

# TR NEWS

## Reenvisioning New York's Legendary Bus Terminal

Plus

**Six-Minute Pitch:  
Showcasing Innovations**

**U.S. DRIVE Partnership:  
Seeking Energy Sustainability**

**Stemming Fatigue  
for Commercial Drivers**

**Walking and Walkability:  
Setting National Goals**

**Transportation's Roles  
in Health Equity**

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New York City's Port Authority Bus Terminal, the busiest in the world, is aging, overcrowded, deteriorating, and unable to accommodate projected growth. An International Design and Deliverability Competition assembled concepts for consideration in planning; the author, who chaired the jury, reviews the challenges and trade-offs addressed and summarizes the jury's observations.

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A National Academies committee has released a report on the status and direction of the government–industry U.S. DRIVE Partnership, which works to accelerate the development of innovative and low-emission light-duty vehicles. The report evaluates and reviews progress in engines and fuel systems, hydrogen-fueled vehicles, electric drive systems, plug-in vehicles, structural materials, and more.

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A new National Academies report offers promising approaches for promoting health equity in communities nationwide. The transportation sector plays a key role in addressing pollution and greenhouse gas production, motor vehicle–related deaths and injuries, mobility and access to employment and to vital goods and services, and support for the active modes—walking, bicycling, and public transit.



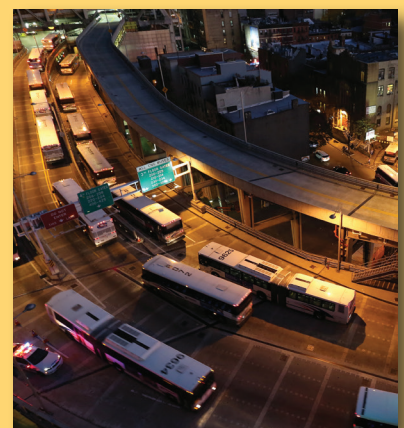
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COVER: The busiest bus terminal in the world, the Port Authority Bus Terminal in Manhattan accommodates 250,000 commuters and intercity passengers via 8,000 buses per day. (Photo: Port Authority of New York and New Jersey)

# TR NEWS

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

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## COMING NEXT ISSUE



PHOTO: MICHAEL PADILLA, SANDIA NATIONAL LABORATORIES

The U.S. Maritime Administration, Sandia National Laboratories, and Red and White Fleet are developing fuel cell-powered designs for operation in San Francisco Bay, one of many initiatives to make marine transportation more environmentally friendly.

Innovative problem solving, trends, applied research, and research needs at the state transportation agency level are the focus of a feature article highlighting findings from the 2017 state partnership visits by TRB senior program officers, covering all transportation modes and functions. The January–February *TR News* also includes articles on measures to control the environmental impacts of marine transportation; public–private partnerships in civil space; rapid response to major oil spills for healthier communities; and more.



# A New Port Authority Bus Terminal in New York

## *First Steps in a Long Journey*

MARTIN WACHS

*The author is Distinguished Professor Emeritus of Civil and Environmental Engineering and of City and Regional Planning, University of California; past Chair of the TRB Executive Committee; and recipient of the TRB W. N. Carey, Jr., Distinguished Service Award, the Pyke Johnson Award, and the Thomas B. Deen Distinguished Lectureship.*

**T**he Port Authority Bus Terminal (PABT) in Manhattan is the busiest bus terminal in the world and is a major contributor to the economies of New York and New Jersey. On a typical weekday, a quarter of a million commuters and intercity passengers arrive or depart via 8,000 buses—some 620 buses depart during the afternoon peak hour. The terminal is convenient to employment centers in Midtown Manhattan, to the burgeoning Hudson Yards—an enormous, mixed-use, high-rise development to the south and west of the terminal—and to 11 subway lines (see Figure 1, next page).

Exclusive ramps connect the terminal to the busy Lincoln Tunnel, which features reversible bus lanes to and from New Jersey, connecting to an exclusive busway west of the tunnel. According to forecasts,

the already cramped and congested terminal will serve approximately 337,000 people and 9,000 buses per day by 2040.

### **Ageing Facility**

For many, the terminal is beloved, like an old pair of shoes. Its status is iconic, and its service efficient, drawing on the ingenuity, experience, and depth of knowledge of its operators, whose teamwork is most evident in a crisis—for example, when a crash blocks the tunnel as a blizzard approaches the city.

(Above:) Ramps that connect the Port Authority Bus Terminal (PABT) with the Lincoln Tunnel are deteriorating and unable to support longer, heavier modern buses.



Lincoln Tunnel's reversible bus lane helps speed the flow of traffic during peak commuting hours.

But the PABT is also the source of endless traveler and operator complaints, reflecting the challenges of adapting an ancient facility to today's needs. As with that old pair of shoes, its importance suggests that a new facility is urgently needed and that the challenge is in finding the right fit.

The aging terminal is overcrowded, obsolete, and deteriorating; the space cannot accommodate the projected growth. The option of doing nothing is not feasible, because the building is nearing the end of its functional life. The ramps and loading bays cannot serve modern double-deck or articulated buses, and the building is poorly equipped to adapt to technological advances.

The old terminal fails to take advantage of the potential that its prime location offers for commercial real estate development. The need to rebuild or reconstruct is unquestioned, but the challenge is

**FIGURE 1** Map of vicinity of Port Authority Bus Terminal.



enormous. Located in the heart of Manhattan, the terminal is adjacent to dense and historical residential communities that do not consider the world's busiest bus terminal an ideal neighbor.

## Design Competition

Recognizing that the PABT is a facility of great complexity and that its possible replacement affects many stakeholders who hold vigorously competing values, the Port Authority of New York and New Jersey recently conducted an International Design and Deliverability Competition. The goal was to assemble and present ideas to the Board of the Port Authority of New York and New Jersey and stakeholders to consider in a planning process now in the early stages.

The Port Authority awarded cash prizes for the most outstanding entries, but made no commitment to adopt or build a facility based on the winning entry. Instead, the Port Authority owns the intellectual property created by the competitors and may consider designs that combine the best ideas from all the entries.

The competition concepts that were submitted have not yet been subjected to detailed design or engineering analyses, to the required environmental impact assessment, or to formal technical review by the many public agencies and private stakeholders affected. The hope is that the concepts will inspire and inform the long process now starting. The Port Authority's capital budget for the coming decade reflects the project as under way but still in the planning and design phases.

The competition emphasized deliverability—it was not an architectural competition to be decided on aesthetics or design criteria. Efficient transportation operations and the logistics of building a terminal in a densely developed metropolis were also central considerations. The complexity of the competition is apparent in the 14 objectives that the entrants were asked to address (see box, page 5).

## Jury Review

The Port Authority invited an international panel of experts to evaluate, compare, and analyze competition concepts (see jury list, page 9). The jury reviewed the 15 preliminary submissions received in response to Phase I of the competition in the context of the design and deliverability objectives. The panel selected the proposals of five entrants, who were invited to develop their concepts more fully in Phase II.

The five finalist teams received detailed instructions from an interdepartmental group of Port Authority staff. In parallel with the competition, the Port Authority engaged an independent consul-

tant team to conduct a Trans-Hudson Commuting Capacity Study; the finalists and the panel received the consultant's interim findings, prepared as draft technical memoranda, about interstate bus network operations and emerging technologies.

The panel convened frequently by teleconference and webinar. At two in-person meetings over several days, members observed the PABT facility and its operations; received in-depth briefings from staff familiar with terminal operations and capital planning; toured the surrounding communities; reviewed media reports about the PABT; considered written submissions, including addenda in response to requests for more information or for clarification; viewed video presentations and examined 3-D depictions of each submitted concept; and formally interviewed representatives from each team. The jurors carefully considered public and stakeholder comments via a competition website, along with letters from local community boards and other stakeholders.

The panel conducted a comparative analysis of the submissions, considering all 14 design and deliverability objectives, and advised the board on the findings. The panel identified three major challenges for the concepts:

1. The ability to support bus operations that are more complex and more numerous than at any similar facility in the world;



PHOTO: PORT AUTHORITY OF NEW YORK AND NEW JERSEY

2. The capital and operating costs involved and the risk of cost escalation; and

3. The impacts on the surrounding communities, including the maximized use of properties owned by the Port Authority and a minimized need to acquire private real estate.

The panel concentrated on the technical and operational challenges and was protected from contact with the political debate surrounding the Port Authority and its capital plan and from sensational media coverage of local and regional politics.

In building a new facility, the Port Authority of New York and New Jersey seeks to maintain the advantages afforded by the current location of PABT but also to overcome access, cost, and other challenges.

## Design and Deliverability Objectives

1. Meets current and projected bus passenger traffic demand with an appropriate level of service, recognizing the role of a new bus terminal in the interstate transportation network, addressing both the commuter and long-distance markets and compatibility with other trans-Hudson transportation operations and investments;
2. Advances a functional and practical transportation solution, reflecting an effective operation for the passengers and bus carriers that rely on the terminal and its services, including appropriate pedestrian connections to mass transit in the vicinity of the new terminal;
3. Minimizes traffic impacts to the surrounding local streets;
4. Provides functionality for bus parking and staging;
5. Considers the potential for other bus storage facilities in alternative locations;
6. Provides a cost-effective solution that takes into account both the capital and future operating costs as an element of "deliverability," given limited financial resources and the history of significant operating losses at the existing facility;
7. Permits scalable and modular solutions that may be phased as needs and standards for the bus terminal evolve;
8. Takes future constructability into account;
9. Sustains the Port Authority's interest in safety and security in terms of design, operations, and site location;
10. Utilizes currently owned Port Authority real estate where possible, minimizing the acquisition of private real estate;
11. Encourages attention of private capital as an element of the project's deliverability, including leveraging the Port Authority's real estate development rights associated with the bus terminal and surrounding area, and potential public-private partnership options as a means of delivering the future project;
12. Takes into account the concerns of the local community, including construction impacts, requirements for non-Port Authority property, bus operation impacts, and a conceptual design that considers the fabric of the surrounding neighborhood;
13. Utilizes sustainable design principles; and
14. Embodies the excitement and dynamism of the New York and New Jersey metropolitan area.

The customer service of the future bus terminal must ensure safety and ease of travel.



PHOTO: PORT AUTHORITY OF NEW YORK AND NEW JERSEY

## Challenges and Trade-Offs

The challenges facing a new bus terminal involve critical trade-offs. Satisfying one objective can make satisfying others more difficult. Some of the most important challenges, trade-offs, and limitations reflected in the submissions are as follows:

- ◆ **Balancing the building's footprint and height.**

A large building footprint is desirable to maximize the efficiency of bus operations, but a small footprint is desirable to minimize disruption to the community. A small footprint requires a taller building, which leads to longer vertical climbs for buses on ramps, circuitous bus movements, and the vertical movement of passengers across many floors to get to and from gates. Restricting bus operations to two or three levels requires a facility that covers greater land area; this has an impact on the surrounding

Some competition submissions grappled with the bus terminal's access to subways and other transit options that are not under the control of the Port Authority.

neighborhoods and may sacrifice opportunities for real estate development.

- ◆ **The importance of operational flexibility.** The current bus terminal performs surprisingly well, despite being obsolete and serving more than its intended capacity. The ingenious staff is able to shift operations in unusual situations or in response to disruptive events. This flexibility derives in part from the current terminal's design, which includes multiple exclusive ramps, street access, and direct tunnel access. The new terminal should be equally flexible for daily operations.

- ◆ **Achieving proximity to traveler origins and destinations.** To maximize access to the origins and destinations of travelers, the future facility should be located as close as possible to the site of the current terminal. That proximity, however, could prove disruptive to nearby residences, businesses, and institutions that for decades have experienced the intrusions of buses and the visual impacts of ramp structures.

- ◆ **Realistically welcoming technological change.** During the decade or more for completing the construction of a new terminal, advances in technology and vehicle designs—from electronically connected vehicles and automated buses to dynamic gate assignment—could completely transform bus operations. Yet the trajectory of technological change is uncertain, and relying too heavily on expected changes that may not eventuate—or that may take longer to realize than their proponents predict—would be irresponsible.

- ◆ **Improving the customer experience.** Pleasant customer experiences will be essential to the success of the future bus terminal. Many factors influence



PHOTO: EVERETT BARNES, FLICKR



good service, including location near transit connections and popular destinations north and east of the current site; terminal ramp designs and gate configurations that allow reliable and efficient travel times to and from the Lincoln Tunnel; in-terminal pedestrian access time from the street to the bus gates; adequacy of vertical circulation paths for pedestrians; ease of wayfinding and availability of real-time traveler information; passenger circulation on concourses; gate areas that allow smooth, safe, and secure movements and comfortable queuing; terminal amenities; and a passenger environment that is pleasant and in compliance with codes and standards.

◆ **Realistically addressing access improvements by other agencies.** As part of a regional transportation network, the PABT cannot function in isolation. The efficiency of bus operations also depends on actions by other agencies, and these are difficult to predict. For example, building an expensive new subway station at West 41st Street and 10th Avenue for access to Subway Line 7 was central to the success of several submissions, but the decision about the project is not under the control of the Port Authority.

◆ **Treating city streets as an asset while respecting communities.** The City of New York and the residents and businesses in the surrounding communities would prefer designs that minimize bus movements and parking on city streets. Today's terminal has struggled to be a good neighbor as constraints on terminal capacity have choked ramps and internal circulation. Future terminal designs that minimize bus traffic on city streets may have to balance the prospect of a new location and a smaller footprint for ramp infrastructure with the potential for expensive reconfiguration of the Lincoln Tunnel ramps and for a possible major modernization of the tunnel.

◆ **Bus parking and staging.** Bus parking and staging are critical, because the PABT peak-hour operations require hundreds of buses that are not used between the peaks. Parking and staging proximate to the new terminal can increase the efficiency of bus operations but also can increase the size and cost of the terminal complex. Staging and storing buses elsewhere in Manhattan increases cost, increases bus movement on crowded streets and through sensitive communities, and could diminish the reliability of tunnel operations. Storing buses in New Jersey increases travel time, consumes valuable movement capacity in the Lincoln Tunnel, affects traffic flow, and impinges on local communities that find no benefit from acres of parked buses.

◆ **Intercity and commuter bus operations—**



PHOTO: STEPHEN WERNER, FLICKR

**complementarities and conflicts.** The privately operated intercity bus market is growing, and curbside bus operations in Manhattan are becoming a major source of traffic congestion. A future intercity bus terminal could consolidate the intercity operations now at the PABT with others. For example, a larger intercity bus terminal could be located away from the commuter terminal and could accommodate PABT's intercity bus operations efficiently. Separating intercity bus operations from a new commuter bus terminal, however, would add the investment costs of two or more Manhattan bus terminals. Depending on their locations, the new intercity bus terminals could add to city street congestion or could decrease the congestion currently caused by curbside loading and unloading.

Congestion around PABT is exacerbated by the confluence of pedestrians, bicyclists, private vehicles, and curbside bus and taxi operations.

A new bus terminal at the current site would require flexibility to reroute buses when normal operations are disrupted.

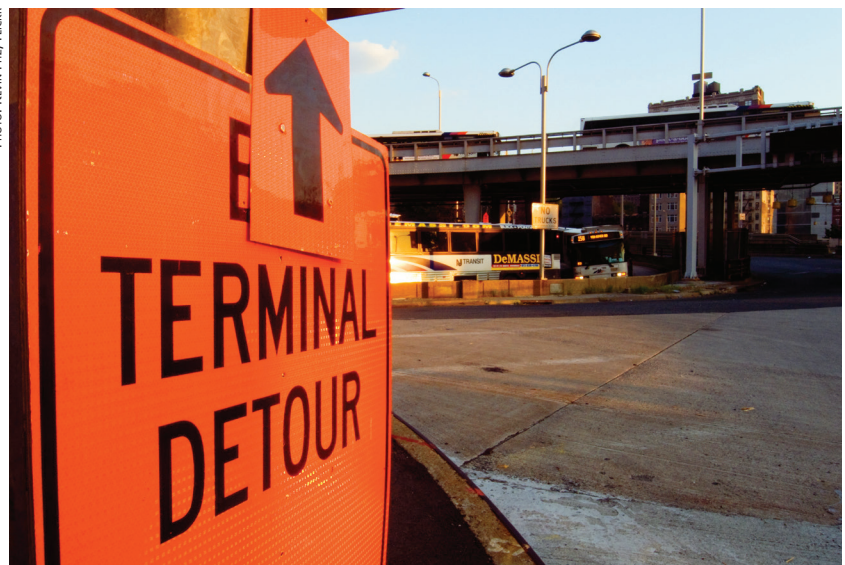


PHOTO: KEVIN FITZ, FLICKR



Located a few blocks from PABT, the Jacob K. Javits Convention Center was proposed as a new terminal site.

◆ **Safety, security, and sustainability.** Travelers and visitors to the terminal must feel safe and secure from petty crime and possible terrorist intrusions. The new terminal must be designed to be easily policed and to discourage and resist potential terrorist activity. The facility also should conserve resources and be energy efficient.

◆ **Minimizing capital costs and cost escalation.** The Port Authority’s capital budget for the coming decade is constrained, with many competing needs. Investment in a new bus terminal is essential, yet the sources for the needed revenue are uncertain and subject to change.

◆ **Real estate.** Activity at a new bus terminal will create incentives for new real estate development. Financial returns from development that can occur on Port Authority land can help finance the high costs associated with the new terminal project.

### No Clear Winner

The submissions showed that all entrants had carefully considered all of the criteria but had addressed them in different ways. The variations, however, can



PHOTO: JASON SMITH, FLICKR

PABT’s facilities have accommodated many changes and adaptations but are nearing the end of their functional life.

inform scoping during the planning process.

At the same time, the panel found that none of the submitted entries was ideal. Addressing some of the criteria well could mean accepting weaknesses in meeting others.

As planning moves forward, a deeper analysis and a more detailed consideration of bus operations inside and outside the terminal are especially important. The submissions addressed alternative operating regimes for buses, alternative gate arrangements, ramp designs, and circulation plans and included bus storage and staging submissions, but all of these were preliminary and would require in-depth analysis and refinements in the next phases of planning.

One entry proposed building the new terminal entirely underground, another proposed repurposing the Javits Convention Center on 34th Street and 11th Avenue as the new bus terminal, and yet another proposed separate terminals to accommodate commuter and intercity operations. Several entrants envisioned new terminals adjacent to the current terminal, but others proposed locations farther west and south.

The panel found all of the submissions stimulating, but no clear winner emerged. At the panel’s recommendation, the Port Authority Board of Commissioners awarded three of the submissions equal shares of the first-place honorarium. The three awardees were uniquely creative and had responded to the major criteria in different ways.

### Panel’s Observations

The panel also offered the Port Authority the following observations derived from a careful consideration of all the entries and from the panel’s extended deliberations:

◆ **Building new bus parking and staging facilities can precede a new bus terminal.** Bus parking and staging are among the most pressing problems in operating the PABT. All of the entries addressed bus staging and parking—within the new terminal, on sites near the proposed terminals, in existing buildings, on proposed decks over other land uses, and on sites in New Jersey. In all likelihood, a combination of bus storage and staging locations will be needed to accommodate demand, and the development of new parking and staging facilities could increase the efficiency of operations at the current bus terminal long before completion of a new terminal.

◆ **Serious consideration should be given to separate terminals for commuting and intercity travel.** The submissions indicated that a combined terminal to meet future bus traffic forecasts would

be massive. Because accommodating future growth in intercity and commuter bus travel would result in a huge terminal structure, a plan to separate these functions has merit. The Port Authority should consider two or more separate facilities with attention to a careful transition. A new commuter bus terminal, for example, could allow the current terminal to serve some intercity operations while a second new terminal is completed. Including a portion of the intercity bus operations in a combined terminal, however, can maximize the use of gates that are busy only during the afternoon–evening rush—that is, a total of 15 hours a week. Moreover, locations away from the current site would take less advantage of the exclusive bus lanes in the Lincoln Tunnel and of the exclusive ramps into the current PABT.

◆ **Consider terminal designs that include underground levels.** Some of the options included structures that were too tall for efficient bus operations; moreover, tall structures would be likely to meet opposition from community stakeholders. The panel therefore suggested consideration of a terminal design that combines above- and below-ground levels. This approach may lower the cost in comparison with that for a terminal entirely underground and may simplify bus operations in comparison with a design that requires buses to climb ramps to six or seven levels above grade.

◆ **Explore the acquisition of private property.** Although the panel and the entrants emphasized minimal or no acquisition of private property, the Port Authority may want to consider private property that may be available for purchase near the current terminal. This could allow for a larger terminal footprint and would lessen the impacts on the community and the resulting objections.

◆ **Rooftop treatments are not a necessity.** Several of the concepts incorporated a “green” roof, featuring gardens and public spaces, as well as rainfall capture. The new terminal should be sustainable in heating and cooling, in the use of energy for transportation purposes, and in the capture and recycling of water. Achieving these goals, however, does not require that the terminal include a park for public use. A proposed park on the roof of the structure raised questions about accessibility via elevators and escalators, security, safety, and the operating, policing, and maintaining of a park on terminal premises. Planners of a future terminal should prioritize sustainability over recreational opportunities.

## Complex of Challenges

The review of the five finalists’ creative submissions for a new terminal revealed the complexity and challenges of the project. The panel found great merit in



PHOTO: CHRIS MERRIO, FLICKR

each submission but noted drawbacks in each, the result of the complexity inherent in achieving a bus terminal design that allows for substantial growth in traffic, has a minimal footprint, requires little or no acquisition of private property, has limited negative impacts on the community, and enhances operational efficiency.

Although the entries could not resolve the political, environmental, and functional challenges in creating a new terminal, they presented those challenges for all to see as the planning for a new terminal gets under way.

Ramp bridges serving the PABT connectors to the Lincoln Tunnel.

## Design and Development Competition Jury

**Martin Wachs**, Distinguished Professor Emeritus of Civil and Environmental Engineering and of City and Regional Planning at the University of California, *Jury Chair*

**Gail Benjamin**, Land Use Director (*retired*), New York City Council

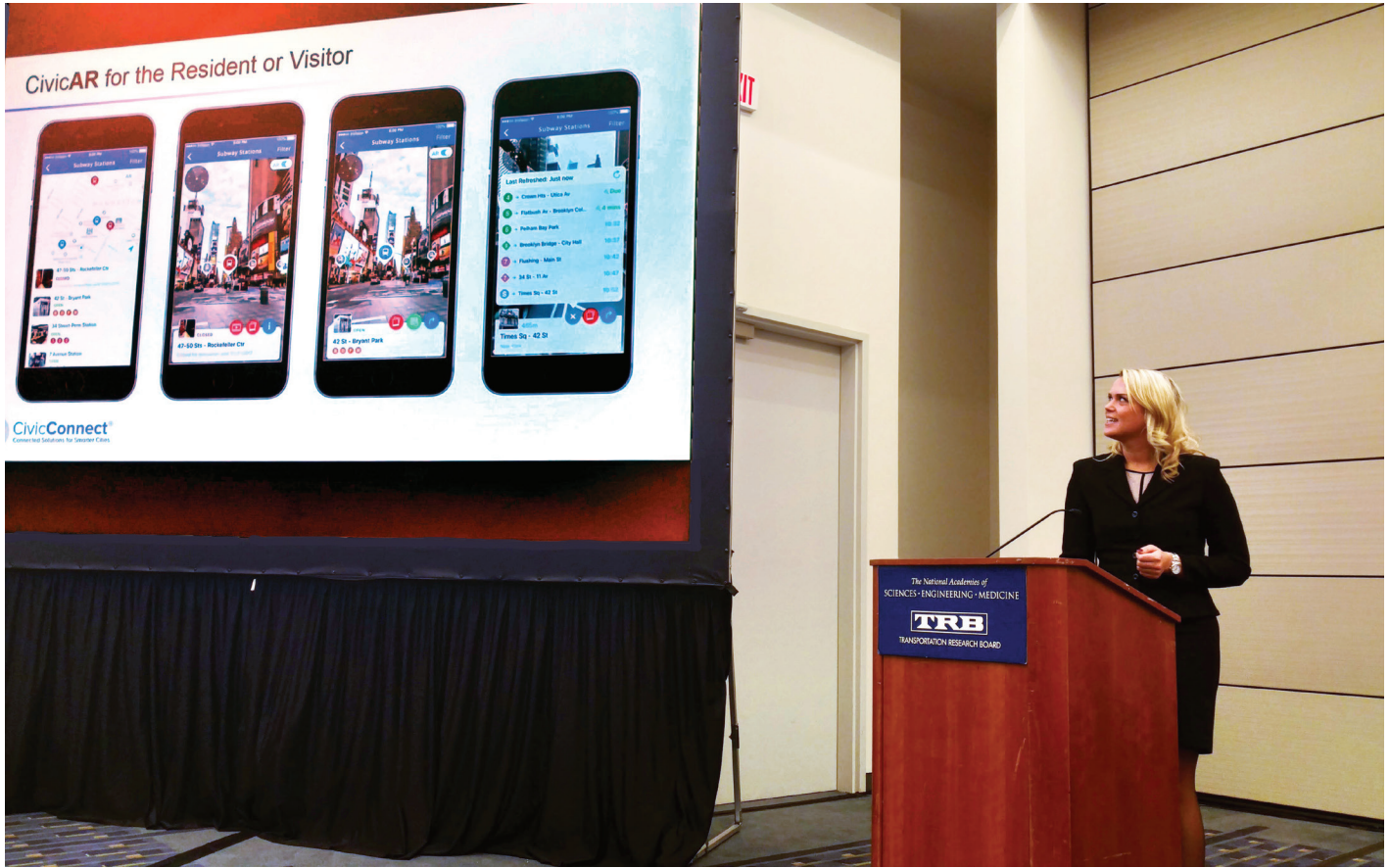
**Tilly Chang**, Executive Director, San Francisco County Transportation Authority

**Robert Paaswell**, Distinguished Professor, Grove School of Engineering, City College of New York

**Robert Puentes**, President and Chief Executive Officer, Eno Center for Transportation

**Dana Skelley**, Director of Asset Management, Surface Transport, Transport for London

**Phillip Washington**, Chief Executive Officer, Los Angeles Metropolitan Transportation Authority



# The Six-Minute Pitch

## *A Retrospective on an Innovation Showcase*

ALEX BIGAZZI

*The author is Assistant Professor, Department of Civil Engineering, University of British Columbia, Vancouver, Canada.*

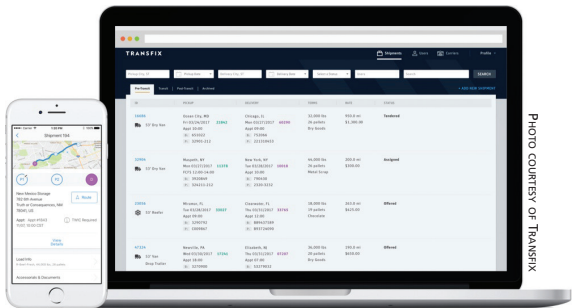
**T**wenty of the freshest ideas for the transportation industry have been presented in two hours over the past five years. In 2018, the Six-Minute Pitch—the transportation industry start-up competition sponsored by the Transportation Research Board (TRB)—enters its sixth year.

The occasion offers an opportunity to look back at the first 20 pitches and to learn how those teams have progressed with their ideas. Past participants were asked to reflect on their pitch experience and to recount their company’s path since the presentation.

Organized by the TRB Young Members Council, the Six-Minute Pitch has become one of the most highly attended sessions at the TRB Annual Meeting. Each year, four presenters are selected from a large pool of applicants age 35 or under to showcase their innovative ideas to a panel of expert judges. Pitch proposals must arrive by a September deadline; the organizing committee concludes review by Novem-

ber and notifies the four selected finalists with an invitation to the Six-Minute Pitch session at the TRB Annual Meeting in January.

Applicants have submitted ideas that span nearly



The Transfix app, winner of the 2015 Six-Minute Pitch, shows real-time tracking for shipments, sends alerts for shipping-status changes, and offers reporting and analytics.

Bre Vergess presents information on the CivicAR augmented reality mobile platform. The Six-Minute Pitch competition offers the opportunity to present innovative ideas in transportation and to receive critical feedback and media exposure.

PHOTO COURTESY OF TRANSFIX

all facets of the transportation industry. Many submittals are oriented to information and communication technology but also have included innovative vehicles, materials, and hardware. Applications arrive from around the globe, with strong participation from Canada and proposals from France, Germany, Ukraine, and more.

## Criteria and a Prize

Ten judges have presided since the beginning of the pitch, including representatives of transportation industry innovators—such as Lyft, Ford Smart Mobility, and Social Bicycles—as well as venture capital concerns—such as Fontinalis Partners and SOSV—and a start-up incubator, 1776. The judges consider each presentation as an individual investment—although no financial investments are made in the competition—and each judge must decide immediately after the presentation and discussion if he or she is “in” or “out”—that is, in support of investment or not.

Presentations are judged on the basis of the commercial viability of the concept, on the potential business plan, and on the demonstration of how the proposed idea meets a critical transportation challenge. The presenter with the most votes wins the competition.

In 2016, 1776 provided the first prize in the history of the competition—a one-year membership in the 1776 Union.<sup>1</sup> The global platform assists entrepreneurs in breaking down barriers and empowers startups to gain access to necessary resources, regardless of location. The value of an annual membership in the 1776 Union is approximately \$1,200.

## Early Pitches

The inaugural competition in 2013 presented a diverse set of ideas for estimating the travel time to reach a flight on time, for sustainable rail fuel, and for managing oil spills. A participant in the 2013 Pitch, Navity, has incorporated and has received patents for intelligent vehicle technology that assists in advanced driver training and licensing.<sup>2</sup>

In 2014, the pitches focused on innovations in the field of transportation data, including intelligent sidewalk mapping, urban travel data synthesis, and transit system performance monitoring. TransitScreen, the 2014 winner, provides customized real-time travel information for a suite of sustainable transportation modes.<sup>3</sup> After the pitch, TransitScreen asked one of the judges, Gabe Klein, to serve as a strategic adviser and was selected by pub-

<sup>1</sup> [www.1776.vc/union/](http://www.1776.vc/union/).

<sup>2</sup> [www.forceofnavity.com/](http://www.forceofnavity.com/).

<sup>3</sup> <https://transitscreen.com/>.



PHOTO COURTESY OF TRANSITSCREEN

lisher Fast Company as a finalist for the prestigious Innovation by Design Award.

## Elevating a Profile

The 2015 competition diversified with pitches on engine and rail hardware, transit planning, and freight management. The 2015 winner, Transfix, provides tools for interstate truck drivers to plan trips, manage loads, and expedite pay.<sup>4</sup> According to Adam Landsman, Head of Sales, Transfix has grown significantly since the competition and “partners with some of the largest companies in the United States to help move truckload freight more economically and to gain critical visibility into the efficiency of their supply chain.”

Participating in the Six-Minute Pitch “enabled Transfix to elevate its profile,” Landsman reports, and generated national media exposure. A recent *Wall Street Journal* article described the company’s

<sup>4</sup> <http://transfix.io/>.

TransitScreen, the winner of the 2014 Six-Minute Pitch, is a real-time travel information platform operating in 10 languages and in five countries.

Hooman Parvardeh concludes his winning presentation for InspectX, a tablet-based bridge inspection app, to a crowded room at the 2017 Six-Minute Pitch.



Since VeloMetro's participation in the Six-Minute Pitch competition, the company has launched its ride-sharing vehicles, enclosed electric-assisted bicycles, in British Columbia, Canada.



PHOTO COURTESY OF VELOMETRO MOBILITY

successful Series C funding round, which raised \$42 million from investors.<sup>5</sup>

## Gaining Exposure

The 2016 competition featured pitches that involved smart vehicle technology, pilot training hardware, roadway data collection, and data analytics. The winner was Total Pave, which developed a new technology for cities to collect pavement condition data via smartphones, offering potentially enormous cost benefits.<sup>6</sup>

Since pitching the technology at the TRB Annual Meeting, Total Pave has launched successfully in cities across Canada and the United States and is piloting several projects with global partners. “The exposure from the Six-Minute Pitch competition was immense, and we directly attribute that to the

<sup>5</sup> July 12, 2017. <https://www.wsj.com/articles/transportation-startup-transfix-raises-42-million-from-investors-1499891859>.

<sup>6</sup> <http://totalpave.com/>.

success we’ve been seeing recently,” says Total Pave CEO Coady Cameron.

## On the Radar

The most recent competition in January 2017 assembled a diverse array of pitches, with innovative ideas for bridge inspection, rail crossings, pedaled–electric hybrid velocars, and augmented reality for transportation systems.

One participant, TRAINFO, provides a suite of data services to travelers, cities, and emergency responders to increase the efficiency and safety of rail crossings.<sup>7</sup> Since participating in the 2017 pitch, TRAINFO has continued to install train monitoring devices across North America—including in Los Angeles, Vancouver, and Montreal—and soon will seek new investment capital to accelerate growth.

“The pitch exposed us to the U.S. Federal Railroad Administration, connected us with another start-up that may lead to a valuable partnership, and helped us prepare for future investor pitches,” comments Garreth Rempel, founder of TRAINFO.

VeloMetro Mobility, another 2017 Pitch participant, has developed an enclosed electric-assisted bicycle with car-like functionality for urban travel.<sup>8</sup> The company is road-testing the vehicles before a pilot launch in Vancouver, British Columbia. John Stonier, VeloMetro’s CFO, says that the TRB Six-Minute Pitch helped place their product “on the radar of some influential automotive” venture capitalists.

<sup>7</sup> <http://trainfo.ca/>.

<sup>8</sup> <https://www.velometro.com/>.



PHOTO COURTESY OF TOTAL PAVE

Total Pave CEO Coady Cameron has credited the Six-Minute Pitch for his company’s global growth.

## Momentum and Insights

Winner of the 2017 pitch, Bridge Intelligence developed an easy-to-use tablet-based bridge inspection app, InspectX, that could transform the bridge inspection industry.<sup>9</sup> Since winning, Bridge Intelligence has worked to refine the product and to connect with new partners and clients. Pilot tests are under way for two state department of transportation contracts, and outreach and development aim to improve integration with bridge management systems.

“Winning the Six-Minute Pitch at TRB was the momentum we needed to push us to the next level,” observes Hooman Parvardeh, Managing Director of Bridge Intelligence. “The judges provided us with great insights and did a great job of guiding us in the right direction. We also took advantage of the prize, a one-year membership in the 1776 Union, and received valuable advice from industry experts with vast experience in transportation and tech startups.”

## Benefits of Participation

The follow-up with past Six-Minute Pitch participants revealed several key themes as they reflected on the benefits of participation. The first was exposure. The TRB Annual Meeting is the largest gathering of transportation professionals in the world, and a high-profile pitch at the conference provides exposure to a broad swath of the transportation industry not easily accessible otherwise, including representatives of local and state agencies, consultants, and academics. This exposure has generated new connections, both as partners and as clients. Participating in or winning the pitch also generated media exposure that some of the companies found valuable—particularly companies early in the development process.

Another important benefit was the feedback that participants received on their ideas and pitches. Participants reported that the input from judges and

<sup>9</sup> [www.bridge-intel.com/](http://www.bridge-intel.com/).



PHOTO COURTESY OF NAVITY

other attendees was valuable in refining and developing their ideas and for potential new applications. Brash Engines<sup>10</sup> and Civil Data Analytics<sup>11</sup> both pivoted their business strategies after the pitch, partly in response to feedback from the judges.

Developing pitch skills also was an important benefit for some participants. Some have gone on to win other contests, awards, and funding. Nahom Beyene, founder and CEO of Navity, credits the TRB Six-Minute Pitch as “the first in a string of many” presentations that culminated in the company’s win at the Cameron Rian Hays Outside the Box Transportation Innovation Competition at George Mason University.

Year six of the Six-Minute Pitch takes place at the TRB Annual Meeting in January 2018. Details are available at [www.sixminutepitch.com](http://www.sixminutepitch.com). Applications for the 2019 competition are due in fall 2018. Past competitions have proved that winning the Six-Minute Pitch requires not just a great idea, but a plan to turn the idea into reality. The judges look for ideas that will be successful and that will have an impact. Do you have the next big idea in transportation?

<sup>10</sup> [www.brashpower.com/](http://www.brashpower.com/).

<sup>11</sup> [www.civildatanalytics.com/](http://www.civildatanalytics.com/).

Many representatives of companies honed their product pitches at the Six-Minute Pitch, which allowed them to win other awards. Navity’s intelligent vehicle technology received an award for transportation innovation from George Mason University.



Participants have ranked the feedback from judges as one of the most valuable aspects of the competition.



NASEM CONSENSUS STUDY

# Review of the Research Program of the U.S. DRIVE Partnership, Fifth Report

## *Achieving Vehicle Efficiency and Energy Sustainability*

JAMES J. ZUCCHETTO

*The author is Senior Scientist, Board on Energy and Environmental Systems, Division on Engineering and Physical Sciences, National Academies of Sciences, Engineering, and Medicine, Washington, D.C., and served as study director for the Review of the Research Program of the U.S. DRIVE Partnership.*

*(Above:) Fueling plaza. The U.S. DRIVE Partnership is working to reduce reliance on petroleum by accelerating the development of new technologies and fuels.*

The energy security, environmental, and economic issues associated with the transportation sector and with light-duty vehicles can be addressed in a variety of ways. Improving automotive technology to achieve affordable vehicles with higher fuel economy is important in the nation's approach to reducing the petroleum consumption and the environmental impact of light-duty vehicles. Another approach is to stimulate the development of vehicles that do not use petroleum but rely on hydrogen, electricity, or biofuels and yield low greenhouse gas and other emissions.

Automotive technology is undergoing rapid changes, stimulated in part by federal government regulations for higher fuel economy, renewable fuels, and reduced greenhouse gas emissions; many states also are focused on stimulating the adoption of zero-emission vehicles that produce no tailpipe emissions. A full array of hybrid electric vehicles (HEVs) is entering the marketplace, along with plug-in hybrid electric vehicles (PHEVs) and battery

electric vehicles that rely completely or partly on energy from the electric grid. In addition, hydrogen fuel cell vehicles (HFCVs) are available in initial, limited offerings.

### Accelerating Research

The federal government, primarily through the U.S. Department of Energy (DOE), has been involved in the research and development (R&D) for many of the advanced technologies in light-duty vehicles. Since the early 1990s, the nation has formed government–industry partnerships to accelerate the R&D.

In 2011, the U.S. DRIVE Partnership—the acronym stands for Driving Research and Innovation for Vehicle Efficiency and Energy Sustainability—superseded the FreedomCAR and Fuel Partnership. The U.S. DRIVE Partnership includes three automotive companies, five energy companies, two electric power companies, and the Electric Power Research Institute, under the federal leadership of DOE. The goal is to accelerate the development of innovative



and low-emission light-duty vehicles.

The U.S. DRIVE Partnership does not have a budget and does not conduct R&D; each partner makes its own decisions about the funding and management of its own projects. The partnership serves as a forum for discussing precompetitive, technology-specific needs; identifying possible solutions; and evaluating progress toward jointly developed technical goals.

The guidance for the work of the U.S. DRIVE Partnership, as well as the setting of research priorities and targets, comes through 12 joint industry-government technical teams; in addition, working groups, formed as needed, address cross-cutting issues. This structure has proved effective in identifying high-priority, long-term precompetitive research needs for each technology.

The National Academies of Sciences, Engineering, and Medicine convened a committee (see box, page 19) under the auspices of the Board on Energy and Environmental Systems to prepare a consensus study—the fifth in an ongoing series—on the status and direction of the U.S. DRIVE Partnership. The report, released this year, evaluates and reviews the functioning of the U.S. DRIVE Partnership, the technologies under study, and the progress since the previous review in 2012 and provides recommendations.<sup>1</sup> (For information about related National Academies studies, see page 16.)

## Engines and Fuel Systems

Internal combustion engines (ICEs) will remain the dominant automotive technology for decades, whether in conventional vehicles, HEVs, PHEVs, or biofueled vehicles. Advanced combustion and emission controls therefore are important; active research is needed into additional opportunities to reduce the fuel consumption and environmental impact of ICE-powered vehicles. Developing the understanding and the tools challenges the state of the art in all engineering sciences.

The three types of engine powertrain systems that are expected to be prevalent in the near term—hybrid, naturally aspirated, and downsized boosted engine systems—are all subject to stretch efficiency goals for 2020 for peak and intermediate engine loads. Research in chemical kinetic development is promoting a fundamental understanding of the interaction between fuel characteristics—such as the research octane number, the motor octane number, and the heat of vaporization—and the engine operating conditions. This work aims to facilitate the integration of advanced, kinetically controlled

<sup>1</sup> <https://www.nap.edu/catalog/24717/review-of-the-research-program-of-the-us-drive-partnership>.



PHOTO: WEINER HOUSE, FLICKR

combustion processes—that is, low-temperature combustion—as part of the engine’s operating map, a longer-term technology.

DOE plans to “downselect” a specific spark ignition candidate fuel this year—that is, to narrow the field of choices—and to demonstrate an optimized, kinetically controlled engine and fuel system by 2025. These are ambitious objectives—although the portfolio of projects will provide the technical data to aid in the selection, the process of choosing an optimized engine and fuel system will be difficult. Each combination will have benefits and drawbacks. Moreover, the process and criteria for selecting an optimal system, as well as the plans for promoting the engine–fuel combination in commercial vehicles, need to be identified.

## Hydrogen-Fueled Vehicles

HFCVs have been in development by the major automotive companies for decades. The engine directly converts a chemical—hydrogen—into electrical

Washington State emissions testing. Washington and several other states follow California’s stringent emissions standards.

Plug-in hybrid electric vehicles and fully electric vehicles are being integrated into the automotive marketplace.



PHOTO: MARINHO59, FLICKR

Researchers at the Idaho National Battery Lab have developed advanced batteries for automotive applications.



PHOTO: IDAHO NATIONAL BATTERY LAB

energy via an electrochemical process that produces zero tailpipe emissions, except for water. In addition, hydrogen derived from energy sources that are green can reduce the environmental impacts throughout the fuel cycle. The major automotive companies have made significant efforts to develop HFCVs, as evidenced by the magnitude of the investments, the number of patents issued, and the engineering accomplishments.

In addition to the lack of an infrastructure for the distribution of hydrogen fuel, technical challenges remain for the market penetration and consumer acceptance of HFCVs; nevertheless, the introduction of a limited number of HFCVs is encouraging. Simultaneously meeting the cost and durability targets for fuel cells remains the most critical barrier to the

## Assessing Technology and Cost Scenarios for Fuel Transitions

The 2008 National Research Council report *Transitions to Vehicles and Fuels: A Focus on Hydrogen* analyzed the costs and benefits for scenarios depicting the entry of fuel cell vehicles and hydrogen fuel into the U.S. light-duty vehicle market through 2050.<sup>a</sup> The light-duty vehicle sector has undergone significant innovations since that report, and the National Academies of Sciences, Engineering, and Medicine—in many cases through the Board on Energy and Environmental Systems—has continued to assess the status and direction of research and advances in light-duty vehicle technologies and fuels.

Two follow-up reports, *Transitions to Alternative Transportation Technologies: Plug-In Electric Vehicles* (2010) and *Transitions to Alternative Vehicles and Fuels* (2013), analyzed scenarios for how various advanced light-duty vehicles and alternative fuels might penetrate the market and examined the associated costs and benefits in comparison with those of conventional spark-ignited gasoline-powered vehicles. The 2013 report addressed ways that the U.S. light-duty vehicle fleet might achieve an 80 percent reduction from the 2005 levels of greenhouse gas emissions and petroleum consumption by 2050. The authoring committee considered a combination of more fuel-efficient gasoline vehicles, hybrid vehicles, plug-in hybrid electric vehicles, battery electric vehicles, fuel cell vehicles, and biofuelled vehicles.

The analyses have included the potential for improved fuel economy in conventional gasoline-powered vehicles. In particular, a 2011 report, *Assessment of Fuel Economy Technologies for Light-Duty Vehicles*, examined technologies and costs for improving fuel economy, and a 2015 follow-up report, *Cost, Effectiveness, and Deployment of Fuel Economy Technologies for Light-Duty Vehicles*, further explored fuel economy improvement and costs for a variety of individual technologies

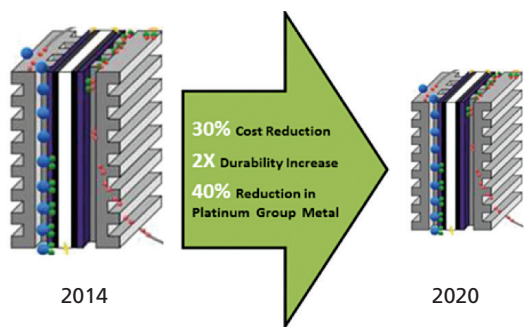
<sup>a</sup> See article by Alan Crane, *TR News*, No. 266, January–February 2010, pp. 28–30, <http://onlinepubs.trb.org/onlinepubs/trnews/trnews266.pdf>.

under the proposed federal Corporate Average Fuel Economy standards for 2025. Another 2015 report, *Overcoming Barriers to Deployment of Plug-In Electric Vehicles*, focused on the infrastructure needs for widespread adoption, especially for charging.

Several studies examined the technologies, economic costs, environmental implications, and outlook for specific alternative fuels. These included the 2009 America's Energy Future report, *Liquid Transportation Fuels from Coal and Biomass*; the 2011 report, *Renewable Fuel Standard: Potential Economic and Environmental Effects of U.S. Biofuel Policy*; and the 2012 report, *Sustainable Development of Algal Biofuels in the United States*.

### Selected National Academies Press Reports on Light-Duty Vehicles and Fuels

- Liquid Transportation Fuels from Coal and Biomass*, 2009
- Transitions to Alternative Transportation Technologies: Plug-in Hybrid Electric Vehicles*, 2010
- Assessment of Fuel Economy Technologies for Light-Duty Vehicles*, 2011
- Renewable Fuel Standard: Potential Economic and Environmental Effects of U.S. Biofuel Policy*, 2011
- Sustainable Development of Algal Biofuels in the United States*, 2012
- Overcoming Barriers to Electric Vehicle Deployment: Interim Report*, 2013
- Transitions to Alternative Vehicles and Fuels*, 2013
- Review of the Research Program of the U.S. DRIVE Partnership, Fourth Report*, 2013
- Cost, Effectiveness, and Deployment of Fuel Economy Technologies for Light-Duty Vehicles*, 2015
- Overcoming Barriers to Deployment of Plug-In Electric Vehicles*, 2015



**FIGURE 1** Advancing fuel cell technology, 2014 to 2020.

technical and commercial viability of HFCVs. DOE has created consortia to focus and coordinate the R&D at national laboratories.

### On-Board Storage

The vehicle's driving range and fueling time are important attributes for prospective HFCV customers. The objective is to achieve a driving range of at least 300 miles for a full line of light-duty vehicles and at the same time meet requirements for performance, packaging, cost, rapid fueling time, and safety (see Figure 1, above).

Production vehicles will use the 700-bar (10,000-psi) hydrogen storage tank for the immediate future, but the technology will continue to evolve. A well-organized DOE program has researched materials-based storage extensively. The significant progress and changes in recent years, however, have not met all the goals for on-board hydrogen storage, and basic scientific research has not produced any easy solutions.

### Hydrogen Fuel Availability

The widespread penetration of HFCVs into the light-duty vehicle fleet requires the availability of hydrogen for refueling. Hydrogen production by natural gas reforming is a cost-effective option for near-term requirements and provides a pathway to reduce greenhouse gas emissions.

The use of renewable sources of energy, such as biomass, wind, and solar, however, is necessary for the further reduction of greenhouse gas emissions. Long-term R&D is focusing on the development of these technologies.

The delivery and dispensing of hydrogen nevertheless is prohibitively expensive and requires technological advances to meet the cost targets that would make the HFCV option viable. The delivery and dispensing of hydrogen (see Figure 2, below) will have to meet the requirements for refueling onboard storage tanks—namely, a higher pressure of 875 to 900 bar at the pump. R&D therefore has sought to develop low-cost compression technologies, as well as innovative materials and concepts, for high-pressure hydrogen storage and transport.

This approach faces several hurdles, and alternative concepts are in development. An action plan is needed to address the issues and barriers to the deployment of a hydrogen infrastructure; the lack of the infrastructure and the cost of hydrogen are the biggest challenges to the widespread deployment of HFCVs.

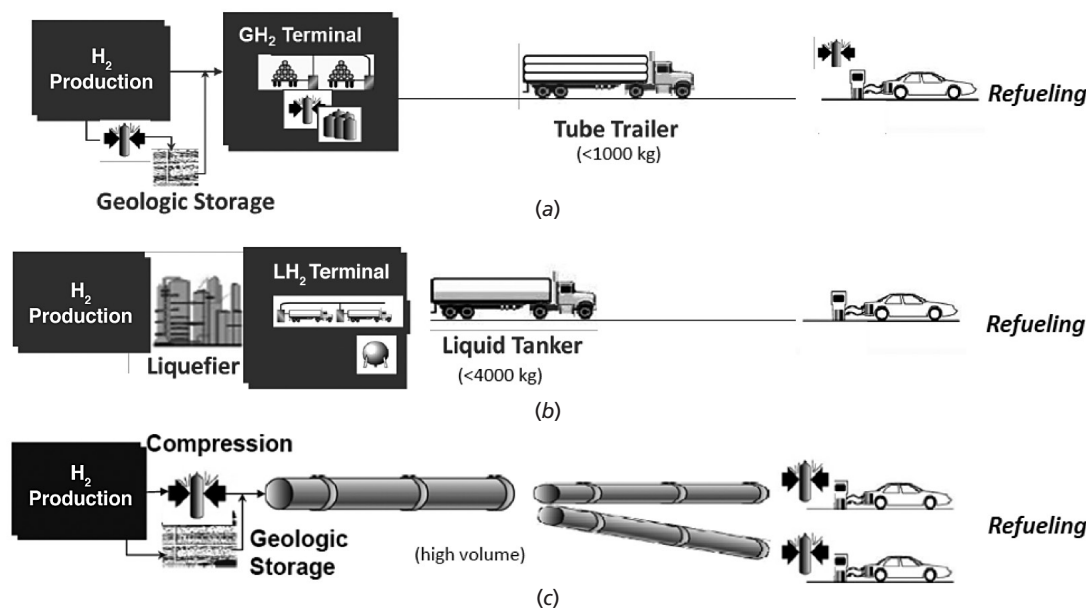
### Electric Drive Systems

An electric drive consists of an electronic motor and an electronic controller and is a critical part of the electrified powertrains for light-duty vehicles. The



PHOTO: FRANK SHELDON, FLICKR

Technology that uses electric power from renewable resources, like wind and solar energy, is key to reduced greenhouse gas emissions.



**FIGURE 2** Transmission and distribution of hydrogen ( $H_2$ ) for vehicle fuel: (a) gaseous hydrogen ( $GH_2$ ) by tube trailer, (b) liquid hydrogen ( $LH_2$ ) by tanker, and (c) gaseous hydrogen by pipeline.



The electric drive system and ways to reduce its size and cost are a focus of U.S. DRIVE Partnership research.

Researchers seek ways to reduce the size of batteries for electric cars.

U.S. DRIVE Partnership therefore is developing technologies to address the cost, weight, and size of the electric drive components to expedite the market penetration of electrified powertrains.

Several motor configurations and designs are under investigation to provide alternatives to expensive rare earth magnets. The U.S. DRIVE Partnership has reported significant progress in power electronics through the use of innovative packaging and the integration of classic inverters and converters.

In addition, the use of wide-bandgap devices for automotive power electronic systems is under exploration. DOE programs have pursued with com-

mendable vigor and intensity ways to apply the size, weight, and efficiencies of wide-bandgap devices in electrified vehicles.

Gallium nitride (GaN) devices grown on silicon (Si) substrates offer an inherent cost advantage compared with silicon carbide (SiC) on SiC substrates. Although the cost of SiC is much higher than that of Si, the expectation is that GaN ultimately will be preferred for automotive applications.

## Electrochemical Storage

Achieving the goals of the U.S. DRIVE Partnership requires improving electrochemical energy storage technologies, such as batteries. All electric drive vehicles—including HEVs, PHEVs, and HFCVs—use batteries and supercapacitors. High cost stands as a main impediment to significant market penetration by plug-in electric vehicles, which require large batteries. Improvements in battery performance characteristics—namely energy density, specific energy, operation at extreme temperatures, charging and discharging rates, and cycle and calendar life—also are needed.

In addition to realizing performance improvements and cost reductions, however, research must address the safety issues associated with lithium batteries. DOE and other government entities, automotive equipment manufacturers, and battery manufacturers are addressing the performance, cost, and safety of lithium-ion batteries. DOE's efforts are exploring alternative battery chemistries that may surpass lithium-ion batteries in performance and at reduced cost.

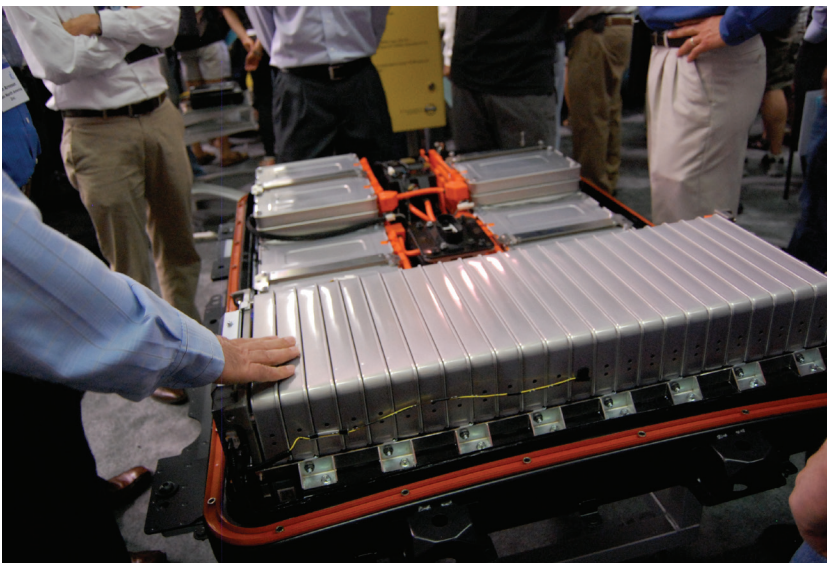
## Plug-In Vehicles

The convenience, affordability, and environmental impacts of electric energy have become an important consideration for the U.S. DRIVE Partnership. The environmental and energy security benefits from plug-in electric vehicles will increase in proportion to their use, commonly measured in electric vehicle miles traveled. The availability and cost of the recharging options weigh importantly in consumer decisions to purchase and use plug-in electric vehicles.

HFCVs also may rely on the electric grid, because the electrolysis of water can provide hydrogen for fuel. In addition, one of these vehicles with a typical automotive power train electric generation capacity of 70 kilowatts could serve as a backup power supply for a small cluster of homes.

## Structural Materials

Reducing the vehicle mass remains a major approach for improving vehicle efficiency and fuel economy.





Development of smaller, lighter-weight vehicles can help improve fuel economy in combustion-engine automobiles.

Typically, a weight reduction of approximately 10 percent could achieve a 3 to 6 percent improvement in fuel economy.

Engineering improvements in vehicle structural efficiency have continued since the 1990s, but added safety features and other consumer-driven content—such as convenience features and infotainment systems—have offset the reductions in weight. More recently, with the adoption of higher fuel economy standards worldwide, the newest vehicle models have reduced weight by 5 to 10 percent or more.

### Strategic Issues

A number of trends and emerging issues indicate that the time is opportune for the U.S. DRIVE Partnership to take stock of its strategic position and to make changes as appropriate. Significant technological advances are occurring in the private sector, such as the emergence of a variety of plug-in electric vehicles, the offerings of HFCVs, and the rapid advances in autonomous vehicle technologies and in models for personal mobility. In addition, the United States is becoming much less dependent on petroleum imports—a situation that is changing rapidly. A limited number of pathways may be available now to achieve the aggressive greenhouse gas reductions needed to address climate change.

The committee that produced the National Academies' report found that in some cases, technology targets are too near-term for a precompetitive focus and that targets perhaps should be set for 2025, if not for 2030, to develop the high-risk technologies that the private sector will not pursue. The U.S. DRIVE Partnership is revisiting many of its technical targets. The deployment of a hydrogen fuel infra-

structure, a critical barrier for HFCVs, is a problem beyond the precompetitive focus of the U.S. DRIVE Partnership.



*Review of the Research Program of the U.S. DRIVE Partnership, Fifth Report*, is available from National Academies Press, <https://www.nap.edu/catalog/24717/review-of-the-research-program-of-the-us-drive-partnership>.

### Committee on the Review of the Research Program of the U.S. DRIVE Partnership, Phase 5

- John H. Johnson**, Michigan Technological University, *Chair*
- Alexis T. Bell**, University of California, Berkeley
- David Bodde**, Clemson University
- Nady Boules**, NB Motors, LLC
- Glenn Eisman**, Eisman Technology Consultants
- David E. Foster**, University of Wisconsin–Madison
- Matt Fronk**, Matt Fronk & Associates
- Robert Nowak**, Defense Advanced Research Projects Agency (*retired*)
- Bernard Robertson**, Daimler Chrysler Corporation (*retired*)
- James A. Spearot**, Mountain Ridgeline Consulting, LLC
- Satish Tamhankar**, Linde, LLC (*retired*)
- Alan Taub**, University of Michigan, Ann Arbor
- Kathleen C. Taylor**, General Motors Corporation (*retired*)
- Brijesh Vyas**, Bell Laboratories (*retired*)



## NASEM CONSENSUS STUDY

# Commercial Motor Vehicle Driver Fatigue, Long-Term Health, and Highway Safety

## Research Needs

ESHA SINHA AND MICHAEL L. COHEN

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(Above:) Most commercial vehicle crashes are caused by a combination of factors—from fatigue to poor road conditions to aging vehicle mechanics.

Crashes involving commercial motor vehicles (CMVs) kill approximately 4,000 people in the United States each year. Although the extent to which the CMV driver's fatigue may contribute to these crashes remains unclear, a reasonable estimate is that fatigue plays a role in 10 to 20 percent of CMV crashes. Research has shown that CMV driver fatigue is related to the stresses of the job, including irregular schedules and economic pressures; combined with the lifestyle of many CMV drivers, these stresses can result in insufficient sleep.

To address the problem of fatigued driving by truck and bus drivers, the Federal Motor Carrier Safety Administration (FMCSA) asked the National Academies of Sciences, Engineering, and Medicine to convene a Panel on Research Methodologies and Statistical Approaches to Understanding Driver Fatigue Factors in Motor Carrier Safety and Driver Health

(see box, page 24). The panel issued a final report, *Commercial Motor Vehicle Driver Fatigue, Long-Term Health, and Highway Safety: Research Needs*, in early 2016. The report describes what is known about the relationship between hours-of-service rules, driver fatigue, and crash risk and what needs to be done to gain more complete knowledge.

### Hours-of-Service Regulations

Hours-of-service regulations have been in place since 1938, and changes have been relatively minor. The current regulations for truck drivers are as follows:

- ◆ The maximum number of hours that a driver can be on duty during a 24-hour duty cycle is 15—this includes driving, loading, and unloading, whether the driver waits for someone else to load or unload or participates.

- ◆ The maximum number of hours that a driver can drive during a 24-hour duty cycle is 11.
- ◆ The maximum number of hours that a driver can drive during a 7-day period is 60, and during an 8-day period, 70.

When assessed as a causal factor for highway safety, the difference between the current and proposed hours-of-service regulations is relatively modest. The differences between the proposals are often small—in some cases, the change is an hour a day or a few hours a week; in addition, drivers have no obligation to use the additional time to sleep.

## Highway Crash Causes

The causes of highway crashes can be grouped into four main categories:

- ◆ **Driver characteristics**, which include health conditions; medications used; recent or chronic lack of sleep; circadian effects; experience driving CMVs; safety record and propensity for risky driving; decision making to pull over because of drowsiness; and work demands;
- ◆ **Truck or bus characteristics**, which include the type and age of the truck or bus; the quality of the brakes and tires; other mechanical conditions; the frequency and history of maintenance; the vehicle's crash history; and the technology on board for collision avoidance and lane deviation;
- ◆ **Carrier factors**, which include the type of operation; the scheduling and logistics practices; the driver turnover rate; fatigue management programs; safety record; and the method of driver compensation—salary or per mile; and
- ◆ **Environmental and situational factors**, which include weather, degree of precipitation, time of day, traffic density, road type, degree of road lighting, hazards, safety features, availability of rest stops, and the behavior of other drivers—a large percentage of highway crashes involving CMVs are not the fault of the CMV driver.

In addition, many crashes have more than one cause, and ascertaining which factors played a smaller or larger role is difficult, especially many minutes after a crash and with limited knowledge about what may have affected the drivers. Because of the variety and number of the factors that could contribute to a crash, developing a full understanding of any individual causal agent—in this case, fatigue—is a challenge. Controlling for or otherwise accounting for the many possible factors has proved problematic.



PHOTOS: RAYMOND CLARKE IMAGES, FLICKR

## Industry Heterogeneity

The world of commercial motor vehicles is complex. The key categories are trucks and buses—carriers that move cargo and those that move passengers, respectively. Carriers and their vehicles in both categories perform a range of tasks, from school buses, to trucks that transport hazardous materials, to long-haul trucking, to van services. For the drivers of some of these vehicles, hours-of-service regulations may be meaningless, because the drivers often work a standard workday or a standard workweek.

Three million CMV drivers work for more than 500,000 carriers; not much is known about many of these carriers. Small carriers operate the majority of trucks and buses, and often the truck is the only vehicle in an owner–operator enterprise. These operations clearly differ from the large corporations that run such trucking companies as J. B. Hunt, Schneider, and Con-Way Freight. These corporations can afford to use scheduling, logistics, and management tools, and can support educational and training programs aimed at reducing fatigue.

Environmental factors beyond the control of the commercial vehicle driver, such as the location and availability of rest stops (*above*) and weather (*below*), contribute to fatigue.



PHOTOS: RAYMOND CLARKE IMAGES, FLICKR



Bus drivers and other commercial vehicle drivers who work standard hours per week struggle with fatigue less frequently than drivers with irregular schedules.

Driver compensation arrangements also differ. Moreover, the driver and carrier populations have frequent turnover—a large portion of CMV drivers and carriers enters and leaves the business every year.

### Measuring Fatigue

The terms referring to fatigue—for example, tired, sleepy, drowsy, or fatigued—are sometimes synonymous and sometimes express different concepts. A person who is tired may be physically spent but not have a sleep deficiency. A person who is sleepy or drowsy may be physically fine but responding to

a sleep deficiency or to circadian pressure, a biologically driven need for sleep. Fatigue indicates an inability to sustain performance over time—but this is not directly measurable.

A reasonable focus then should be on the components of fatigue that are directly measurable; drowsiness is one. Being drowsy is essentially the same as being sleepy and refers to a lack of recent sleep. Circadian pressure is commonly experienced between 2:00 and 4:00 a.m., and to a lesser extent between 2:00 and 4:00 p.m.

The amount of alcohol in the bloodstream of a driver stopped by police officers can be measured, but no known biomarker offers a way of directly measuring fatigue. The psychomotor vigilance test (PVT), however, can measure alertness and attention from psychomotor speed, lapses of attention, and impulsivity induced by fatigue; the test measures reaction time and takes 3 to 10 minutes. A PVT can serve as a reliable way of identifying people whose reaction times are impaired by a lack of sleep.

### Reducing Fatigue

Drivers of CMVs and of passenger vehicles try a variety of means to reduce the symptoms of fatigue and to stay awake while driving. Many drivers are unaware, however, that splashing cold water on the face, playing the radio loudly, turning up the air conditioner, or lowering the windows are ineffective ways of reducing fatigue.

Caffeine and other stimulants can alleviate the symptoms in the short term, but the effectiveness declines quickly. The only permanent way to alleviate the symptoms of fatigue is to obtain sufficient sleep.

The North American Fatigue Management System is an online resource developed by FMCSA and Canadian agencies to help educate CMV drivers, carrier managers, and others about the effects of sleep deficiency on crash risk and about ways of mitigating the risk.

### Data Collection

One of the major difficulties in understanding the links between hours of service, fatigue, and crash risk is that the information needed to support research is not commonly available. This includes information about sleep duration and about hours of service over several days, about the level of driver fatigue, and about the rate of crashes caused by fatigue.

These variables are not easy to obtain. Asking drivers how much they slept the night before does not yield high-quality information. The drivers may inflate their responses if their sleep has been insufficient and if they are worried about repercussions;



PHOTO: EVERETT COLLECTION, FLICKR

Many truck stops stock high-sugar, high-caffeine snacks and drinks; however, these items have proved ineffective in combatting fatigue.



moreover, people seldom have a clear awareness of how long they slept.

Similarly, drivers who are asked to provide information about hours of service may have a motive to misinform if they have driven longer than the legal limits. Further, a driver's paper logs are not a reliable way to determine the amount of driving during a given period, because some drivers adjust the logs to conform to legal limits.

### Data Sources

A few sources of data, although not perfect, can help researchers assess the link between fatigue and crash risk. First, field surveys of truckers and bus drivers have collected information on the amount of their recent sleep, as well as on their recent crash rate and their recent adherence to hours-of-service regulations. These surveys, however, often cover small samples, tend to be geographically concentrated, and rely on driver responses; the quality of some of the information is unclear.

Another data source is the Large Truck Crash Causation Database, which used careful investigative data collection to determine the causal factors for a sample of 963 serious crashes involving large trucks between 2001 and 2003. Although somewhat dated now, the database remains one of the best sources on the frequency of various factors in large truck crashes.

In addition, state and federal agencies routinely collect limited observational data on crashes involving commercial motor vehicles. The Fatality Analysis Reporting System (FARS) is a census of motor vehicles involved in fatal traffic crashes in the United States. Collected from police accident reports, death certificates, medical examiner reports, hospital reports, and emergency medical services reports, the FARS data set contains crash characteristics, environmental conditions, driver distractions, circumstances obscuring the driver's vision, and descriptive information about the drivers and vehicles.

The General Estimates System is a sample of police-reported crashes involving damage, injury, or death. The system generates estimates for a set of descriptors on crashes. Another resource, the Motor Carrier Management Information System, is a census of all trucks and buses involved in a crash that included a fatality, an injury transported for medical attention, or at least one vehicle towed because of disabling damage.

### Database Limitations

These various observational databases have limitations in exploring the relationship between fatigue, hours of service, and crash risk:



Photo: Michael McCullough, Flickr

- ◆ All originate with crash reports from police officers, who have little access to data on driver sleep deficiency, crash history, or the relevant confounding information; and
- ◆ All lack information about what takes place on the roads when CMVs are not involved in crashes.

Field surveys of truck crashes can help determine contributing factors, such as weather or environmental conditions.

As a result, data are lacking to determine if factors that seem to occur often with crashes may occur more often during driving periods without crashes. Moreover, understanding the role of any individual causal factor requires knowledge of all confounding factors. These clear gaps in data collection limit the utility of these databases for research.

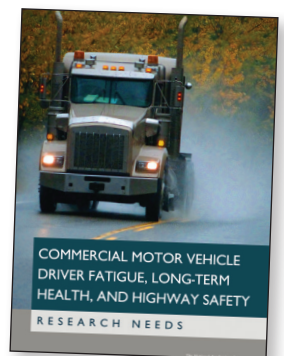
### Role of New Technologies

Studies of collision avoidance and fatigue alert technologies, which can lessen the impact of fatigue on crash risk, have been conducted in laboratories, with driving simulators, and in the field. The results have not sufficiently validated the efficacy of these techniques in reducing crash risk. Additional research, development, and demonstration of validity are needed.

These technologies monitor the vehicle and driver to determine driver alertness, examining the wheel movements and the instances of hard braking, swerving, and speeding, in addition to collecting vehicle miles traveled and other information. A large carrier that has instituted some of these new technologies throughout its fleet could make these data available to researchers, allowing access either before or after use or during the take-up, assuming a promise of confidentiality for individual identifiable information.

### Unanswered Questions

Despite the limited information available, progress has been considerable in understanding the role of sleep deficiency in increasing crash risk. The extent to which the individual factors or their interactions adversely affect performance is unknown. Neverthe-



The 272-page consensus study report, *Commercial Motor Vehicle Driver Fatigue, Long-Term Health, and Highway Safety: Research Needs*, is available from National Academies Press: <https://www.nap.edu/catalog/21921/commercial-motor-vehicle-driver-fatigue-long-term-health-and-highway-safety>.



Trucks built with sleeping areas facilitate adherence to driving schedules that allow for sufficient breaks and sleep times.

less, research has shown that insufficient sleep leads to decreased alertness and eventually to performance decrements.

Some of the practicable ways of reducing or eliminating driver fatigue include adhering to work-and-rest scheduling that permits sufficient sleep, driving primarily during the daytime, being cognizant of the two circadian lulls in the 24-hour day, obtaining sleep immediately before a long trip, planning for and taking periodic breaks from driving, and inserting time for naps into a trip plan. Consuming caf-

fine can provide temporary relief, and rumble strips can alert drivers that they may be falling asleep, but these and other measures provide only temporary assistance.

Much more remains to be determined:

1. How much sleep do typical CMV drivers need to maintain suitable sustained levels of alertness and to avoid becoming drowsy to the point of driving while impaired?

2. To what extent would any proposed change in hours-of-service regulations affect the amount of sleep obtained by CMV drivers in different industry sectors?

3. What degree of obstructive sleep apnea causes enough sleep loss to increase the risk of crashes for CMV drivers?

4. To what extent does regular use of positive airway pressure therapy and other treatment technologies mitigate the increased risk related to obstructive sleep apnea?

5. How useful are the various new technologies for collision avoidance, lane deviation detection, and driver fatigue assessment in reducing the risk of crashes?

6. What substances reduce impairment caused by sleep insufficiency?

7. To what extent is chronic sleep deprivation related to an increased risk of developing health threats or various medical conditions?

8. To what extent do CMV drivers, their employers, corporate officials, fleet supervisors, safety and risk managers, and drivers' families make use of the North American Fatigue Management Program materials on the Internet?

9. To what extent do fatigue awareness training and fatigue management initiatives result in behavioral improvements in CMV drivers?

### Expediting Progress

How hours-of-service regulations affect fatigue and crash risk is an important public policy question. Many potential influences complicate the matter, which involves a large, heterogeneous group of drivers and carriers. Progress has been steady but could be expedited by greater access to information about the key variables and the confounding factors and through greater use of state-of-the-art statistical techniques to overcome data limitations.

Statistical expertise and greater access to needed information will make the links between fatigue and crash risk more clear. As programs that address fatigue incorporate the new research findings, effective behavioral changes for individual drivers and for carriers will become commonplace.

### Panel on Research Methodologies and Statistical Approaches to Understanding Driver Fatigue Factors in Motor Carrier Safety and Driver Health

- Matthew Rizzo**, University of Iowa, *Cochair*
- Hal S. Stern**, University of California, Irvine, *Cochair*
- Daniel F. Blower**, University of Michigan Transportation Research Institute
- Charles A. Czeisler**, Harvard Medical School
- David F. Dinges**, University of Pennsylvania School of Medicine
- Joel B. Greenhouse**, Carnegie Mellon University
- Feng Guo**, Virginia Polytechnic Institute and State University
- Richard J. Hanowski**, Virginia Tech Transportation Institute
- Natalie P. Hartenbaum**, OccuMedix, Inc.
- Gerald Krueger**, Krueger Ergonomics Consultants
- Melissa M. Mallis**, M3Alertness Management, LLC
- John R. Pearson**, Council of Deputy Ministers Responsible for Transportation and Highway Safety, Ottawa, Ontario, Canada
- Dylan Small**, Wharton School, University of Pennsylvania
- Elizabeth A. Stuart**, Johns Hopkins Bloomberg School of Public Health
- David H. Wegman**, University of Massachusetts at Lowell



# Walking and Walkability

## *Shared National Goals in Public Health and Transportation*

GEOFFREY P. WHITFIELD, DANIEL GOODMAN, KENNETH ROSE, AND SUSAN A. CARLSON

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The September–October 2015 issue of *TR News* focused on the growing recognition of the intersection between the fields of transportation and public health. In their article, “Why Public Health and Transportation: Setting the Stage,” Andrew L. Dannenberg and Ipek N. Sener explored the themes that link the two fields (1). They discussed areas of shared interest, including safety, air quality, physical activity, equitable access, and noise control.

Dannenberg and Sener cited possible cobenefits associated with health-oriented transportation investments, such as reducing government health care spending and freeing up resources for other activities, providing transportation choices to a younger generation that chooses not to drive, reducing carbon emissions, preventing traffic caused by induced demand, and fostering support from the

The findings and conclusions in this article are those of the authors and do not necessarily represent the official positions of the Centers for Disease Control and Prevention or of the Federal Highway Administration.

public health community for these kinds of transportation investments. Encouraging safe and convenient choices for walking is one way to promote health through transportation, because walking is a daily activity for most people (2).

### Two Federal Initiatives

Walking is a health-promoting behavior and a mode of transportation and therefore a logical connection between the fields of public health and transportation. Two U.S. government organizations have released documents that support walking:

- ◆ The Department of Health and Human Services, with *Step it Up! The Surgeon General’s Call to Action to Promote Walking and Walkable Communities* (3), and
- ◆ The Federal Highway Administration (FHWA) of the U.S. Department of Transportation (DOT),

(Above:) Pedestrians navigate New York City streets.



The Surgeon General's Call to Action encourages communities to make walking and bicycling safe through redesigning physical spaces and promoting community programs. FHWA's Strategic Agenda similarly seeks to "get more people walking and bicycling."

with the *Strategic Agenda for Pedestrian and Bicycle Transportation* (4).

The Call to Action, released in September 2015, presents five science- and practice-based goals to increase walking in the United States through improved access to safe and convenient places to walk and wheelchair-roll and through a culture that supports these activities for all ages and abilities (3). Each goal (see sidebar, below) includes actionable strategies for many sectors, including transportation, land use, and community design; parks, recreation, and fitness; education; business and industry; volunteer and nonprofit; health care; media; and public health. The Call to Action complements other

guidance on physical activity, including the 2008 *Physical Activity Guidelines for Americans* (5) and the *National Physical Activity Plan* (6). The complete report is available online.<sup>1</sup>

The Strategic Agenda, released in September 2016, provides a framework for FHWA's pedestrian and bicycle activities. The framework emphasizes collaboration and partnerships and identifies four goals involving connected multimodal networks, safety, equity, and trips. The activities contribute to making walking and bicycling viable forms of transportation for people of all ages and abilities in communities throughout the United States (see sidebar, page 27) (4).

Each goal specifies multiple action items relating to capacity building, policy, data, and research. The goals and actions align with other U.S. DOT policies on pedestrian and bicycle activities, including the *Policy Statement on Bicycle and Pedestrian Accommodation Regulations and Recommendations* (7). The complete report is available online.<sup>2</sup>

## Shared Vision

The shared vision in the Surgeon General's Call to Action and FHWA's Strategic Agenda may not be immediately apparent, because of differences in

<sup>1</sup> [www.surgeongeneral.gov/library/calls/walking-and-walkable-communities/call-to-action-walking-and-walkable-communities.pdf](http://www.surgeongeneral.gov/library/calls/walking-and-walkable-communities/call-to-action-walking-and-walkable-communities.pdf)

<sup>2</sup> [https://www.fhwa.dot.gov/environment/bicycle\\_pedestrian/publications/strategic\\_agenda/](https://www.fhwa.dot.gov/environment/bicycle_pedestrian/publications/strategic_agenda/)

## Goals and Strategies of "Step It Up!"

### *The Surgeon General's Call to Action to Promote Walking and Walkable Communities* (3)

1. Make walking a national priority.
  - Encourage people to promote walking and make their communities more walkable.
  - Create a walking movement to make walking and walkability a national priority.
2. Design communities that make it safe and easy to walk for people of all ages and abilities.
  - Design and maintain streets and sidewalks so that walking is safe and easy.
  - Design communities that support safe and easy places for people to walk.
3. Promote programs and policies to support walking where people live, learn, work, and play.
  - Promote programs and policies that make it easy for students to walk before, during, and after school.
  - Promote worksite programs and policies that support walking and walkability.
  - Promote community programs and policies that make it safe and easy for residents to walk.
4. Provide information to encourage walking and improve walkability.
  - Educate people about the benefits of safe walking and places to walk.
  - Develop effective and consistent messages and engage the media to promote walking and walkability.
  - Educate relevant professionals on how to promote walking and walkability through their profession.
5. Fill surveillance, research, and evaluation gaps related to walking and walkability.
  - Improve the quality and consistency of surveillance data collected about walking and walkability.
  - Address research gaps to promote walking and walkability.
  - Evaluate community interventions to promote walking and walkability.

vocabulary and structure. The documents also differ in their perspectives and intended audiences.

The Call to Action approaches walking from a public health perspective and encourages a range of partners and stakeholders to take action in support of walking and walkable communities. The Strategic Agenda approaches walking from a transportation perspective and primarily informs the transportation sector's activities related to nonmotorized transportation.

In addition, the Call to Action seeks a population-level increase in physical activity, focuses on walking as a common and accessible activity, and acknowledges that improving walkability can benefit other nonmotorized users, such as bicyclists. The Strategic Agenda seeks an increase in nonmotorized transportation and focuses on walking and bicycling as primary modes of travel.

Despite these differences, the documents have much in common. Highlighting the areas of shared vision and identifying potential opportunities for collaboration, while avoiding duplication of efforts, is important.

## Acknowledging All Abilities

Both the Call to Action and Strategic Agenda clearly state that efforts to increase walking should include people of all ability levels, including people with disabilities. Both documents acknowledge wheelchair rolling as an important form of transportation and as a health behavior.

Promoting street designs and maintenance projects that comply with the Americans with Disabilities Act and accessibility standards (8) is a measurable action toward this shared goal. Another action is to address specific safety hazards for people with differing levels of ability. The Strategic Agenda, for example, promotes and expands road safety assessments to identify potential concerns. Similarly, the Call to Action discusses several walking programs by community organizations that address physical limitations and safety.

## Importance of Equity

Equity is a central shared theme. Although the approaches to equity may differ, both documents emphasize access for everyone to safe and convenient places to walk.

The Call to Action emphasizes the many benefits of increased walking and improved walkability for all and directly addresses equity through several strategic actions. For example, under Goal 1, to make walking a national priority, the second strategy recommends linking organizations that have facilities for walking with programs tailored for particular



Photo: New York City DOT

groups, including traditionally underserved populations and people with disabilities. Many underserved groups report low levels of physical activity and large burdens of chronic diseases (9); increased walking could help narrow these health disparities.

Goal 3 of the Strategic Agenda defines transportation equity as the provision of “access to affordable and reliable transportation to fairly meet the needs of all community members, particularly traditionally underserved populations.” The focus is on ensuring that all members of a community have transportation options to destinations such as jobs, schools,

Programs like International Walk to School Day and New York City's “We're Walking Here NYC” challenge students to get around their cities and neighborhoods by walking.

## Goals of the Strategic Agenda for Pedestrian and Bicycle Transportation

*FHWA's Framework (4)*

1. **Networks:** Achieve safe, accessible, comfortable, and connected multimodal networks in communities throughout the United States.
2. **Safety:** Improve safety for people walking and bicycling.
3. **Equity:** Promote equity throughout the transportation planning, design, funding, implementation, and evaluation process.
4. **Trips:** Get more people walking and bicycling.

National goals that will inform FHWA's pedestrian and bicycle activities in the coming years are the following:

- ◆ Achieve an 80 percent reduction in pedestrian and bicycle fatalities and serious injuries in 15 years and zero pedestrian and bicycle fatalities and serious injuries in the next 20 to 30 years.
- ◆ Increase the percentage of short trips represented by bicycling and walking to 30 percent by the year 2025. This will indicate a 50 percent increase over the 2009 value of 20 percent. Short trips are defined as trips 5 miles or less for bicyclists and 1 mile or less for pedestrians.



Walkable street design accounts for all ability levels.

and health care. Because low-income households are less likely to own a car, walking and bicycling are important modes of transportation to work and to other economic activities (10).

### Design for Safety

Both the Call to Action and the Strategic Agenda emphasize designing and building communities and roadways that make walking comfortable, convenient, and safe. This is most evident on Goal 2 of the Call to Action, which focuses on designing communities that make walking safe and easy for people of all ages and abilities.

The first strategy in Goal 2 acknowledges transportation’s role in designing and maintaining streets and sidewalks for safe and easy walking. The first goal in the Strategic Agenda is a clear corollary—to

achieve safe, accessible, comfortable, and connected multimodal networks in communities throughout the nation.

Both documents highlight a Complete Streets approach, which supports the design and operation of streets that are safe for people using all travel modes and that serve as convenient multimodal networks (11). According to the National Complete Streets Coalition, “over 1,060 agencies at the local, regional, and state levels have adopted Complete Streets policies” as of March 2017 (11). The coalition and Smart Growth America have developed the Complete Streets Implementation Resource Appendix to help communities turn policy into practice (11). Complete Streets initiatives provide a forum for health and transportation professionals to work together toward shared goals.

In addition, both documents describe design features that specifically improve pedestrian safety on and near roadways. Pedestrian refuge islands and medians, raised crosswalks, and crosswalk visibility aids are cited as effective safety measures. Both documents identify features that reduce vehicle speeds along multimodal corridors, consistent with the recommendations of the Safe Routes to School National Partnership (12) and Vision Zero initiatives (13).

The Strategic Agenda highlights design flexibility that allows communities to design and implement projects that meet community needs and promote safety for all users, including pedestrians. Through these and other design efforts, communities can make walking a more attractive option for residents of all ages and abilities.

### Supportive Programs

Programmatic approaches to increase walking are important in both the Call to Action and the Strategic Agenda. Goal 3 of the Call to Action highlights the role of community programs and policies that support walking where people live, work, and play. Many of the strategies under Goal 3 encourage social support programs that facilitate group walking or other physical activities, including walking clubs at worksites and walking groups or buddy systems for the community in general.

The Call to Action also points out the role that volunteer and nonprofit organizations can play in motivating people to walk. GirlTrek, for example, has accrued pledges from more than 80,000 women to walk in their neighborhoods every Saturday and to encourage others to join in (14). Another group, Walk with a Doc, has engaged medical professionals to lead walking clubs and has established 289 chapters in 44 states (15).

The Strategic Agenda also includes programs and

Grand Canyon National Park faced challenges when buses, trains, and cars competed with pedestrians. A 2011 redesign project created a new bus depot that improved traffic and pedestrian safety.



activities that promote and monitor safe walking and bicycling. The Strategic Agenda recommends continued support for local and state Safe Routes to School initiatives (12). These programs promote safe, non-motorized access to schools and can provide health and environmental benefits to the community.

The Strategic Agenda also highlights FHWA's Every Day Counts, which is a state-based program to identify and deploy proven but underutilized innovations (16). The Strategic Agenda suggests a new edition of Every Day Counts to implement cost-effective pedestrian safety features in roadway design. Both documents clearly recognize the importance of programs in promoting walking and offer a range of examples from the private and public sectors.

## Education and Training

Disseminating information about walking and walkability with the public and relevant professionals is another shared topic. Goal 4 in the Call to Action focuses on providing information to encourage walking and to improve walkability; strategies include educating the general public, communicating with the media, and educating professionals. Suggested actions include providing public signs and maps for wayfinding along safe routes for walking; using popular communications channels such as walking apps to market walking and walkability; and offering continuing education for teachers, community planners, and transportation professionals to promote walking and walkability.

The Strategic Agenda describes capacity building, one of four categories of actions, as the provision of guidance and educational resources in support of pedestrian and bicycle transportation. All four



PHOTO: CDC PUBLIC HEALTH IMAGE LIBRARY

Strategic Agenda goals therefore include education-based actions:

Worksite walking programs can motivate employees to walk.

- ◆ A recommendation under Goal 1 is to develop a model curriculum for pedestrian and bicycle coordinators that establishes a baseline level of pedestrian and bicycle knowledge.

- ◆ Goal 2 recommends the continued operation of a National Pedestrian and Bicycle Information Center (17) to disseminate techniques, strategies, and educational programs for improving pedestrian and bicyclist safety.

- ◆ Goal 3 recommends training professionals and advocates who work with disadvantaged communities to advance equity through pedestrian, bicycle, and transit work.



PHOTO: TED EYMAN, FLICKR

The Walk with a Doc program encourages healthy transportation options through doctor-led outings.

Police teach a Cub Scout troop about bicycle safety. Education is a key component of the Strategic Agenda.



PHOTO: GREG HILDEBRAND, FLICKR

◆ Finally, Goal 4 recommends educating stakeholders on sources of federal funds for nonmotorized count programs.

These are a few of the examples demonstrating the multisectoral role that education and training play to increase walking in the United States.

## Data Gathering

Another area of agreement and emphasis is the need for additional surveillance, research, and evaluation related to walking and walkability. Goal 5 of the Call to Action focuses on data and includes strategies to fill information gaps through surveillance, research, and evaluation. The Strategic Agenda similarly recommends data collection and research across the four goal areas of networks, safety, equity, and trips.

## Surveillance

In public health, surveillance is the ongoing, systematic collection, analysis, interpretation, and dissemination of data regarding a health-related event for use in public health action to reduce morbidity and mortality and improve health (18). In transportation, collecting data on walking and bicycling activity and infrastructure serves the same purpose. Both the Call to Action and the Strategic Agenda recommend expanding and improving data collection on walkable infrastructure and walking behaviors to inform decision making and to improve outcomes.

Surveillance of walkable infrastructure may include street audits or sidewalk and bicycle lane inventories (19). Surveillance of pedestrian and bicyclist behaviors could involve adding questions about walking and bicycling trips to periodic travel surveys (20) or monitoring walking and bicycling at strategic locations with automated or manual counters (21).

The Strategic Agenda notes an ongoing effort to establish the Traffic Monitoring and Analysis System as a national repository of pedestrian and bicycle volume data. This system will help organize and



PHOTO: CDC PUBLIC HEALTH IMAGE LIBRARY

Sidewalks and pedestrian crossing signals are components of Complete Streets designs.



distribute data across sectors to serve several functions—such as calculating risk estimates for the public safety sector, estimating mode share for the transportation sector, and tracking physical activity for the public health sector. With this broad need for walking and biking data, collaboration across multiple sectors likely will be important, to provide sufficient resources for data collection and to facilitate shared access and use of the data.

### Research and Evaluation

The Call to Action and the Strategic Agenda note the importance of continuing and expanding research and evaluation efforts on walking and walkability. The Call to Action proposes several research topics to identify the most effective ways to improve walkability, increase walking, and determine the costs and benefits. For example, the document identifies a need for research into the economic impacts of multimodal networks in communities, including workforce attraction and the impact on local business.

The Strategic Agenda also recommends operational research to identify and develop best methods for assessing and monitoring networks, safety, equity, and trips. Despite slight differences, both documents agree that collaborative efforts are crucial for advancing this research, with input from transportation, public health, law enforcement, health care, information technology, engineering, and academic institutions.

The Call to Action stresses evaluation as part of the initial planning and early implementation of projects and interventions. Evaluation during all phases can help justify continued funding for programs and can help others replicate what has



PHOTO: NASHVILLE AREA MPO

worked and avoid what has not.

The Strategic Agenda—and the transportation field, in general—relies on performance measurement for the same purpose. Performance measures guide transportation planning and investment that align with national goals for the transportation system (22). Goal 2 of the Strategic Agenda highlights the first-time inclusion of bicycle and pedestrian safety performance measures in the Highway Safety Improvement Program. This new regulation brings nonmotorized safety into sharper focus and helps determine the best methods to improve pedestrian and bicyclist safety.

A walkable main street area—also a strategic site for counting pedestrians.

## Additional Resources for Information and Involvement

To learn more about the links between transportation and health and to get involved in the activities described in the Surgeon General's Call to Action and FHWA's Strategic Agenda, consult the following resources:



- ◆ The September–October 2015 *TR News* ([www.trb.org/Main/Blurbs/173417.aspx](http://www.trb.org/Main/Blurbs/173417.aspx)) presents articles on a range of transportation and health topics, from conducting health impact assessments to preventing the spread of communicable diseases.

- ◆ The TRB Health in Transportation Joint Subcommittee maintains a website of news and events ([www.trbhealth.org](http://www.trbhealth.org)).

- ◆ The TRB Task Force on Arterials and Public Health welcomes participants ([www.trbarterialhealth.org/](http://www.trbarterialhealth.org/)).

- ◆ FHWA's Bicycle and Pedestrian Program website offers key resources and publications ([https://www.fhwa.dot.gov/environment/bicycle\\_pedestrian/](https://www.fhwa.dot.gov/environment/bicycle_pedestrian/)).

- ◆ The Centers for Disease Control and Prevention have established health-oriented transportation recommendations from a public health perspective (<https://www.cdc.gov/transportation/default.htm>).



The Surgeon General's Call to Action and FHWA's Strategic Agenda address the needs of low-income communities, whose residents often have lower levels of physical activity.

## Opportunities for Collaboration

*Step It Up!* The Surgeon General's Call to Action to Promote Walking and Walkable Communities and the Strategic Agenda for Pedestrian and Bicycle Transportation reflect the needs and perspectives of their respective fields. Nevertheless, the two documents share goals to promote walking in the United States.

The similarities in the two documents are good examples of the growing union between the fields. Public health and transportation professionals may wish to explore opportunities to work together to achieve shared goals and to streamline efforts, and the Call to Action and Strategic Agenda highlight areas for this cooperation.

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NASEM CONSENSUS STUDY

# Communities in Action

## *Pathways to Health Equity*

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(Above:) Health disparities and location often are linked; active, available transportation can help residents of underserved communities maintain health.

A nation's well-being depends in part on the well-being of its communities. Yet insufficient access to jobs, transportation, healthy food options, safe and affordable housing, parks, and open space—all necessary for thriving—are challenges for many communities. The lack of equitable opportunity leads to disparities in health status and health outcomes between different areas of the country.

Health equity offers everyone the opportunity to attain full health potential. Health inequities stem from structural inequities, the systemic disadvantage of one social group in comparison with other groups. Structural inequities are deeply embedded in the fabric of society, in policy, law, governance, and culture.

Health inequities are in large part a result of historic and ongoing poverty, structural racism, and discrimination. Yet policies and community action can mitigate these inequities in powerful ways. A new report from the National Academies of Sciences, Engineering, and Medicine, *Communities in Action: Pathways to Health Equity*,<sup>1</sup> offers promising

<sup>1</sup> For a full list of references and resources, see the report at <http://nationalacademies.org/hmd/reports/2017/communities-in-action-pathways-to-health-equity.aspx>.

approaches for promoting health equity (see box, page 37, for list of authoring committee members).

### Health Disparities

Examples of the uneven distribution of health in the United States include the following:

- ◆ Infant mortality is much higher in certain populations. For instance, in 2013, the mortality rate for non-Hispanic white babies was about 5 in every 1,000. The rate reached more than 7 in 1,000 for Native Americans and about 11 in every 1,000 for African Americans.

- ◆ The opioid drug epidemic, which is worsening, primarily affects low-income people in rural communities throughout the United States.

- ◆ Rates of serious conditions such as obesity, heart disease, cancer, and stroke are substantially higher in the poorest parts of the United States. These disparities stem from systems and structures that make healthy living harder for poor people.

Health is shaped by more than individual choices. Research shows that for important health metrics



Nutritionists in Santa Ana, California, share healthy living tips with children who have Type-2 diabetes.

**FIGURE 1** A conceptual model for community-based solutions to promote health equity.

such as life expectancy, a zip code may matter more than a person’s genetic code. Where a person lives can determine a difference of up to 25 years in life expectancy from one neighborhood to the next. Life expectancy also can vary dramatically—by as much as 15 years for men and 10 years for women—depending on income level and education.

### Social Determinants

The conditions in the environments in which people live, learn, work, play, worship, and age that affect a range of health, functioning, and quality-of-life out-

comes and risks are referred to as the social determinants of health. These social determinants play a far greater role in health outcomes than do individual choices and include transportation, education, employment, health systems and services, housing, income and wealth, the physical environment, public safety, and the social environment. Communitywide problems such as poverty, unemployment, low educational attainment, lack of public transportation, inadequate housing, exposure to violence, and neighborhood deterioration—whether social or physical—shape health and contribute to health inequities. (See Figure 1, below left.)

To address the root causes, the underlying conditions that contribute to health inequities, and the interdependent factors that create them, new partners in education, transportation, housing, planning, public health, business, and beyond are joining forces with community members to promote health equity. The transportation sector has a key role.

### Transportation and Health

The literature on the social determinants of health typically discusses transportation as a feature of the physical—or built—environment. The new National Academies report, however, highlights transportation as a separate determinant of health, because transportation has many health-related facets, such as pollution and greenhouse gas production, motor vehicle–related deaths and injuries, mobility and access to employment and to vital goods and services, and active transportation—that is, walking and bicycling.

The report considers transportation in terms of the network, services, and infrastructure that provide residents with the means to get from one place to another and to access goods, services—including health and social services—social networks, and employment. Properly designed and maintained transportation facilitates safe mobility and is accessible to all residents, regardless of geographic location, age, or disability status.

Nevertheless, research suggests that transportation costs are a barrier to mobility for households in poverty, which are disproportionately represented by African Americans and Hispanics. Long commute times and high transportation costs are significant barriers to employment and financial stability.

From analyses of census data, researchers at the Brookings Institution have concluded that the suburbanization of poverty disproportionately affects proximity to jobs for poor and minority populations compared with their nonpoor and white peers. Particularly in rural communities, lack of public trans-



portation poses a barrier for access to health care and other vital services.

Transportation also produces negative externalities such as air pollution, noise, and motor vehicle-related injuries and deaths that are unevenly distributed—these are more prevalent in low-income and minority communities with poor infrastructure. Low-income and minority populations are more likely to live near environmental hazards, including transportation-related sources of pollution and toxic emissions such as roadways, bus depots, and ports.

## Active Transportation

Since the mid-20th century, road design and transportation planning have centered on the automobile, with multiple and interconnected consequences for health and equity. Promoting active transportation—walking and cycling, complemented by public transportation or any other active mode—would reduce environmental barriers to physical activity and improve health outcomes.

The evidence for the relationship between active transportation, physical activity, and health has been accumulating. The authoring committee of a 2005 report from the Transportation Research Board and the Institute of Medicine noted that “[r]esearch has not yet identified causal relationships to a point that would enable the committee to provide guidance about cost-beneficial investments or state unequivocally that certain changes to the built environment would lead to more physical activity or be the most efficient ways of increasing such activity.”<sup>2</sup> Since then, other researchers have found important relationships between active travel, such as walking and cycling, and the built environment.

## National Initiatives

The Centers for Disease Control and Prevention (CDC) have developed a set of transportation recommendations that address all of the facets described above and have developed a Transportation Health Impact Assessment Toolkit.<sup>3</sup> The CDC and the U.S. Department of Transportation (DOT) have produced a Transportation and Health Tool to share indicator data on transportation and health.<sup>4</sup>

Multiple national initiatives in the past two to three decades have aimed at improving livability and sustainability across the United States, and transportation equity is a mainstay of much of this work

<sup>2</sup> *Does the Built Environment Influence Physical Activity? Examining the Evidence*, [www.trb.org/Main/Blurbs/155343.aspx](http://www.trb.org/Main/Blurbs/155343.aspx).

<sup>3</sup> [https://www.cdc.gov/healthyplaces/transportation/promote\\_strategy.htm](https://www.cdc.gov/healthyplaces/transportation/promote_strategy.htm).

<sup>4</sup> <https://www.transportation.gov/transportation-health-tool>.

PHOTO: ORAN WIRVINYC, FLICKR



(see the box on page 36 for an example of a regional planning agency that seeks to improve access to transportation). Initiatives have ranged from the federal Sustainable Communities Partnership, launched by U.S. DOT, the U.S. Department of Housing and Urban Development, and the U.S. Environmental Protection Agency in 2009 to help U.S. communities “improve access to affordable housing, increase transportation options, and lower transportation costs while protecting the environment,”<sup>5</sup> to Safe Routes to School, which aims to improve children’s safety while walking and riding bicycles.<sup>6</sup>

## Model Approaches

The report also examines and shares solutions implemented in several communities as models that other communities may adapt, applying lessons learned to foster community-based approaches in their own unique environments. Communities working to promote health equity or to address the conditions in their neighborhoods may use different types of part-

<sup>5</sup> <https://www.sustainablecommunities.gov/>.

<sup>6</sup> <https://www.saferoutespartnership.org/>.

The link between physical activity and health has caused transportation and city planners to rethink the function of streets.

For much of the twentieth century, road and neighborhood design centered on the automobile.

PHOTO: MICHIGAN STATE HISTORIC PRESERVATION OFFICE





Photo: North Carolina DOT

Communities often work together to promote health through such activities as Bike to School days.

Partnerships between community-based organizations, local government agencies, and residents. These varied coalitions are important in creating opportunities and structures for change.

The report identifies three elements critical to community success (see Figure 1, page 34):

1. Multisector collaboration,
2. Health equity as a shared vision and value, and
3. Community capacity to shape outcomes.

### Community Capacity

Community capacity refers to the ability of communities to come together to identify common needs and to build social and political capital by drawing on ties

with residents, local businesses, elected officials, and others both inside and outside the community. Community-led action is only possible when communities have the capacity to organize for a common goal.

To change the living conditions in a community, the members must have vision, leadership, voice, and power—the capacity and ability to act. Building community capacity therefore is the primary mechanism that ensures the democratization of decision making around health equity. In addition, community capacity and involvement are keys for sustained change.

One of the community-driven examples examined in the report is the Indianapolis Congregation Action Network (IndyCAN), a multiracial, nonpartisan organization in central Indiana that catalyzes marginalized people and faith communities to act collectively for racial and economic equity. One of its programs, the Ticket to Opportunity initiative, works to mitigate the effects of inadequate transit to employment opportunities.

Building a partnership of faith-based organizations, businesses, government, and community leaders, the IndyCAN initiative supported a regional referendum to triple bus service in Indianapolis. Ticket to Opportunity created a dialogue with 80,000 marginalized voters of color through large-scale, integrated voter engagement and built a sustained capacity for achieving transit equity.

The expanded bus service is expected to fuel economic development and to increase job access for low-income communities threefold. The IndyCAN efforts highlight ways that multiple sectors can work together successfully to address determinants

## Promoting Health and Sustainability Through Transportation Projects

The Nashville Metropolitan Planning Organization (MPO), a local planning agency for seven counties in Tennessee, also functions as a convener for local communities and state leaders to collaborate on strategic planning for the region's multimodal transportation system. The mission of the organization is to "develop policies and programs that direct public funds to transportation projects that increase access to opportunity and prosperity, while promoting the health and wellness of Middle Tennesseans and the environment."

The Nashville MPO developed a regional transportation plan in 2015 and outlined the following objectives to help communities grow in a healthy and sustainable way:

- ◆ Align transportation decisions with economic development initiatives, land use planning, and open-space conservation efforts;

- ◆ Integrate healthy community design strategies and promote active transportation to improve the public health outcomes of the built environment;

- ◆ Encourage the deployment of context-sensitive solutions to ensure that community values are not sacrificed for mobility improvement;

- ◆ Incorporate the arts and creative place-making into planning and public works projects to foster innovative solutions and to enhance the sense of place and belonging;

- ◆ Pursue solutions that promote social equity and contain costs for transportation and housing; and

- ◆ Minimize the vulnerability of transportation assets to extreme weather events.

The MPO plans to evaluate its projects with criteria that include health-related indicators such as physical activity, air quality, and traffic collisions.



Increased public transit to health facilities and pharmacies supports sustainable communities and healthier residents.

of health. The community-driven work increased community capacity.

### Improving Policy Decisions

Although communities play a crucial role in improving health equity, they cannot do it alone. Communities operate in the context of federal and state policies that can affect local government decisions about health through laws and regulations, the allocation of resources, and the shaping of political will on issues and approaches.

Policies ranging from education to land use and housing, the environment, transportation, and criminal justice can be relevant to health disparities. Policies can vary across geographic areas and over time in establishing priorities, providing funding, or encouraging collaboration. Policies can provide opportunities or raise barriers for health equity.

To improve policy decisions, the authoring committee of the report recommends that all government agencies that support or conduct planning related to land use, housing, transportation, and other areas that affect populations at high risk of health inequity should do the following:

- ◆ Add specific requirements for outreach processes to ensure robust and authentic community participation in policy development.

To spread the word about how the transportation sector can be involved, connect with #PromoteHealthEquity on Twitter or share a new sector brief available at [www.nap.edu/TransportationforHealthEquity](http://www.nap.edu/TransportationforHealthEquity).

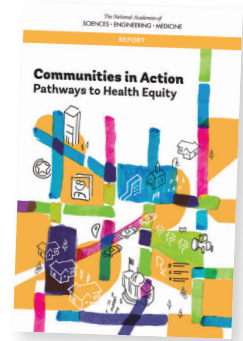
- ◆ Collaborate with public health agencies and others to ensure a broad consideration of unintended consequences for health and well-being, including whether the benefits and burdens will be equitably distributed.

- ◆ Highlight the cobenefits of—or the shared wins that could be achieved by—considering health equity in the development of comprehensive plans; for example, improving public transit in transit-poor areas supports physical activity, promotes health equity, and creates more sustainable communities.

- ◆ Prioritize affordable housing, implement strategies to mitigate and avoid displacement and its serious health effects, and document the outcomes.

### Multisector Cooperation

Health depends on more than individual choice; many communities therefore are addressing the systemic root causes of health inequities. Working to address unemployment, concentrated poverty, access to safe transportation, and school dropout rates can seem overwhelming to communities, but when residents, businesses, state and local government, and other local institutions work together across multiple sectors, communities gain the power to change the narrative and to promote health equity through enduring community-driven interventions.



*Communities in Action: Pathways to Health Equity* is available from National Academies Press: <https://www.nap.edu/catalog/24624/communities-in-action-pathways-to-health-equity>.

### Committee on Community-Based Solutions to Promote Health Equity in the United States

- James N. Weinstein**, Dartmouth-Hitchcock Health System, *Chair*
- Hortensia De Los Angeles Amaro**, University of Southern California School of Social Work and Keck School of Medicine
- Elizabeth Baca**, California Governor's Office of Planning and Research
- B. Ned Calonge**, University of Colorado and The Colorado Trust
- Bechara Chouair**, Kaiser Permanente (formerly Trinity Health until November 2016)
- Alison Evans Cuellar**, George Mason University
- Robert H. Dugger**, ReadyNation and Hanover Provident Capital, LLC
- Chandra Ford**, University of California, Los Angeles, Fielding School of Public Health
- Robert García**, The City Project and Charles Drew University of Medicine and Science
- Helene D. Gayle**, McKinsey Social Initiative
- Andrew Grant-Thomas**, EmbraceRace
- Sister Carol Keehan**, Catholic Health Association of the United States
- Christopher J. Lyons**, University of New Mexico
- Kent McGuire**, Southern Education Foundation
- Julie Morita**, Chicago Department of Public Health
- Tia Powell**, Montefiore Health System
- Lisbeth Schorr**, Center for the Study of Social Policy
- Nick Tilsen**, Thunder Valley Community Development Corporation
- William W. Wyman**, Wyman Consulting Associates, Inc.

# The One-Stop Shop

## Traveler Information Tool for Multistate Road Trips

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Real-time traveler information is a valuable tool for protecting and enhancing traveler safety and mobility, especially in rural areas. Knowing about potential safety challenges before a trip—including snow, ice, high winds, fires, and other hazards—is particularly important for rural travelers. These hazards—as well as vehicle crashes and work zones—pose challenges that can degrade mobility.

Information about these challenges, however, generally is scattered over many sources. As a result, many rural travelers may not seek, find, or even be aware of all the information that is available. This lack of awareness about various traveling conditions may result in increased delays and degraded safety.

### Research and Solution

In 2010, the California Department of Transportation (Caltrans) and the Western States Rural Transportation Consortium (WSRTC) together launched a proof-of-concept research project to provide traveler information through a single, easy-to-use source. Researchers at the Western Transportation Institute (WTI) at Montana State University created a traveler information tool, the One-Stop Shop,<sup>1</sup> to benefit users in the selected initial region. The WTI team demonstrated the feasibility and attractiveness of a comprehensive application for real-time traveler information in rural areas.

The One-Stop Shop application is an umbrella website of traveler information that can be used as a primary point of reference for trip planning (see Figure 1, above right). The website features an accessible and intuitive interface that allows travelers to plan in-state trips, as well as trips across state borders. Because it was developed as a proof of concept, One-Stop Shop has a scalable design, so that the system can expand to additional routes and states.

“The long-distance traveler doesn’t care that he has crossed a state line or district boundary—what he wants is accurate, timely and reliable road condition and weather information all along a route, from beginning to end,” observes Ian Turnbull, Chief of the Caltrans Office of Intelligent Transportation Systems Engineering and Support. “The One-Stop Shop finally gives us the ability to get route-oriented, real-time traveler information to the public in an effective manner.”

<sup>1</sup> <http://oss.weathershare.org>.

FIGURE 1 The One-Stop Shop mobile application is available on smartphones and tablets.



### Ongoing Research

From the beginning, the team has treated the One-Stop Shop as an ongoing research project and test bed. The team constantly gauges the website’s use and usability via online surveys and in-depth tracking and analytics. Team members adopted a hybrid approach that combined systems engineering and spiral development; this has enabled the rapid incorporation of changes into the system in response to feedback from surveys and usage tracking.



FIGURE 2 Postclipse traffic congestion, shown live on the One-Stop Shop.





Icy conditions, snow, and fallen trees closed Washington State's I-90 to travel in January. Washington State is a member of the Western States Rural Transportation Consortium, which contributed to the development of the One-Stop Shop traveler information tool.

By operating at the edge of change, the One-Stop Shop has addressed many challenges of interface design and deployment that have helped to pave the way for related efforts, such as the popular Caltrans QuickMap, an online map layered with information about traffic speed, lane and road closures, incident reports, changeable message sign contents, camera snapshots, and more.<sup>2</sup>

The project team recently investigated the impact of the 2017 eclipse on system usage in real time (see Figure 2, page 38). The team found that some users observed both the eclipse and its impact on travel from afar; in addition, those who traveled to see the total eclipse in person used the One-Stop Shop in conjunction with their journeys.

The project team also has conducted research on data quality. A beneficial side effect is that this has enabled the project team to identify any emerging problems with the data feeds. On several occasions, the project team has been able to contact the data providers to fix the problems before critical times of use—for example, in advance of a major winter weather event.

The collection, assimilation, and distribution mechanisms for the One-Stop Shop data have covered a large geographic expanse and have required the cooperation of many agencies in several states. The One-Stop Shop was one of the first web-based traveler information portals to integrate information from several state departments of transportation.

The website also incorporates key information from other sources, such as real-time weather information from the National Weather Service and information about congested traffic locations from Google Traffic. These are major accomplishments that have relied on extensive research and development.

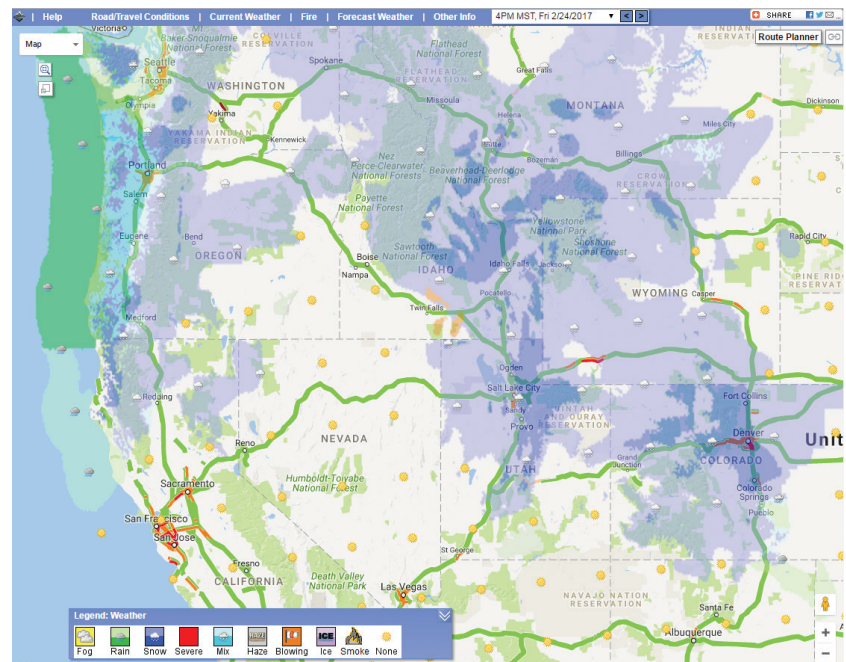
<sup>2</sup> <http://quickmap.dot.ca.gov/>.

**Decision-Making Tool**

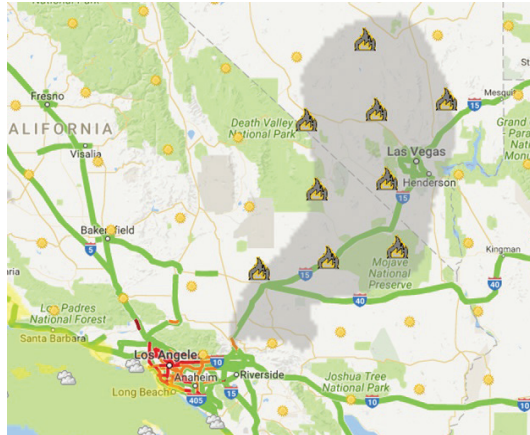
By combining all of these resources, the One-Stop Shop provides motorists with a single, seamless decision-making tool for long-distance travel. When users view a route on the website, they can access features that include the following:

- ◆ Route planning,
- ◆ Closed-circuit television images,
- ◆ Construction activity,
- ◆ Incident locations,
- ◆ Current and forecasted weather,
- ◆ Levels of traffic congestion,
- ◆ Active fire zones,

**FIGURE 3** The One-Stop Shop covers an 11-state region. This screenshot from early 2017 displays a snow forecast across multiple states.



**FIGURE 4** In 2016, One-Stop Shop users could view smoke forecasts for wildfires that spread across Southern California and Nevada.



- ◆ Chain requirements,
- ◆ Elevation profiles,
- ◆ Rest areas, and
- ◆ Points of interest.

### Expanding Access

Caltrans, WTI, and their partners launched the original One-Stop Shop web application in 2011, providing traveler information to the four-state region of California, Oregon, Washington, and Nevada. In 2014, coverage expanded significantly to seven more Western states: Arizona, Colorado, Idaho, Montana, New Mexico, Utah, and Wyoming (see Figure 3, page 39). With the size of this new coverage area, the One-Stop Shop enables travelers to see current and projected conditions for long-distance routes such as Seattle, Washington, to San Diego, California; or Denver, Colorado, to Boise, Idaho.

The application serves a range of users, especially those who need information about real-time conditions—for example: local, regional, and long-distance travelers; local and state transportation agency personnel; emergency responders; and commercial vehicle operators.

At the end of 2016, the application went mobile, again expanding access.<sup>3</sup> The mobile site is available on smartphones and tablets and is attracting a broader audience. In addition, the mobile app gives travelers easy access to updates—although motorists are urged not to use the app while driving.

### Benefits

The One-Stop Shop offers numerous benefits to individual and institutional users:

- ◆ Protecting and enhancing traveler safety and mobility in rural areas;
- ◆ Enabling travelers to “know before they go,” so that they can make well-informed travel decisions;

<sup>3</sup> <http://oss.weathershare.org/m/>.

- ◆ Reducing the impacts of nonrecurring congestion and unexpected delays; and
- ◆ Enhancing the capability of the agencies that manage the transportation system.

User feedback and usage statistics suggest that travelers have found the One-Stop Shop particularly helpful during holiday periods and during severe storms—especially when both may occur simultaneously. For example, in December 2015, the desktop version of the One-Stop Shop hosted more than 63,000 user sessions for the month, with nearly 6,200 of the sessions—or almost 10 percent—occurring on Christmas Eve.

Usage continues to grow. In January 2017, during a bad weather season that included heavy, ongoing rains on the West Coast, the One-Stop Shop hosted 128,730 user sessions—an all-time record for monthly usage.

The One-Stop Shop also has proved beneficial to the agencies that plan and coordinate emergency response activities (see Figure 4, above left). After lightning-induced fires in Northern California this year, a dispatcher at the Caltrans Traffic Management Center reported that the One-Stop Shop “was instrumental in gauging where the fires could be headed, based on wind speed. This allowed our center to be better prepared for all of the many what-if situations.”

Recognizing these benefits, as well as the project’s pioneering use of transportation technologies, ITS America selected the One-Stop Shop as the winner of its Best of ITS Award for 2014 in the category of Best New Innovative Practice—Research, Design, and Innovation.

Caltrans funded the One-Stop Shop research, and WSRTC supported the ongoing research and development. In addition, the Federal Highway Administration provided funding for an early project task related to road weather information.

*For more information about the One-Stop Shop, contact Sean Campbell, Senior Transportation Engineer—Electrical Specialist, Division of Research, Innovation, and System Information, Caltrans, P.O. Box 942873, Sacramento, CA 94273-0001; Sean.Campbell@dot.ca.gov; 916-654-8868; or Douglas Galarus, Program Manager, Systems Engineering Development and Integration, Western Transportation Institute, Montana State University, P.O. Box 174250, Bozeman, MT 59717-4250; dgalarus@montana.edu; 406-994-5268.*

EDITOR’S NOTE: Appreciation is expressed to B. Ray Derr, Transportation Research Board, for his efforts in developing this article.

Suggestions for Research Pays Off topics are welcome. Contact Stephen Maher, Transportation Research Board, Keck 486, 500 Fifth Street, NW, Washington, DC 20001; 202-334-2955; smaher@nas.edu.

# CALENDAR

## TRB Meetings

### January 2018



**7-11 TRB 97th Annual Meeting**  
Washington, D.C.

30-31 Planning for Shifting Trade Workshop\*  
Tampa, Florida

### 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

15-16 National Household Travel Survey Data for Transportation Applications Workshop  
Washington, D.C.

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

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

15-28 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

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

### September

25-27 Workshop on Managed Lanes  
Bellevue, Washington

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

### October

21-23 14th National Light Rail and Streetcar Conference  
Jersey City, New Jersey

### November

TBD TRANSED 2018: 15th International Conference on Mobility and Transport for Elderly and Disabled Persons  
Taipei, Taiwan

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

\*TRB is cosponsor of the meeting.

## C. James (Jim) Kruse

*Texas A&M Transportation Institute*

As director of the Center for Ports and Waterways at the Texas A&M Transportation Institute, C. James (Jim) Kruse administers research involving waterborne freight transportation and its multimodal connections—work that covers a range of ever-changing topics, from economic analyses of ports and waterways to statistical evaluations of vessel traffic to innovative intelligent transportation system technologies.

“Marine transportation is something very few individuals interact with on a frequent basis, yet it is absolutely vital for a growing and healthy economy,” Kruse observes. “Consumer goods, raw materials, oil—it all gets here by ship.”

Kruse is conducting research to determine the best use of automated identification service data in assessing the performance of marine activities in a port complex, part of a nation-

Authority to advise her on border issues.

After leaving Brownsville, Kruse joined Foster Wheeler Environmental Corporation as a regional program manager for the Ports, Harbors, and Waterways Program. He assisted with port-related projects around the country, including a dredging management action plan for the Maine Department of Transportation, analysis of nearshore fill issues for the Port Authority of New York and New Jersey, assistance with oversight of the Alexander Island spill cleanup in Texas, and dredging and infrastructure improvements at the Port of Pascagoula in Mississippi.

“Technology and new sources of information are leading the marine transportation industry into an era of unprecedented change,” Kruse comments. “The use of new technology tools presents unique challenges in marine transportation. The field is wide open to those who can devise the best way to use technology to improve the management and control of marine assets.”

Kruse was an early member of the Transportation Research Board (TRB) Task Force on Marine Environmental Issues, which became a full committee in 2008. He assisted with paper review coordination for several years and has chaired the committee since 2012, serving as its representative to the Marine Group. He also was active in the Standing Committee on Ports and Channels from 2003 to 2013 and recently rejoined. In addition, he held membership in



**“For our work to make a difference, we researchers must be able to provide context for the data we generate.”**

wide effort to develop adequate metrics for freight fluidity within specific supply chains. He recently has assessed the impact of the expanded Panama Canal on ports in the Gulf of Mexico and has conducted a peer review of the U.S. Environmental Protection Agency’s “Category 3 Commercial Marine Bunker Fuel Demand Update.”

“For our work to make a difference, we researchers must be able to provide context for the data we generate,” Kruse notes. “We need to help the reader understand the story the data tell and what the possible responses to the data may be. Information alone without context or analysis is not very useful.”

Kruse received a master’s degree in international business and human resources from Houston Baptist University and a master’s of business administration from the University of Kansas. From 1988 to 1997, he served in a senior executive capacity at the Port of Brownsville, Texas, including eight years as port director. He led a successful effort to acquire a presidential permit for the New International Bridge Crossing between Brownsville and Matamoros, Tamaulipas, Mexico. Kruse supervised the planning, design, and implementation of \$100 million in facility improvements at the port. Then-Governor Ann Richards also appointed him to the Texas–Mexico

the Standing Committee on Inland Water Transportation from 2007 to 2013 and was appointed by the National Academies to the policy study committee on Reinvesting in Inland Waterways: What Policy Makers Need to Know. The policy study was published in 2015. Kruse also has participated in TRB meetings and conferences, as a moderator for a 2009 TRB Annual Meeting session on Climate Change and Maritime Transportation and as a member of the planning committee for the 2018 research development conference cosponsored biennially in Washington, D.C., by TRB and the Committee on the Marine Transportation System.

Kruse has served as principal investigator on three National Cooperative Freight Research Program projects: North American Marine Highways, Marine Highway Transport of Toxic Inhalation Hazard Materials, and Integrating Marine Transportation System (MTS) Commerce Data with Multimodal Freight Transportation Performance Measures to Support MTS Maintenance Investment Decision Making.

Kruse has completed appointments to many local, state, and national boards and task forces and is a member of the Marine Transportation System National Advisory Committee. Fluent in Spanish, he has worked on projects in Latin America.

## Brian Ray *Kittelson & Associates, Inc.*

**B**rian Ray’s passion for and approach to transportation planning and geometric design were formed early in his career, when he first worked at CH2M Hill and had the opportunity to work with Jack and Joel Leisch in the offices of Jack E. Leisch and Associates. Ray was trained to approach projects from a systems planning and functional design perspective. He most enjoys the early project development stages—considering, screening, and refining alternatives. “Understanding each user’s perspective is foundational in determining roadway geometrics,” he notes.

When Ray was in high school, civil engineer Jory Abrams hosted him at a National Engineering Week dinner and helped guide him to the civil engineering program at Portland State University in Oregon. Ray became student chapter president of the American Society of Civil Engineers (ASCE) and was active



**“Understanding each user’s perspective is foundational in determining roadway geometrics.”**

in the Oregon Section, later receiving ASCE’s Outstanding Younger Member award for the section.

After he received a bachelor’s degree in 1985 from Portland State University, Ray discovered transportation as a career path at C2HM Hill. As an engineer in training, he watched Joel Leisch assess and diagnose the freeway corridor, roadway network, and 1960s-era ramps. “He so easily defined system hierarchy, local roadway and transit user needs, and freeway traffic operations,” Ray recalls. “I remember thinking, ‘Well, of course!’”

In 1995, Ray joined Kittelson & Associates, Inc., where he still works. As a senior principal engineer based in Portland, Ray serves as a project manager and technical specialist. He has led National Cooperative Highway Research Program (NCHRP) projects on guidelines for selecting speed-reduction treatments at high-speed intersections, ramp and interchange spacing, and on performance-based analysis of geometric design of highways and streets. He also led Federal Highway Administration efforts to generate information guides for four alternative intersections: the displaced left turn, restricted-crossing U-turn, median U-turn, and diverging diamond interchange.

Ray also focuses on context-sensitive solutions for freeways and interchanges, rural highway corridor preservation, and intersection control evaluations. “I love the operational effects of geometric design,” he comments, adding that new staff who come to him for input on an intersection concept are likely to get a lesson in speed profiles and the value of self-describing and self-enforcing roadways. “I know sometimes they just want the answer to a basic question, but sharing the principles leading to that answer will help them long after the immediate project.”

Recent projects include developing a transportation safety action plan for Clackamas County, Oregon—the first of its kind for a county in the state; providing analysis and observations to the Office of the Mayor of Birmingham, Alabama, to enhance decision making about a proposed freeway system project; applying *Highway Safety Manual* freeway and interchange safety prediction methodologies to evaluation of a 7.6-mile segment of I-10 in Phoenix, Arizona; and evaluating interchange forms in Alaska, leading to the state’s first diverging diamond interchange.

In 1995, Ray joined the Transportation Research Board (TRB) Standing Committee on Geometric Design. He was active in the research subcommittee and served as committee chair from 2006 to 2012, reorganizing its structure to focus on developing research needs statements and on promoting activities, conferences, and joint work sessions with the American Association of State Highway and Transportation Officials. He helped develop a committee strategic research plan that led to the funding of many research projects.

“It’s surprising how long it takes to get from a research needs statement to a completed research report,” he notes, adding that he is proud of the committee volunteers and of the amount of applied research completed on behalf of the National Cooperative Highway Research Program. Ray also is a member of the Task Force on Arterials and Public Health and chairs the Subcommittee on Context-Sensitive Solutions. He has served as chair of the Design Section since 2012.

Each year, Ray looks forward to representing the Design Section at the TRB Annual Meeting session for new attendees. “TRB is a large organization, and the Annual Meeting can be daunting for a new attendee,” he observes. “Helping them connect with fellow TRB professionals—even outside geometric design—is always satisfying.”

As Geometric Design Committee chair, Ray has emphasized support for emerging professionals, the involvement of younger members on the committee, and the promotion of TRB workshops for students. “So many people invested in me—it’s a pleasure to share with and support others,” he comments. “Allocating time for students creates an exciting learning opportunity.”

## Preparing for Automated Vehicles and Shared Mobility

*National Academies–TRB Forum Addresses Critical Research*

KATHERINE A. KORTUM

*The author is Senior Program Officer, Studies and Special Programs Division, Transportation Research Board.*

The National Academies of Sciences, Engineering, and Medicine and the Transportation Research Board (TRB) have convened a forum for representatives from the private sector, research organizations, and government to identify and facilitate fact-based research on automated vehicles and shared mobility services to inform policy that can best meet long-term goals—increasing safety and environmental sustainability, reducing congestion, enhancing accessibility, and encouraging economic development and equity.

Also known as roundtables, National Academies forums bring together researchers, industry representatives, and policy makers on an ongoing basis to discuss issues of mutual concern. Because forum members are not subject to conflict-of-interest restrictions, participants from sponsor organizations and other government officials can participate fully in the forums. A forum may not generate formal recommendations or reports, but may commission individually authored papers and may sponsor workshops.

The need and background for a forum on automated vehicles and shared mobility arose out of discussions at such events as the TRB symposium Partners in Research: Transformational Technologies

in Detroit, Michigan, in fall 2016, and a forum scoping meeting held in July in San Francisco, California. The forum will begin meeting in 2018, cochaired by Kirk Steudle, Michigan Department of Transportation; Gregory Winfree, Texas A&M Transportation Institute; and Peter Sweatman, CAVita.

TRB is working with stakeholders to identify specific forum activities, but these likely will include the following:

- ◆ **Share information and perspectives among forum participants on an ongoing basis.** The forum will feature twice-yearly meetings supplemented by conference calls. Members will share perspectives on issues and developments associated with incorporating automated vehicles and shared mobility services into the transportation system, discuss ongoing and recently completed research activities, and may commission papers.

- ◆ **Identify research needs and priorities.** Forum members will develop and update a research roadmap that identifies the highest-priority research needs for fulfilling the forum's goals.

- ◆ **Facilitate the conduct of the needed research.** TRB's Cooperative Research Programs will use input



Seattle firefighters examine new dockless bikeshare bicycles. A new NASEM–TRB forum addresses the rapid pace of transportation innovations in automated vehicles and shared mobility.

from the forum in developing their research needs. Forum members can raise topics for consensus policy studies and other studies conducted by TRB or by other divisions of the National Academies of Sciences, Engineering, and Medicine. Members also may form and develop research partnerships outside of the National Academies and TRB.

◆ **Engage the broader stakeholder community.** The forum will sponsor sessions at the annual Automated Vehicle Symposium, cohosted by TRB and by the Association for Unmanned Vehicle Systems International, and at the TRB Annual Meeting. Members will partner with relevant TRB standing committees to support related activities, including conferences, workshops, and webinars, and will participate in activities of other organizations.

Collectively, the forum sponsors will determine the areas of highest priority to address, although the following topics are likely to be included:

◆ **Safety impacts.** Potential safety scenarios during the transition to highly automated vehicles, potential adverse safety effects, liability in a world of automated vehicles, minimum sets of safety data needed, and safe operations of commercial vehicles.

◆ **Transportation system impacts.** Infrastructure enablers for connected and automated vehicles, critical paths and timeline scenarios for Levels 4 and 5 automation, synergies within the transportation ecosystem, changes in traveler behavior and freight movement, and automated vehicle deployment by shared mobility providers.

◆ **Social, environmental, energy, and economic impacts.** The net positive and social impacts of automated vehicle and shared mobility deployment, social inclusion and equity issues, connections to alternative fuels, and impacts on land use.

◆ **Data considerations.** The size of data sets, public-sector use of private-sector data, cybersecurity and privacy challenges, protocols for data sharing, and data analytics for policy guidance.

◆ **Cross-cutting topics.** Cooperative national research planning for automated vehicles and shared mobility systems, precursory policy analyses, scenario planning and use cases, definition of pilot testing successes and failures, and education for users and the general public.

PHOTO: U.S. DEPARTMENT OF TRANSPORTATION



Sponsoring organizations include federal, state, and local transportation agencies; automobile manufacturers; shared mobility providers; technology and equipment companies; consulting firms; and academic and research institutions. The forum also will include liaisons to several TRB committees, in addition to partner organizations such as the American Association of State Highway and Transportation Officials, the American Public Transportation Association, the Institute of Transportation Engineers, and the Intelligent Transportation Society of America.

For more information, contact Mark Norman at [mnorman@nas.edu](mailto:mnorman@nas.edu) or Patrice Davenport at [pdavenport@nas.edu](mailto:pdavenport@nas.edu).

Vehicle-to-infrastructure communication technologies warn drivers about collisions (*above*) and other road hazards (*below*).

PHOTO: U.S. DEPARTMENT OF TRANSPORTATION



## Early Deployment of Automated Vehicles May Save Lives

Early implementation of highly automated vehicles (HAVs) would reduce road fatalities, according to a recent study from the RAND Corporation. Researchers addressed several questions, including how safe HAVs should be before being introduced to consumers and what short- and long-term conditions would result in more lives saved.

Using an automated vehicle safety model, RAND researchers compared road fatality predictions for HAVs that performed at a level 10 percent better than the average human driver with HAVs that performed at levels 75 and 90 percent better. The data were applied with a methodology that incorporated

scenario planning and probabilistic risk analysis over thousands of possible future conditions to assess which situation yielded fewer road fatalities.

According to the study, results showed that approximately half a million lives could be saved by deploying HAVs, even if the performance was only 10 percent better than that of the average driver. Researchers added that real-world driving is key to improving HAV technology and that significant safety improvements may be difficult to develop before deployment.

For more information, visit [www.rand.org/pubs/research\\_reports/RR2150.html](http://www.rand.org/pubs/research_reports/RR2150.html).

## Rural Public Transit on the Rise

Public transit use in rural areas has grown nearly 8 percent in the past decade, despite a steady population decline in those areas, according to a new study by the American Public Transportation Association (APTA).

APTA gathered data from multiple agencies, including the National Highway Traffic Safety Administration, the Insurance Institute for High-

way Safety's Highway Loss Data Institute, and the U.S. Census. Several factors influenced the growing use of—and need for—transit in rural and small towns: increasing populations of senior citizens and of young people without driver's licenses, as well as a poverty rate higher than in urban areas.

According to the study, public transit use increases active lifestyles and is vital for rural residents with otherwise limited access to health care, local businesses, and job opportunities. Research results showed that seniors, veterans, and people with disabilities used public transit the most; travelers with limited mobility took 50 percent more transit trips than those who were unimpaired.

Rural households spend 7 percent more of their budgets on vehicle expenditures than their urban counterparts. Taking public transit can reduce these costs drastically, researchers note.

For more information, visit [www.apta.com/resources/reportsandpublications/Documents/APTA-Rural-Transit-2017.pdf](http://www.apta.com/resources/reportsandpublications/Documents/APTA-Rural-Transit-2017.pdf).

Use of public transit in rural areas is on the rise—especially among seniors, veterans with disabilities, and young people without driver's licenses.



PHOTO: CHANZI, FLICKR

## Legalized Marijuana Linked to Crash Increase

The legalization of marijuana in Colorado, Oregon, and Washington has resulted in collision claim frequencies approximately 3 percent higher than would be expected without legalization, according to a new report.

The study used data from before and after recreational marijuana legalization in Colorado, Oregon, and Washington. Recreational marijuana use was approved by voters in 2012 in Colorado and Washington, and retail sales began in 2014; Oregon voters approved marijuana legalization in 2014, and retail sales began in 2015. Before that, marijuana was permitted only for medical use in all three states.

The study used control data from neighboring states that have not legalized recreational marijuana: Idaho, Montana, Nevada, Utah, and Wyoming. Data were gathered for collision claims filed between January 2012 and October 2016 for vehicles with model years from 1981 to 2017. Researchers also controlled for differences in the rated driver population, insured vehicles, urban and rural exposure, unemployment, weather, and seasonality.

Collision claim frequency is the number of collision claims divided by the number of insured vehicle years. Researchers found that Colorado's collision claim frequency was 14 percent higher than that of



adjacent states. Washington State experienced an estimated increase in claim frequency of 6.2 percent and Oregon an increase of 4.5 percent.

For more information, visit [www.iihs.org/iihs/sr/statusreport/article/52/4/1](http://www.iihs.org/iihs/sr/statusreport/article/52/4/1).

## Most Dangerous Driver Distraction? Texting

Participants in a 2016 study by the University of Houston and Texas A&M Transportation Institute drove the same segment of highway under four different conditions: normal driving, or driving focused; while distracted with math equations—that is, with a cognitive stressor; while distracted with emotionally stirring questions—that is, with an emotional stressor; and while texting—that is, with a sensorimotor stressor.

Researchers used sensors to detect heart rates, breathing, eye movements, and palm reactions to understand the effects of each driving condition. The data set and methodology recently were made available in Scientific Data.

All three distractions caused changes in driver response, but significant lane deviations and unsafe driving occurred only in the texting test. In the cognitive and emotional stressor tests, researchers explained, drivers experienced the paradoxical “sixth sense”—the brain engaged the body physically to counteract the distraction. When drivers



PHOTO: DOUGERTON SKILHAUSE, FLICKR

A study found texting to be the most dangerous of driver distractions.

texted and drove, however, they removed their hands from the wheel to use the phone—breaking the sixth sense response.

For more information about the original 2016 report, visit <https://www.uh.edu/news-events/stories/2016/May/051216PavlidisTextingStudy.php>. To see the methodology and data released in 2017, visit <https://www.nature.com/articles/sdata2017110>.

## Blue and White for Safety

Blue and white lights cut through snow and fog better than amber lights, according to a study and pilot program from the Iowa Department of Transportation (DOT). The project examined how best to reduce rear-end collisions with snowplows.

In 2015, Iowa DOT requested a three-year study that would allow replacement of the usual amber lights on 175 of Iowa's 845 snowplows with lights that flash blue and white. The expectation was that the new lights would be more visible to other vehicles during plowing conditions.

In two years, crashes have decreased by more than 65 percent. Iowa DOT officials decided that the results were definitive and further testing was not necessary. The cost of replacing lights on additional plows is \$335,000; the benefits include decreased repair costs, reduced downtime for plow repair, a lessened workload for claims managers, and greater efficiency.

For more information, visit <http://www.desmoinesregister.com/story/news/2017/10/25/iowa-dot-big-safety-benefits-using-blue-and-white-lights-snowplow-trucks/793775001/>.



PHOTO: MICHAEL KAPPEL, FLICKR

A trial program that replaced the amber lights on snowplows with blue and white lights was so successful in reducing crashes that the study ended early.



### **Standard Design and Construction Guidelines for Microtunneling (36/15)**

American Society of Civil Engineers (ASCE), 2015; 160 pp.; ASCE members, \$82.50; nonmembers, \$110; 978-0-78-441363-0.

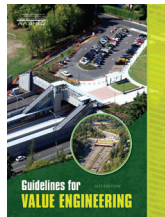
Microtunneling has become widely accepted for pipeline construction, and this standard takes into account advances in technology and construction practices in covering the planning, design, materials, and construction for trenchless installations.



### **Guidelines for Value Engineering, 4th Edition**

American Association of State Highway and Transportation Officials (AASHTO), 2017; 38 pp.; AASHTO members, \$15; nonmembers, \$20; 978-1-56051-679-8.

This single-user PDF download assists state departments of transportation (DOTs) in developing successful value engineering programs that offer maximum flexibility.



### **Urban Street Stormwater Guide**

National Association of City Transportation Officials. Island Press, 2017; 168 pp.; hardcover, \$45; e-book, \$44.99; 978-1-61091-812-1.

This volume provides design guidance for innovative green stormwater infrastructure to support the health of urban areas. Successful strategies, implemented by multiple states, are examined in text, diagrams, and photographs.

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

## TRB PUBLICATIONS

### **Socioeconomics, Sustainability, Health, and Human Factors**

Transportation Research Record 2605

Among the topics explored in this volume are livable streets, equity of bikeway distribution, transportation policy at the ballot box, and revamping tribal road networks.

2017. *Subscriber categories: society, economics, policy.* For more information, visit <http://trjournalonline.trb.org/toc/trr/2017/2605/+>.

### **Revenue, Finance, Pricing, and Economics**

Transportation Research Record 2606

The 15 papers in this record examine aspects of the economics of transportation and infrastructure: road pricing, variable congestion charges, dynamic tolls, original revenue sourcing, and more.

2017. *Subscriber categories: finance, policy.* For more information, visit <http://trjournalonline.trb.org/toc/trr/2017/2606/+>.

### **Railroads, Volumes 1–2**

Transportation Research Records 2607 and 2608

Railway ballast permeability and cleaning, track

support measurements for improved resiliency of railway infrastructure, the role of automation, locomotive voice and video recorders, crash frequencies and analysis of crash injury severity, and ridership forecasting are among the topics presented in these volumes.

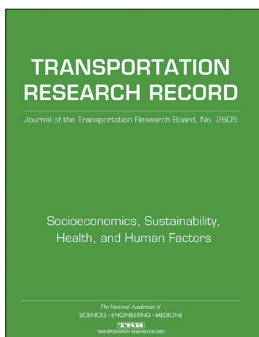
2017. *Subscriber category: railroads.* For more information, visit <http://trjournalonline.trb.org/toc/trr/2017/2607/+> and <http://trjournalonline.trb.org/toc/trr/2017/2608/+>.

### **Freight Systems, Volumes 1–2**

Transportation Research Records 2609 and 2610

Authors present research on logistics chain modeling for urban freight, key factors in urban pickup and delivery of goods, spatial analysis of warehouses and distribution centers in Southern California, and other topics.

2017. *Subscriber categories: Vol. 1, terminals and facilities, motor carriers; Vols. 1–2: freight transportation.* For more information, visit <http://trjournalonline.trb.org/toc/trr/2017/2609/+> and <http://trjournalonline.trb.org/toc/trr/2017/2610/+>.



**TRB PUBLICATIONS** *(continued)***Marine Transportation and International Trade**  
Transportation Research Record 2611

The impacts of free trade agreements on domestic transportation gateways, corridors, and ports; a Chilean maritime highway; and an underkeel clearance reliability model for dredged navigation channels are among the topics explored in this volume.

2017. *Subscriber categories: marine transportation, freight transportation, safety and human factors.* For more information, visit <http://trrjournalonline.trb.org/toc/trr/2017/2611/+>.

**Maintenance and Preservation**

## Transportation Research Record 2612

Authors present research on addressing raveling resistance in chip seal specifications, modeling long-term highway staffing requirements for state transportation agencies, the use of unmanned aircraft systems for bridge inspections, and more.

2017. *Subscriber categories: maintenance and preservation, pavements, bridges and other structures.* For more information, visit <http://trrjournalonline.trb.org/toc/trr/2017/2612/+>.

**Maintenance Services, Transportation Weather, and Winter Maintenance**

## Transportation Research Record 2613

Subjects explored in this volume include the use of calorimetry to measure ice-melting capacity, snow removal performance metrics, and the use of snow fences to reduce the impacts of snowdrifts on highways.

2017. *Subscriber category: maintenance and preservation.* For more information, visit <http://trrjournalonline.trb.org/toc/trr/2017/2613/+>.

**Research and Education**

## Transportation Research Record 2614

Research- and education-related topics include trends in transportation research, student proposals for riverfront access in Northern Virginia, and the use of the TRB Research Needs Statements Database.

2017. *Subscriber categories: research about research, administration and management, education and training.* For more information, visit <http://trrjournalonline.trb.org/toc/trr/2017/2614/+>.

**Highway Capacity and Quality of Service**

## Transportation Research Record 2615

Research related to highways—connected vehicles, driver-assistive truck platooning, and work zones—is explored in this volume.

2017. *Subscriber category: operations and traffic management.* For more information, visit <http://trrjournalonline.trb.org/toc/trr/2017/2615/+>.

[trrjournalonline.trb.org/toc/trr/2017/2615/+](http://trrjournalonline.trb.org/toc/trr/2017/2615/+).

**Freeway Operations; Regional Systems Management and Operations; Managed Lanes**  
Transportation Research Record 2616

Speed, geometric factors, ramp metering, the effect of rain, and active traffic management systems on American freeways are some of the topics explored in this volume.

2017. *Subscriber categories: operations, safety.* For more information, visit <http://trrjournalonline.trb.org/toc/trr/2017/2616/+>.

**Visibility and Work Zone Traffic Control**

## Transportation Research Record 2617

Authors present research on topics including pilot vehicles, traffic and message signs, and calibration of digital cameras.

2017. *Subscriber categories: operations and traffic management, safety and human factors.* For more information, visit <http://trrjournalonline.trb.org/toc/trr/2017/2617/+>.

**Operational Effects of Geometrics and Access Management**

## Transportation Research Record 2618

This volume comprises nine papers that explore geometric issues such as diverging diamond interchanges and J-turns, as well as such access management issues as wrong-way crashes and ramp curves.

2017. *Subscriber categories: operations and traffic management, design.* For more information, visit <http://trrjournalonline.trb.org/toc/trr/2017/2618/+>.

**Traffic Signal Systems, Volumes 1–2**

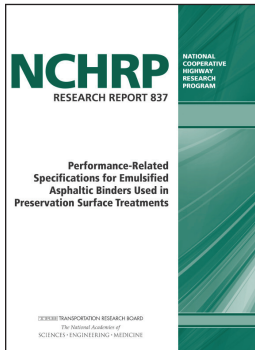
## Transportation Research Records 2619–2620

These volumes explore such traffic signal issues as coordination with connected vehicles, transit priority signal phasing, and cybervulnerability.

2017. *Subscriber categories: Vol. 1, operations and traffic management, safety and human factors; Vol. 2, operations and traffic management.* For more information, visit <http://trrjournalonline.trb.org/toc/trr/2017/2619/+> and <http://trrjournalonline.trb.org/toc/trr/2017/2620/+>.

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](http://www.TRB.org/TRROnline).

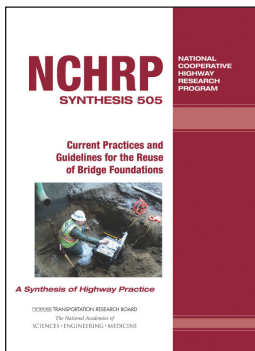
## TRB PUBLICATIONS (continued)

**Intelligent Transport Systems**

Transportation Research Record 2621

Rear-end collision warning systems, infrastructure-to-vehicle communications, in-car advice, and global navigation satellite systems are among the intelligent transportation systems topics examined in this volume.

2017. *Subscriber category: operations and traffic management.* For more information, visit <http://trjournalonline.trb.org/toc/trr/2017/2621/+>.

**Traffic Flow Theory and Characteristics, Volumes 1–2**

Transportation Research Records 2622–2623

Authors present research on pedestrian crowd dynamics at merging sections, mechanics-based acceleration modeling of multilane traffic flow, the transferability of car-following models between driving simulator and field traffic, a platooning strategy for connected and autonomous vehicles, and more.

2017. *Subscriber categories: operations and traffic management, planning and forecasting.* For more information, visit <http://trjournalonline.trb.org/toc/trr/2017/2622/+> and <http://trjournalonline.trb.org/toc/trr/2017/2623/+>.

**Traffic Control Devices**

Transportation Research Record 2624

The papers in this volume assess the legibility of highway sign fonts, driver accuracy in logo identification, effectiveness of elongated pavement marking signs, and more.

2017. *Subscriber categories: operations and traffic management, safety and human factors.* For more information, visit <http://trjournalonline.trb.org/toc/trr/2017/2624/+>.

**Performance-Related Specifications for Emulsified Asphaltic Binders Used in Preservation Surface Treatments**

NCHRP Research Report 837

This report presents emulsion performance grade specifications for asphalt emulsions used in chip seal, microsurfacing, and spray seals. The specifications are climate-driven and are applicable to anticipated traffic loads. Also presented are suggested test protocols for evaluating binder properties.

2017; 114 pp.; TRB affiliates, \$52.50; nonaffiliates, \$70. *Subscriber categories: maintenance and preserva-*

*tion, materials.*

**Guidelines for Optimizing the Risk and Cost of Materials QA Programs**

NCHRP Research Report 838

This volume offers a methodology for establishing a quality assurance (QA) program that optimizes risk and cost by providing types, levels, and frequencies of agency testing and inspection.

2017; 210 pp.; TRB affiliates, \$65.25; nonaffiliates, \$87. *Subscriber categories: construction, materials, safety and human factors.*

**A Performance-Based Highway Geometric Design Process**

NCHRP Research Report 839

This report reviews the evolution of highway design, presents key principles for design challenges, and provides suggestions for a new highway geometric design process.

2017; 278 pp.; TRB affiliates, \$69; nonaffiliates, \$92. *Subscriber category: design.*

**A Watershed Approach to Mitigating Stormwater Impacts**

NCHRP Research Report 840

Provided is a practical decision-making framework that enables state DOTs to identify and implement off-site water quality solutions for stormwater impacts when on-site treatment and mitigation are not possible.

2017; 128 pp.; TRB affiliates, \$52.50; nonaffiliates, \$70. *Subscriber categories: highways, environment, hydraulics and hydrology.*

**Development of Crash Modification Factors for Uncontrolled Pedestrian Crossing Treatments**

NCHRP Research Report 841

This report quantifies the safety benefits of four types of pedestrian crossing treatments and presents a crash modification factor for each treatment type.

2017; 162 pp.; TRB affiliates, \$55.50; nonaffiliates, \$74. *Subscriber categories: highways, design, operations and traffic management.*

**Current Practices and Guidelines for the Reuse of Bridge Foundations**

NCHRP Synthesis 505

Information is presented on reusing bridge foundations—current practices, time and cost savings, environmental benefits, and significant challenges.

2017; 107 pp.; TRB affiliates, \$52.50; nonaffiliates, \$70. *Subscriber categories: bridges and other structures,*

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## TRB PUBLICATIONS (continued)

maintenance and preservation, construction, highways, geotechnology.

### **Effective Utility Coordination: Application of Research and Current Practices**

NCHRP Synthesis 506

This synthesis documents the core elements of effective utility coordination, current practices to manage consultant-led utility coordination, and current practices to perform in-house utility coordination, as reported by state transportation agencies.

2017; 62 pp.; TRB affiliates, \$42.75; nonaffiliates, \$57. Subscriber categories: design, finance, highways, safety and human factors.

### **Traffic Signal Preemption at Intersections Near Highway–Rail Grade Crossings**

NCHRP Synthesis 507

This volume explores practices related to traffic signal preemption, maintenance, funding, and operations.

2017; 76 pp.; TRB affiliates, \$48; TRB nonaffiliates, \$64. Subscriber categories: highways, operations and traffic management.

### **Data Management and Governance Practices**

NCHRP Synthesis 508

This synthesis explores the ways that agencies access, manage, use, and share data.

2017; 53 pp.; TRB affiliates, \$37.50; nonaffiliates, \$50. Subscriber categories: administration and management, data and information technology, highways.

### **Highway Worker Safety**

NCHRP Synthesis 509

Identified in this synthesis are the ways in which state DOTs use highway worker safety and health data to reduce injuries and manage risk in policy implementation.

2017; 149 pp.; TRB affiliates, \$59.25; nonaffiliates, \$79. Subscriber categories: administration and management, education and training, highways, safety and human factors.

### **Guidebook for Developing Ramp Control Facilities**

ACRP Research Report 167

This guidebook on ramp control facilities is accompanied by an online support tool to help users address considerations such as facility requirements, staffing, training, and technology.

2018; 104 pp.; TRB affiliates, \$50.25; nonaffiliates, \$67. Subscriber category: aviation.

### **Runway Protection Zones Risk Assessment Tool Users' Guide**

ACRP Research Report 168

Although runway protection zones (RPZ) are supposed to be clear of structures and people, activities commonly occur outside the control of the airport operator. This guide and accompanying online tool help airport operators evaluate the risks of an aircraft accident within an RPZ.

2016; 78 pp.; TRB affiliates, \$45.75; nonaffiliates, \$61. Subscriber categories: aviation, planning and forecasting.

### **Clean Water Act Requirements for Airports**

ACRP Research Report 169

This report describes the environmental regulations and permitting programs for airports regarding stormwater discharge, sewer systems, wastewater treatment, and more.

2017; 40 pp.; TRB affiliates, \$36; nonaffiliates, \$48. Subscriber categories: aviation, environment.

### **Guidebook for Preparing Public Notification Programs at Airports**

ACRP Research Report 170

Standards and practices are presented to help airports develop and implement customized programs for delivering routine and incident- and emergency-related notifications to the public.

2017; 160 pp.; TRB affiliates, \$55.50; nonaffiliates, \$74. Subscriber categories: aviation, safety and human factors, security and emergencies.

### **Establishing a Coordinated Local Family Assistance Program for Airports**

ACRP Research Report 171

Federal requirements, key terminology, and the history of the Aviation Disaster Family Assistance Act, as well as a strategic plan for assisting victims of aviation disasters, are covered in this report.

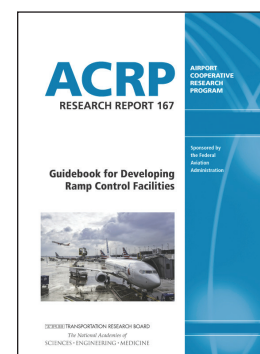
2017; 156 pp.; TRB affiliates, \$55.50; nonaffiliates, \$74. Subscriber categories: aviation, operations and traffic management, safety and human factors.

### **Guidebook for Considering Life-Cycle Costs in Airport Asset Procurement**

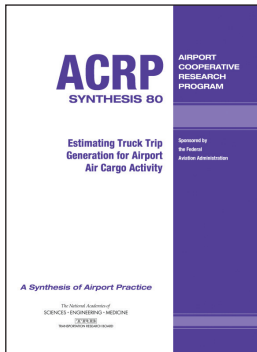
ACRP Research Report 172

This volume explores how other industries use the total cost of ownership (TCO) approach for initial procurement and how airports can integrate TCO into procurement practices. A TCO Tool and five videos on its use accompany.

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## TRB PUBLICATIONS (continued)

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ACRP Research Report 173

This report examines the environmental and health impacts of per- and polyfluoroalkyl substances (PFASs) typically found in aqueous film-forming foams (AFFFs). Methods of identification and remediation are described.

2017; 222 pp.; TRB affiliates, \$65.25; nonaffiliates, \$87. Subscriber categories: aviation, environment.

**Green Stormwater Infrastructure, Volumes 1–2**

ACRP Research Report 174

These volumes, a primer and guidebook, define and discuss management strategies for green stormwater infrastructure. The primer is written for airport managers, planners, and engineers and the guidebook for airport staff.

2017; 166 pp.; TRB affiliates, \$59.25; nonaffiliates, \$79. Subscriber categories: aviation, environment.

**Guidance for Usage of Permeable Pavement at Airports**

ACRP Research Report 178

Presented in this report is guidance on the advantages and disadvantages of permeable pavement at airports, including potential locations for installation, environmental considerations, and a matrix to determine applicability.

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**Estimating Truck Trip Generation for Airport Air Cargo Activity**

ACRP Synthesis 80

This synthesis compiles literature and research on the generation of truck trips related to air cargo, for use in community planning and investing, as well as in air cargo operations and airport management.

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**Food and Beverage and Retail Operators: The Costs of Doing Business at Airports**

ACRP Synthesis 81

This synthesis offers a compilation of the communication practices of airports to improve the communication of cost data to retail and concessions operators and to facilitate better understanding and forecasting of operating costs.

2017; 120 pp.; TRB affiliates, \$52.50; nonaffiliates, \$70. Subscriber categories: aviation, finance.

**Uses of Social Media to Inform Operational Response and Recovery During an Airport Emergency**

ACRP Synthesis 82

Airports glean information and intelligence from social media posts and messages and apply this information to enhance situational awareness and resource allocation decisions by emergency managers. Such uses raise the stakes for timely data extraction and validation of results.

2017; 100 pp.; TRB affiliates, \$48; nonaffiliates, \$64. Subscriber categories: aviation, data and information technology, security and emergencies.

**Preparing Airports for Communicable Diseases on Arriving Flights**

ACRP Synthesis 83

This synthesis examines current disease preparedness and response practices at U.S. and Canadian airports in coordination with public health officers and partners. Preparedness and response lessons are widely transferable to all sizes of airports as well as to local public health officers.

2017; 94 pp.; TRB affiliates, \$50.25; nonaffiliates, \$67. Subscriber categories: aviation, security and emergencies, society.

**Transportation Network Companies: Challenges and Opportunities for Airport Operators**

ACRP Synthesis 84

Presented in this synthesis are experiences and effective practices by airports in facilitating customer access to transportation network companies (TNCs) like Uber and Lyft, the amount of revenue airports receive from TNCs, and how TNCs are affecting airport operations and other businesses.

2017; 72 pp.; TRB affiliates, \$45.75; nonaffiliates, \$61. Subscriber categories: aviation, public transportation.

**Alternative Fuels in Airport Fleets**

ACRP Synthesis 85

Although most transportation fuels are consumed by aircraft, the use of alternative fuels in airport fleets is one opportunity airports have to control emission, fuel costs, and maintenance. This volume includes information on eight alternative fuels: biodiesel, renewable diesel, compressed natural gas, renewable natural gas, liquefied natural gas, liquefied petroleum gas, hydrogen, and electricity.

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

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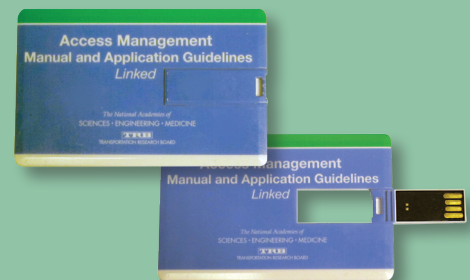
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