecasting practitioners. The TFResource webpage, in wiki format, allows for input from and interaction among researchers across the globe.

Among the titles Gardner has coauthored are "Integrated Land Use–Transport Model System with Dynamic Time-Dependent Activity–Travel Microsimulation," published in the *Transportation Research Record: Journal of the Transportation Research Board, No. 2303*, in 2012, and "A GIS-Based Framework for Modeling Nonmotorized Transportation," presented at the TRB 91st Annual Meeting in January 2012.

Roger Olson

Minnesota Department of Transportation

After receiving a degree in civil engineering in 1968 from North Dakota State University in Fargo, Roger Olson joined the Minnesota Department of Transportation (DOT) as an engineer in training. He served as assistant county engineer in Scott County, Minnesota, managing design, predesign, construction traffic, and maintenance projects. In 1978, Olson returned to Minnesota DOT to work in materials and pavement research. He initially retired in 2010, but worked part-time on road and pavement research–related activities until 2015.

"I was able to participate in many interesting research projects, primarily in the area of asphalt technology, pavement rehabilitation, pavement maintenance, and pavement preservation," Olson notes. He conducted studies related to the implementation of Superpave® and to low-temperature cracking, reflective cracking, and waste-product utilization.

"Even though there are now many pavement evaluation tools available, it often is said that the best evaluation tool is the human eye."

One notable study was an extensive evaluation of studded tire damage to pavements. "The results of this study convinced the Minnesota state legislature in 1971 to ban the use of studded tires—this resulted in saving millions of dollars in pavement repairs," Olson recalls.

Minnesota DOT has developed a strong pavement research program including the Minnesota Road Research Facility (MnROAD) on Interstate 94 near Albertville, an outdoor research facility representing various road building materials and designs. The MnROAD test facility, in operation since 1994, includes a 3.5-mile mainline test Interstate with live traffic and a 2.5-mile low-volume loop that simulates county and city conditions.

Minnesota DOT has strongly advocated developing partnerships with other agencies, private-sector organizations, and academia. MnROAD has been a big part of these partnerships, initially with the Transportation Road Research Alliance and now with the National Road Research Alliance. Minnesota DOT also has enjoyed a strong partnership with Scandinavian countries.

"Developing partnerships, exchanging information, and pooling resources go a long way in developing a robust research program," Olson comments.

Olson served as chair of Transportation Research Board (TRB) standing committees for 12 years—the Standing Committee on Pavement Rehabilitation from 2002 to 2008 and the Standing Committee on Pavement Maintenance from 2008 to 2014. He was awarded an emeritus membership in the Pavement Rehabilitation Committee in 2014 and in the Pavement Maintenance Committee in 2017. In his 12 years as committee chair, Olson emphasized collaboration with other committees through cosponsored sessions and workshops.

"Because the TRB meeting is a forum for information exchange, it is extremely important to work with other committees," he notes.

Olson also has served as a member of the standing committees on Sealants and Fillers for Joints and Cracks, Pavement Preservation, Nonbinder Components of Asphalt Mixtures, and Surface Requirements of Asphalt Mixtures. He is a panel member of National Cooperative Highway Research Program Project 20-05, Synthesis of Information Related to Highway Problems.

After serving on the American Association of State Highway and Transportation Officials' Lead States Team on Pavement Preservation from 1995 to 2000, Olson realized the importance of continuing the pavement preservation initiative. He helped initiate the Midwest Pavement Preservation Partnership, which evolved into four partnerships across nearly all U.S. state transportation agencies and many Canadian provinces.

Minnesota DOT also developed an increased emphasis on pavement preservation—both asphalt and portland cement concrete. Among the significant accomplishments of this period was the implementation of a chip seal program. A rational design method was developed including the use of cubical, one-sized aggregate and of polymerized emulsion and the use of a fog seal on the chip seal to attain proper chip embedment.

At Minnesota DOT, Olson also conducted investigations of research test sections and premature pavement failures. "Even though there are now many pavement evaluation tools available, it often is said that the best evaluation tool is the human eye," Olson observes. "Of course, in Minnesota, we like to soften our evaluation terminology—so we would often refer to a failed test section or pavement segment as having 'mixed result,' and of a successful section, we would say 'we had good luck.'" He adds that with evaluation and persistence, many test sections that showed "mixed results" changed to "having good luck."

"We often would make an effort to evaluate failed pavements to understand the failure mechanism better," Olson comments. "It is worthwhile to spend extra effort studying long-life and surviving pavements to understand better why they succeeded."

Photo: Jakob Harter, Flickr

Cognitive demand while driving is exacerbated by onboard technologies like navigation and entertainment systems.

Vehicle Technologies Add to Driver Distraction

Although vehicle-based information and entertainment technologies may have removed cell phones and other devices from motorists' hands, research suggests that these technologies offer their own distractions. Researchers from the University of Utah and the AAA Foundation for Traffic Safety studied four tasks—texting, tuning the radio, dialing the phone, and programming navigation—to determine which is the most demanding during driving.

Researchers studied 120 drivers between the ages of 21 and 36, driving 30 different vehicle models on a two-mile stretch of road with an investigator in the passenger seat. Data were collected subjectively and objectively as the participants drove the course several times while completing different tasks. The tasks ranged from a baseline condition of no distraction to high cognitive demand.

According to researchers, texting and navigation were associated with significantly higher levels of cognitive demand than tuning the radio and making a phone call. Navigation required not only more eyes-off-road time but also ranked the longest in completion time.

To read more, visit www.aaafoundation.org/visual-and-cognitive-demands-using-vehicle-information-systems.

Bicyclist Risk Patterns Analyzed

Florida bicyclists are three times more likely to be in fatal crashes than their peers nationwide, and bicyclists overall experience a disproportionate rate of fatalities compared to other motorists. The Center for Urban Transportation Research (CUTR) in Tampa, Florida, studied bicyclist behavior to find rider patterns and infrastructure challenges that contribute to dangers.

In order to analyze patterns, the CUTR team developed a data system capable of collecting key bicycle behavior data and a database for analysis. Using video and digital information gathered from 100 participants in the Tampa Bay area over 2,000 hours of riding, researchers were able to pinpoint several trouble spots in bicyclist and driver interactions, notably at intersections and with right-turning vehicles. Most of these close calls were due to vehicles failing to yield the right-of-way, the lack of bike lanes, or narrow bike lane widths.

According to researchers, women and younger cyclists were less likely to comply with traffic rules, drove more aggressively, and were considered a high distraction risk. Among all cyclists, both compliance and awareness were higher in the nighttime hours.

For more information, visit www.fdot.gov/research/Completed_Proj/Summary_SF/FDOT-BDV25-977-13-rpt.pdf.

Photo: Daniel Ones, Flickr

Intersections and right-turning vehicles are the biggest trouble spots for cyclists.

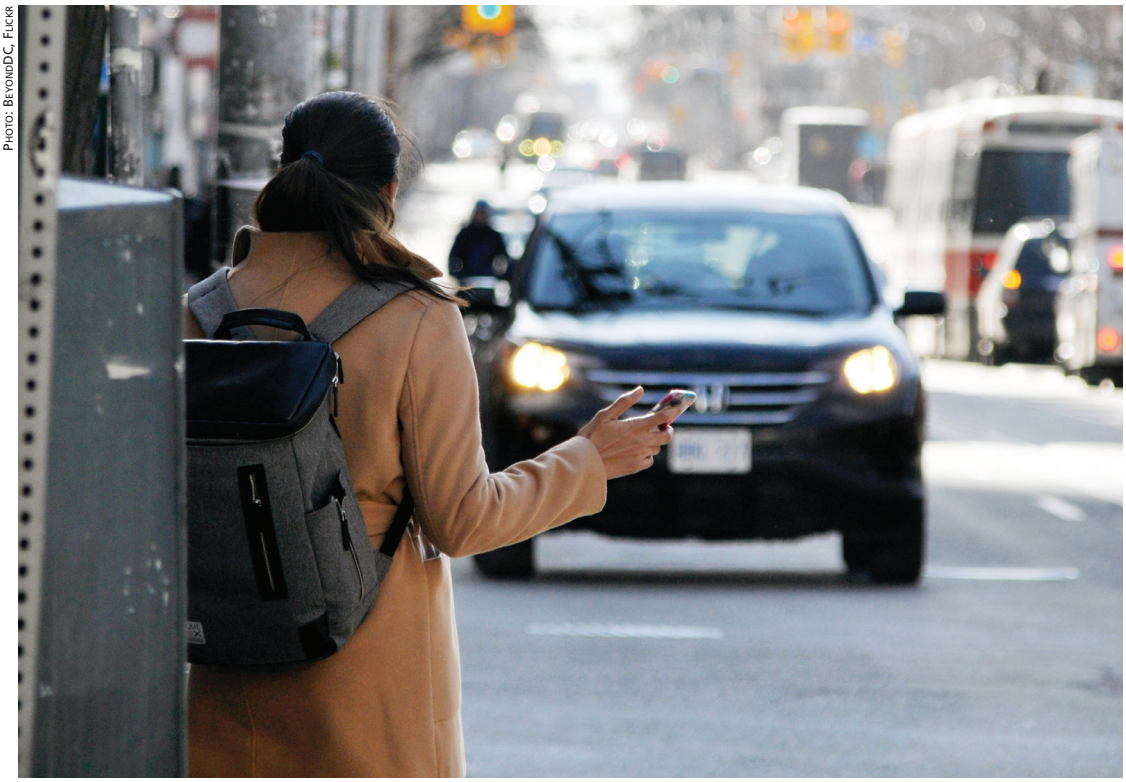


Photo: BeyondDC, Flickr

Uber, Lyft, and other ride-hailing services may add to urban congestion and draw riders away from transit and cycling.

Ridesharing May Increase Vehicle Miles Traveled

The rapid growth of ridesharing services like Uber and Lyft in urban areas may be increasing congestion and emissions—contributing to more vehicle miles traveled rather than reducing them.

Building on reports from the American Public Transportation Association and the Pew Research Center, researchers at the Institute of Transportation Studies at the University of California, Davis, conducted a two-phase survey in seven U.S. metropolitan areas. More than 4,000 responses were collected and analyzed.

Survey results showed that up to 61 percent of ridesharing trips either would not have been made at all without the service, or would have been made by transit, biking, or walking. The survey also showed that, on average, survey respondents reduced their transit use because of ridesharing. Thirty-seven percent of survey respondents stated that they used ridesharing services to avoid parking in urban areas; 33 percent cited the desire to avoid drinking and driving.

For more information and a link to the report, visit www.sfgate.com/business/article/Uber-Lyft-reduce-transit-use-increase-vehicle-12267774.php.

INTERNATIONAL NEWS

Higher Traffic Pollution Related to Lower Birth Weights

A recent study by the School of Public Health of Imperial College in London links traffic-related air pollution and the health of unborn babies. According to the study, pregnant mothers with higher exposure to air pollution had a higher risk of delivering babies with low birth weight.

Researchers examined national birth registries to study 540,000 single, full-term births in the London area over a four-year period, using home addresses to estimate the average exposure to traffic-related pollutants as well as to traffic noise levels.

Increases in noise pollution alone did not appear to affect birth weight, but increases in traffic-related air pollutants influenced the odds of having a low-birth-weight baby by 1 to 3 percent. Although the risks are considerably smaller than those posed by exposure to smoking, researchers note, a larger population is affected by traffic pollution.

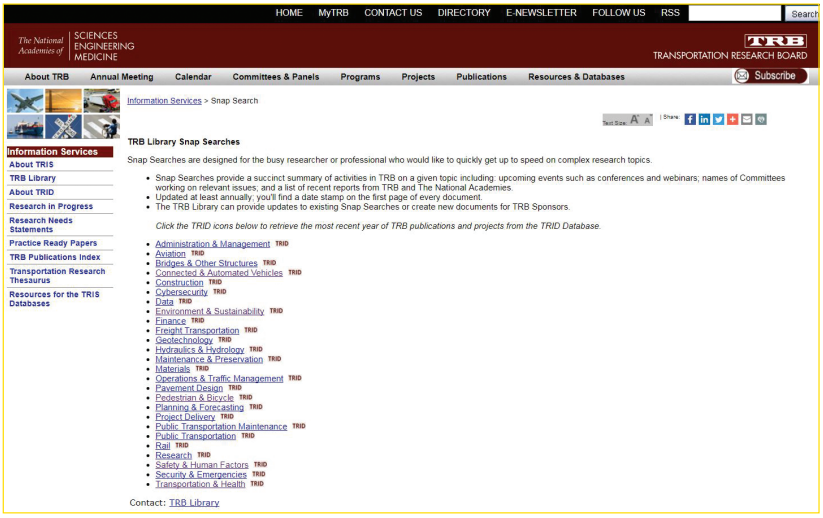
For more information, visit www.bmj.com/content/359/bmj.j5299.

Getting Up to Speed with Snap Search

WILLIAM B. MCLEOD

The Transportation Research Board (TRB) Library, part of Transportation Research Information Services, released its new Snap Search series at TRB's 97th Annual Meeting in January. Snap Searches are designed for the busy researcher or professional who wishes to quickly access an overview of information about complex research subjects.

Snap Searches provide a succinct summary of the activities in TRB on any given topic. Search results include upcoming events like conferences and webinars; the names of committees working on relevant issues; and a list of recent reports from TRB and the National Academies of Sciences, Engineering, and Medicine.



◆ Snap Searches are PDFs and are updated at least annually. Searchers will find a date stamp on the first page of every document.

◆ All resources link to the full text or complete description on TRB's web site or the website of the National Academies Press, which publishes National Academies, Engineering, and Medicine reports.

◆ The TRB Library can provide updates to existing Snap Searches and can create custom searches for TRB sponsors.

◆ Every Snap Search includes a link to a preconfigured search in TRB's TRID Database[1] so that customers can always see the most recent TRB publications and projects on each topic.

Snap Searches are publicly accessible at www.trb.org/InformationServices/snap.aspx. More than 25 Snap Searches cover an array of modes and topics. Recent additions include data,[2] environment and sustainability,[3] and transportation and health.[4] Searches are free to download and are free for widespread redistribution.

For more information, e-mail the TRB Library at trblibrary@nas.edu.

McLeod is Transportation Research Information Services Manager, Transportation Research Board.

[1] https://trid.trb.org.
[2] http://onlinepubs.trb.org/onlinepubs/trblibrary/overview/data.pdf.
[3] http://onlinepubs.trb.org/onlinepubs/trblibrary/overview/Environmentandsustainability.pdf.
[4] http://onlinepubs.trb.org/onlinepubs/trblibrary/overview/transportationandhealth.pdf.

TRB's Most Downloaded Publications of 2017

1. *Transit Cooperative Research Program (TCRP) Research Report 191: Public Transportation Guidebook for Small- and Medium-Sized Public–Private Partnerships (P3s)*—**3,079 downloads**
2. *National Cooperative Highway Research Program (NCHRP) Web-Only Document 226: Data Visualization Methods for Transportation Agencies*—**2,318 downloads**
3. *Strategies to Advance Automated and Connected Vehicles*—**2,271 downloads**
4. *TCRP Research Report 192: Decision-Making Toolbox to Plan and Manage Park-and-Ride Facilities for Public Transportation—Guidebook on Planning and Managing Park-and-Ride*—**2,158 downloads**
5. *NCHRP Research Report 845: Advancing Automated and Connected Vehicles—Policy and Planning Strategies for State and Local Transportation Agencies*—**2,132 downloads**
6. *NCHRP Synthesis 500: Control of Concrete Cracking in Bridges*—**1,943 downloads**
7. *National Cooperative Freight Research Program Research Report 38: Guide for Conducting Benefit–Cost Analyses of Multimodal, Multijurisdictional Freight Corridor Investments*—**1,619 downloads**
8. *NCHRP Research Report 840: A Watershed Approach to Mitigating Stormwater Impacts*—**1,589 downloads**
9. *NCHRP Synthesis 505: Current Practices and Guidelines for the Reuse of Bridge Foundations*—**1,547 downloads**
10. *NCHRP Research Report 834: Crossing Solutions at Roundabouts and Channelized Turn Lanes for Pedestrians with Vision Disabilities—A Guidebook*—**1,468 downloads**

CALENDAR

TRB Meetings

March

6–7 Airport Cooperative Research Program Insight Event: Airport Roles in Reducing Transmission of Communicable Diseases
Washington, D.C.

21–23 2018 Ferry Safety and Technology Conference*
New York, New York

April

16–18 International Conference on Advances in Materials and Pavement Performance Prediction*
Doha, Qatar

16–19 Transport Research Arena 2018*
Vienna, Austria

May

2–4 8th Symposium on Pavement Surface Characteristics 2018*
South Brisbane, Australia

16–18 Road Safety on Five Continents*
Jeju Island, South Korea

20–22 10th National Aviation System Planning Symposium
Anchorage, Alaska

27–30 4th GeoShanghai International Conference*
Shanghai, China

June

1–4 3rd International Conference on Infrastructure and Materials*
Tianjin, China

6–8 International Transportation and Economic Development Conference
Washington, D.C.

18–20 6th National Bus Rapid Transit Conference
Los Angeles, California

18–21 2018 World Transport Convention*
Bejing, China

19–21 5th Biennial Marine Transportation System Research and Technology Conference
Washington, D.C.

24–27 7th International Conference on Innovations in Travel Modeling
Atlanta, Georgia

July

9–13 9th International Conference on Bridge Maintenance, Safety, and Management*
Melbourne, Australia

14–17 12th National Conference on Transportation Asset Management
San Diego, California

15–18 57th Annual Workshop on Transportation Law
Boston, Massachusetts

17–19 12th Access Management Conference
Madison, Wisconsin

23–25 GeoChina 2018 International Conference*
Hangzhou, Zhejiang, China

August

8–9 National Household Travel Survey Data for Transportation Applications Workshop
Washington, D.C.

22–24 16th National Tools of the Trade Transportation Planning Conference
Kansas City, Missouri

September

5–6 Freight Fluidity Performance Measurements Implementation
Washington, D.C.

10–13 TRB Workshop at the 69th Highway Geology Symposium 2018*
Portland, Maine

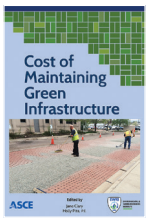
25–27 2018 Workshop on Managed Lanes
Bellevue, Washington

30–Oct. 3 23rd National Conference on Rural Public and Intercity Bus Transportation
Breckenridge, Colorado

Additional information on TRB meetings, including calls for abstracts, meeting registration, and hotel reservations, is available at www.TRB.org/calendar, or e-mail TRBMeetings@nas.edu.

*TRB is cosponsor of the meeting.

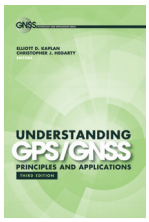
Cost of Maintaining Green Infrastructure



American Society of Civil Engineers (ASCE), 2017; 74 pp.; ASCE members, $40; nonmembers, $60; 978-0-78-441489-7.

Authors present findings from a survey and literature review to capture and quantify the expenses associated with operating and maintaining sustainable stormwater management technologies.

Understanding GPS/GNSS: Principles and Applications, Third Edition

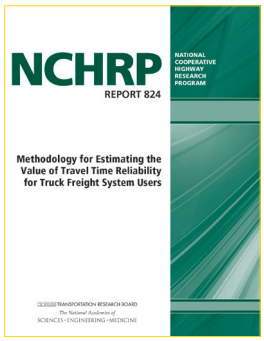


Elliott D. Kaplan and Christopher Hegarty. Artech House, 2017; 1,064 pp.; $179; 978-1-63-081058-0.

This updated edition provides a current and comprehensive treatment of global navigation satellite systems, including new chapters on GPS, the European Galileo system, and the Chinese Beidou system, along with other regional systems.

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

TRB PUBLICATIONS



Mapping Heavy Vehicle Noise Source Heights for Highway Noise Analysis

NCHRP Research Report 842

This report provides an analysis to determine height distributions and spectral content for sources of heavy vehicle noise. The report also explores the incorporation of an extended heavy vehicle noise source database into traffic noise models.

2017; 94 pp.; TRB affiliates, $50.25; nonaffiliates, $67. Subscriber categories: design, environment, highways.

Long-Term Field Performance of Warm Mix Asphalt Technologies

NCHRP Research Report 843

Compared in this volume are the material properties and field performance of warm mix asphalt across more than two dozen locations in the United States.

2017; 124 pp.; TRB affiliates, $50.25; nonaffiliates, $67. Subscriber categories: construction, materials, pavement.

Guide for Integrating Goods and Services Movement by Commercial Vehicles in Smart Growth Environments

NCHRP Research Report 844

Common issues pertaining to smart growth are examined in this report, as well as how those issues manifest in different environments and the integration of goods and services movement via commercial vehicles.

2017; 130 pp.; TRB affiliates, $52.50; nonaffiliates, $70. Subscriber categories: freight transportation, motor carriers, planning and forecasting.

Advancing Automated and Connected Vehicles: Policy and Planning Strategies for State and Local Transportation Agencies

NCHRP Research Report 845

This report assesses policy and planning strategies at the state, regional, and local levels that could influence private-sector automated and connected vehicle choices in the areas of crashes, congestion, pollution, land development, and mobility. A briefing document accompanies the report.

2017; 160 pp; TRB affiliates, $59.25; nonaffiliates, $79. Subscriber categories: operations and traffic management, policy.

Improving Findability and Relevance of Transportation Information, Volumes 1–2

NCHRP Research Report 846

This two-volume report offers practices and tools for retrieving information stored in project files, libraries, and other agency archives.

2017; 236 pp.; TRB affiliates, $65.25; nonaffiliates, $87. Subscriber categories: administration and management, data and information technology.

Variability of Ignition Furnace Correction Factors

NCHRP Research Report 847

Examined in this volume are significant influences that can affect the variability of asphalt and aggregate correction factors for ignition furnaces.

2017; 128 pp.; TRB affiliates, $52.50; nonaffiliates, $70. Subscriber category: materials.

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

TRB PUBLICATIONS *(continued)*

Inspection Guidelines for Bridge Posttensioning and Stay Cable Systems Using NDE Methods
NCHRP Research Report 848

The methods outlined in this report explore different condition assessments, including corrosion, section loss, breakage, and grout conditions, with nondestructive evaluation (NDE) methods that include ground-penetrating radar, infrared thermography, and impact echo.

2017; 258 pp.; TRB affiliates, $66.75; nonaffiliates, $89. Subscriber category: bridges and other structures.

Strand Debonding for Pretension Girders
NCHRP Research Report 849

Proposed revisions to provisions for the American Association of State Highway and Transportation Officials' *Load and Resistance Factor Design Bridge Design Specifications* with detailed examples are provided in this report.

2017; 102 pp.; TRB affiliates, $48; nonaffiliates, $64. Subscriber category: bridges and other structures.

Applying Risk Analysis, Value Engineering, and Other Innovative Solutions for Project Delivery
NCHRP Research Report 850

Research is presented on managing project development and delivery through application of value engineering to achieve a balance between project needs and resources.

2017; 106 pp.; TRB affiliates, $20.25; nonaffiliates, $67. Subscriber categories: highways, administration and management, construction.

Resource Allocation of Available Funding to Programs of Work
NCHRP Synthesis 510

Explored in this synthesis are the processes, techniques, tools, and data used to evaluate and select funding allocations around the country.

2017; 82 pp.; TRB affiliates, $45.75; nonaffiliates, $61. Subscriber categories: administration and management, finance, highways, planning and forecasting.

Relationship Between Chemical Makeup of Binders and Engineering Performance
NCHRP Synthesis 511

This volume offers information on the selection of binders and postproduction additives and modifiers and their effect on engineering performance.

2017; 118 pp.; TRB affiliates, $50.25; nonaffiliates, $67. Subscriber categories: construction, highways, materials, pavement.

Use of Fiber-Reinforced Polymers in Highway Infrastructure
NCHRP Synthesis 512

Identified in this synthesis are fiber-reinforced polymer (FRP) applications in highway infrastructure, current research on FRPs, and barriers to their widespread use.

2017; 168 pp.; TRB affiliates, $59.25; nonaffiliates, $79. Subscriber categories: design, finance, safety and human factors.

Evolving Debt Finance Practices for Surface Transportation
NCHRP Synthesis 513

A variety of debt mechanisms and tools to finance transportation infrastructure are explored in this synthesis, including new developments in flexible finance tools.

2017; 88 pp.; TRB affiliates, $48; nonaffiliates, $64. Subscriber categories: administration and management, finance, highways.

Statewide and Megaregional Travel Forecasting Models: Freight and Passenger
NCHRP Synthesis 514

This synthesis documents current practices and emerging trends in travel forecasting models—institutional constraints, performance monitoring, multistate corridors, and new transportation modes.

2017; 124 pp.; TRB affiliates, $52.50; nonaffiliates, $70. Subscriber categories: freight transportation, highways, planning and forecasting.

Improving Intelligibility of Airport Terminal Public Address Systems
ACRP Research Report 175

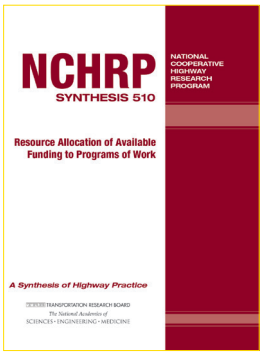
Presented in this report are guidelines to improve the public address systems in airports of all sizes and types. Consideration is given to terminal finishes, background noise, and acoustical shortcomings.

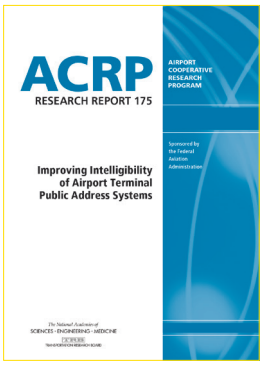
2017; 158 pp.; TRB affiliates, $59.25; nonaffiliates, $79. Subscriber categories: aviation, passenger transportation, terminals and facilities.

Generating Revenue from Commercial Development On or Adjacent to Airports
ACRP Research Report 176

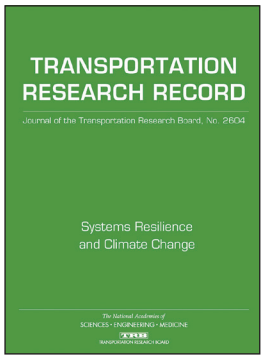
This report offers specific checklists and examines methods and factors to assist airports in preparing and implementing a commercial development plan.

2017; 308 pp.; TRB affiliates, $71.25; nonaffiliates, $95. Subscriber categories: aviation, economics, terminals and facilities.





TRB PUBLICATIONS *(continued)*



Enhancing Airport Wayfinding for Aging Travelers and Persons with Disabilities
ACRP Research Report 177

Presented is guidance for assisting travelers with cognitive, sensory, and mobility challenges through pedestrian wayfinding systems. A wayfinding accessibility audit checklist and PowerPoint presentation accompany the volume.

2017; 318 pp.; TRB affiliates, $72.75; nonaffiliates, $97. Subscriber categories: aviation, passenger transportation, terminals and facilities.

Guidance for Usage of Permeable Pavement at Airports
ACRP Research Report 178

This report offers guidance on permeable pavement at airports, including installation locations and operational and economic considerations. A decision matrix and guidance appendixes accompany the volume.

2017; 88 pp.; TRB affiliates, $48; nonaffiliates, $64. Subscriber categories: aviation, environment, pavements.

Dispersion Modeling Guidance for Airports Addressing Local Air Quality Health Concerns
ACRP Research Report 179

This report explores the challenges associated with modeling airport-related emissions to understand their impacts on human health.

2017; 44 pp.; TRB affiliates, $37.50; nonaffiliates, $50. Subscriber categories: aviation, environment.

Guidebook for Quantifying Airport Ground Access Vehicle Activity for Emissions Modeling
ACRP Research Report 180

Reviewed in this volume is the significance of, and regulatory framework related to, emissions from taxis, shuttles, rental cars, and other ground access vehicles. A PowerPoint tutorial accompanies the report.

2017; 48 pp.; TRB affiliates, $39.75; nonaffiliates, $53. Subscriber categories: aviation, environment.

Systems Resilience and Climate Change
Transportation Research Record 2604

The papers in this volume explore analysis and modeling for transportation system resilience, including examples from recent hurricanes, fires, and tsunamis.

2017. Subscriber category: aviation. For more information, visit http://trrjournalonline.trb.org/toc/trr/2017/2604/+.

Connected and Automated Vehicles
Transportation Research Record 2625

The seven papers in this volume examine the technology, risks, driver decision making, and public acceptance related to connected and automated vehicles.

2017. Subscriber categories: operations and traffic management, vehicles and equipment. For more information, visit http://trrjournalonline.trb.org/toc/trr/2017/2625/+.

Aviation
Transportation Research Record 2626

Aspects of aviation including airport-adjacent communities, transponder-based devices, and allocating capacity under severe weather conditions are covered in this volume.

2017. Subscriber category: aviation. For more information, visit http://trrjournalonline.trb.org/toc/trr/2017/2626/+.

Air Quality
Transportation Research Record 2627

Aspects of air quality related to transportation explored in this volume include light-duty gasoline vehicle and heavy-duty truck emissions, odd-even day traffic restriction effects, and turbo-roundabouts.

2017. Subscriber categories: environment, energy. For more information, visit http://trrjournalonline.trb.org/toc/trr/2017/2627/+.

Environment and Energy
Transportation Research Record 2628

This volume includes research on the life-cycle benefits of recycled highway materials, harvesting thermoelectric energy from pavement, the appeal of California's electric vehicle rebate, and more.

2017. Subscriber categories: environment, energy. For more information, visit http://trrjournalonline.trb.org/toc/trr/2017/2628/+.

The TRR Online website provides electronic access to the full text of more than 15,000 peer-reviewed papers that have been published as part of the Transportation Research Record: Journal of the Transportation Research Board *(TRR) series since 1996. The site includes the latest in search technologies and is updated as new TRR papers become available. To explore TRR Online, visit www.TRB.org/TRROnline.*

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.

FEATURES are timely articles of interest to transportation professionals, including administrators, planners, researchers, and practitioners in government, academia, and industry. Articles are encouraged on innovations and state-of-the-art practices pertaining to transportation research and development in all modes (highways and bridges, public transit, aviation, rail, marine, and others, such as pipelines, bicycles, pedestrians, etc.) and in all subject areas (planning and administration, design, materials and construction, facility maintenance, traffic control, safety, security, logistics, geology, law, environmental concerns, energy, etc.). Manuscripts should be no longer than 3,000 words (12 double-spaced, typed pages). Authors also should provide charts or tables and high-quality photographic images with corresponding captions (see Submission Requirements). Prospective authors are encouraged to submit a summary or outline of a proposed article for preliminary review.

RESEARCH PAYS OFF highlights research projects, studies, demonstrations, and improved methods or processes that provide innovative, cost-effective solutions to important transportation-related problems in all modes, whether they pertain to improved transport of people and goods or provision of better facilities and equipment that permits such transport. Articles should describe cases in which the application of project findings has resulted in benefits to transportation agencies or to the public, or in which substantial benefits are expected. Articles (approximately 750 to 1,000 words) should delineate the problem, research, and benefits, and be accompanied by one or two illustrations that may improve a reader's understanding of the article.

NEWS BRIEFS are short (100- to 750-word) items of interest and usually are not attributed to an author. They may be either text or photographs or a combination of both. Line drawings, charts, or tables may be used where appropriate. Articles may be related to construction, administration, planning, design, operations, maintenance, research, legal matters, or applications of special interest. Articles involving brand names or names of manufacturers may be determined to be inappropriate; however, no endorsement by TRB is implied when such information appears. Foreign news articles should describe projects or methods that have universal instead of local application.

POINT OF VIEW is an occasional series of authored opinions on current transportation issues. Articles (1,000 to 2,000 words) may be submitted with appropriate, high-quality illustrations, and are subject to review and editing.

BOOKSHELF announces publications in the transportation field. Abstracts (100 to 200 words) should include title, author, publisher, address at which publication may be obtained, number of pages, price, and ISBN. Publishers are invited to submit copies of new publications for announcement.

LETTERS provide readers with the opportunity to comment on the information and views expressed in published articles, TRB activities, or transportation matters in general. All letters must be signed and contain constructive comments. Letters may be edited for style and space considerations.

SUBMISSION REQUIREMENTS: Manuscripts submitted for possible publication in *TR News* and any correspondence on editorial matters should be sent to the *TR News* Editor, Publications Office, Transportation Research Board, 500 Fifth Street, NW, Washington, DC 20001, telephone 202-334-2986, or e-mail lcamarda@nas.edu.

◆ 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.

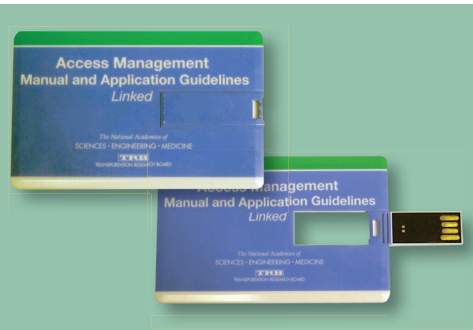
◆ Use the units of measurement from the research described and provide conversions in parentheses, as appropriate. The International System of Units (SI), the updated version of the metric system, is preferred. In the text, the SI units should be followed, when appropriate, by the U.S. customary equivalent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

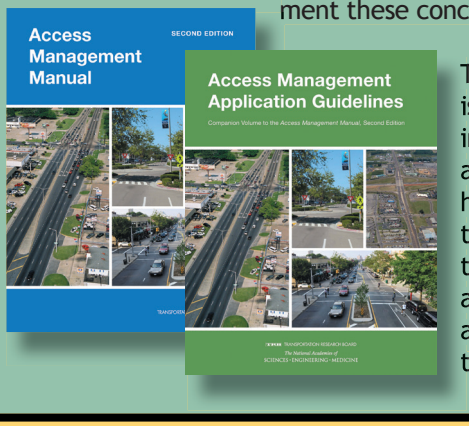
NOTE: Authors are responsible for the authenticity of their articles and for obtaining written permissions from publishers or persons who own the copyright to any previously published or copyrighted material used in the articles.

Access Management USB!

Access Management: Manual and Applications Guidelines—Linked

TRB's *Access Management Manual, Second Edition* (AMM2) and *Access Management Application Guidelines* (AMAG) are now available together on a USB flash drive. This USB includes the complete text of each volume with links between material common to both. Content is linked within each volume and between the two. Where possible, references are linked to their online versions. The drive also includes the AMAG's Microsoft Excel workbooks and self-calculating spreadsheet tools. The workbooks demonstrate the basic concepts introduced in the books, and the spreadsheet tools enable users to implement these concepts in their own projects.





The AMM2 comprehensively addresses issues related to access management, including its role in corridor, network, and land use planning. The AMAG is a how-to tool for continuing the evolution of access management applications in the United States and provides additional rationale and guidance for applying the guidelines and concepts in the AMM2.

To order your copy of *Access Management: Manual and Applications Guidelines—Linked* and find out more about special discounts on the AMM2 and AMAG, visit **http://www.trb.org/amm14**.

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