TR NEWS
January–February 2023 NUMBER 343

Electric Bicycles

Evolution, Research, and the Move Forward

PLUS

In Pursuit of Equity

Lighting Rural Intersections

RESEARCH PAYS OFF

Damping Vibrations in Traffic Signal Mast Poles

NATIONAL ACADEMIES Sciences Engineering Medicine

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NATIONAL ACADEMIES *Sciences Engineering Medicine*

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* Membership as of February 2023.

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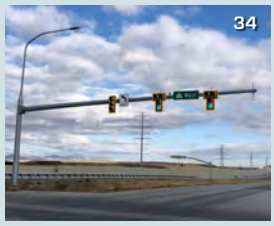

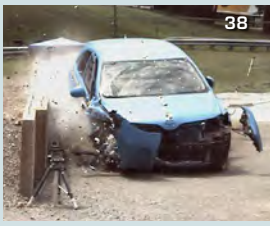

COVER Electric bicycles line up curbside in Madrid, Spain, where—as in cities and suburban areas around the globe—they are meeting a demand for micromobility options. The public mindset changed during the COVID-19 pandemic, which led to a surge in electric bike share programs and advances in e-bikes. (Alamy)

Coming Next Issue

In the March–April 2023 issue of *TR News*, one author gives an account of the challenges—and peculiarities—the height of the COVID-19 pandemic presented while conducting research on the effects of roadside mowing on insect pollination. Another author examines how the move toward cashless fare collection impacts transit agencies. And transportation professionals gathered in Washington, DC, for the 102nd TRB Annual Meeting. Read the highlights and much more.

Master pollinators, bees are not alone in moving grains of pollen from the male anther of a flower to the female stigma. Bats, birds, and other creatures also do their part. However, research throughout New York State is looking at how mowing their roadside habitat affects pollinators.

Nel Botha, Pixabay

ALSO IN THIS ISSUE

TRB COVID-19 Resources

Agencies and organizations can use TRB publications and online resources for useful and timely information to help address issues related to the COVID-19 pandemic. To read about TRB's current research and activities, and for a list of relevant publications, visit www.nationalacademies.org/trb/blog/transportation-in-the-face-of-communicable-disease.

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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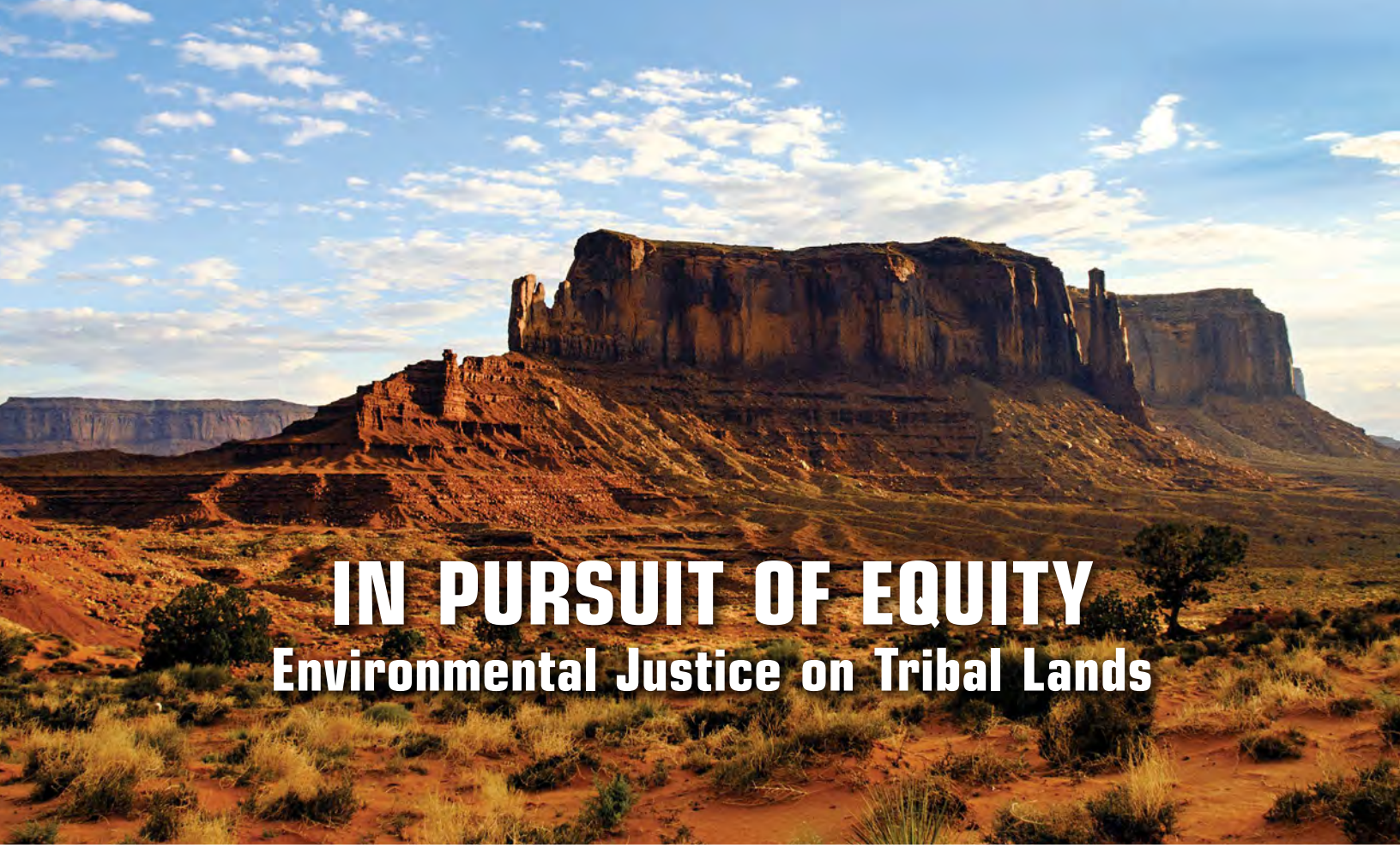


IN PURSUIT OF EQUITY

Environmental Justice on Tribal Lands

Pedro Szekely, Flickr, CC BY-SA 2.0

MARC BRENMAN

The author is a managing partner at IDARE, LLC, in Baltimore, Maryland, and former executive director of the Washington State Human Rights Commission in Olympia.

Known for its scenic vistas, Monument Valley in the Navajo Nation on the Utah–Arizona border contains nitrate, sulfate, and uranium contaminants of concern in groundwater. Tribal land has withstood a disproportionate amount of mining or other industrial operations, as well as lingering pollution caused by such land use, but recent legislation paves the way to fairness.

Environmental justice and Native American transportation issues intersect in ways that vary by transportation mode and geographic location and are addressed at different levels of government and by different stakeholders. These challenges make it difficult to ensure that the rights and needs of the tribes are addressed in an ethical way and in accordance with state and federal laws. Adding to the challenges are the number of officially recognized Native American tribes and communities—more than 574—spread out across the United States. There are also tribes recognized by states but not recognized by the federal government.

Environmental justice is the confluence of environmental and civil rights law. It concerns preventing and avoiding adverse environmental and health impacts on people of color and those who live in low-income communities. The environmental justice movement encompasses

- Civil rights and environmental racism;
- The environmental health movement;
- Native American struggles for land, sovereignty, and cultural survival; and
- The labor movement for a safer workplace.

Those professionals involved in environmental justice include legal and scientific environmentalists, as well as academics who have begun investigating the disproportionate contamination of certain communities based on race and class. Environmental justice is important to tribes because every organization that receives federal financial assistance is supposed to pay attention to environmental justice to avoid, prevent, eliminate, or reduce the adverse effects of their activities on protected people. Tribes interact with many federal and state agencies, including transportation departments and the components of the U.S. Department of Transportation (U.S. DOT)—all of

which commonly are referred to as operating administrations. Tribes, like other government entities, depend upon transportation infrastructure—especially roads—for social and economic mobility, goods delivery, and ready movement of customers to tribal revenue resources such as casinos, hotels, and resort areas. For this reason, it is important to understand where and how environmental justice concerns in tribal transportation are addressed administratively.

Federal Orders

Executive Order 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations (59 FR 7629, February 16, 1994) requires federal agencies to identify disproportionately high and adverse human health or environmental effects on minority and low-income populations that may result from federal programs, policies, and activities. Federal agencies must take action to address, reduce, and eliminate such disparities. Some population groups experience higher levels of risk than the general population. Multiple factors, including social, psychosocial, economic, physical, chemical, and biological determinants, may contribute to disproportionately high and adverse human health or environmental impacts.

The U.S. DOT's Environmental Justice Order 5610.2B, Department of Transportation Actions to Address Environmental Justice in Minority Populations and Low-Income Populations, specifically includes coverage of Native Americans and some Native American concerns, including consumption patterns. The U.S. DOT has issued a Tribal Consultation Plan[1] that also covers Alaska Native communities. Tribal consultation is not the same as public involvement. Tribal governments must be formally notified of agency actions and proposals. It is appropriate for tribal governments to be afforded the same courtesies and opportunities for participation and review that are given to other governments.

[1] View at https://www.transportation.gov/sites/dot.gov/files/docs/DOT_Tribal_Consultation_Plan.pdf.

The U.S. DOT order suggests that tribal representation should be sought in traditional public outreach efforts, such as meetings, negotiations, rulemaking efforts, advisory committees, and focus groups. U.S. DOT and state transportation officials are bound by federal law to recognize the rights of tribal governments to represent their interests as governments.

State DOT Environmental Justice Practices

Some states also have enacted environmental justice practices. For example, the writing of one of Michigan's environmental justice policies included tribal representatives. The goal of Michigan's Tribal Consultation Policy is to strengthen the consultation, communication, coordination, and collaboration between tribal governments and the State of Michigan.[2] Michigan also has a government-to-government accord with the 12 federally recognized Indian tribes in Michigan.[3] This accord serves as an acknowledgment by the state of each tribes' sovereignty and right to self-governance and self-determination. The accord also is a commitment by the state to use a process of consultation with the tribes to minimize and avoid disputes. The California Department of Transportation has an Environmental Justice Grant Program that promotes the involvement of low-income communities, minority communities, and tribal governments in planning transportation projects.

Other Legal Foundations

The National Environmental Policy Act (NEPA) and Title 23 of the United States Code, Section 109(h) require that social, economic, and environmental consequences of programs be considered when contemplating any action having federal financial support.

Title VI of the Civil Rights Act of 1964 applies to all planning and project development programs, policies, and activities. Environmental justice should be considered in project-development decisions, whether they are processed with environmental impact statements, environmental assessments, categorical exclusions, or records of decision. These are all elements of the transportation planning process. Potential impacts to the human environment should drive a decision as much as potential impacts to the natural environment.

The scoping stage of the NEPA process is the appropriate time to consider Title VI and environmental justice. It is preferable to identify minority and low-income populations as early as possible and to examine and address their concerns during planning. Because the nondiscrimination requirements of Title VI extend to all programs and activities of state DOTs and their respective subrecipients and contractors, environmental justice concepts apply to all state projects, including those that do not involve federal aid funds.

Under federal transportation law, metropolitan planning organizations (MPOs) are responsible for surface transportation planning within their jurisdictions. They are obligated to represent all of the transportation stakeholders in a region, and they cover most of the populated regions of the United States. While some MPOs have successfully integrated tribal participation into their planning processes, others have assumed—incorrectly—that tribal involvement is primarily a federal concern. MPOs need the active participation of both individuals and tribal governments to identify and address the transportation needs of Native Americans. This early involvement will help avoid costly delays and controversies later in the transportation planning and building process.

Environmental Justice Issues of Particular Concern on Tribal Lands

There are specific issues of concern to tribes that involve—either directly or indirectly—transportation and the development of natural resources. These issues involve tensions between the federal regulations and policies designed to protect

[2] See https://www.michigan.gov/egle/about/organization/environmental-justice/tribal-relations.
[3] Read at https://www.michigan.gov/egle/-/media/Project/Websites/SOM/Media/SOM-Government—Tribal-Government/2002-Government-to-Government-Accord.pdf.

the tribes and preservation of tribal sovereignty. Some examples are provided in this section.

MINING OF NATURAL RESOURCES

Use of mineral resources can reveal traditional tensions among economic development, the development of mineral resources, and the need for jobs. Such tensions have been evident in long-term controversies surrounding uranium mining on Navajo Nation lands and nuclear waste storage in the Skull Valley within the Goshute Nation. Natural resources are a transportation issue because the material must be transported by pipeline, truck, or rail—all of which are regulated by U.S. DOT.

A case in the early stages concerns a rail line in Utah's Uinta Basin and the project's impacts on the Ute Indian Tribe.[4] The Surface Transportation Board approved the proposal in 2021. As part of the final environmental impact statement, the Board's Office of Environmental Analysis considered alternatives to the project as required by NEPA. The Office of Environmental Analysis identified an alternative for the rail line to avoid or minimize major environmental impacts and recommended additional environmental conditions to address environmental justice concerns posed by the rail line. The line would run through the region where the tribe lives, and the petitioners argued that the tribe would be disproportionately and directly harmed by the greenhouse gas emissions in the region due to the construction of the rail line. The Seven County Infrastructure Coalition was seeking board authority to construct and operate this proposed rail line, which would extend approximately 85 miles from two terminus points in the Uinta Basin near South Myton Bench and Leland Bench to an existing Union Pacific Railroad Company rail line near Kyune, Utah. The Office of Environmental Analysis conducted a literature review of previous studies, books, and other materials regarding the ethnography of the Ute Indian Tribe of the Uintah and Ouray Reservation and analyzed each document for information relating to the Uinta Basin. Based on government-to-government consultation between the Office of Environmental Analysis and the Ute Indian Tribe, sensitive tribal cultural resources were found outside the project footprint. Examples include the Pariette cactus and the Uinta Basin hookless cactus (both rare and threatened by human activity), historic properties, and archeological sites. To protect tribal confidentiality, the Office of Environmental Analysis did not report the number, locations, or characteristics of these resources.

This case serves as a reminder that companies and investors involved in natural resources (such as oil and gas) and transportation projects should be aware of—and budget for—the potential for citizen suits focused on environmental justice issues. To avoid the expense and delays of such suits, it is to the advantage of all parties to plan and consider these issues in advance.

Grant Young, U.S. Fish and Wildlife Service

This Uinta Basin hookless cactus is a threatened species. Similarly, the only Pariette cactus in the world is found nearby. Both can survive on a mere 6 to 9 inches of annual precipitation but non-native cactus hunters may cause their extinction. As oil- and gas-related roads are constructed through their habitat, illegal collection rates have increased.

TRANSPORTATION OF HAZARDOUS MATERIALS VIA PIPELINE

Pipelines are regulated by U.S. DOT and increasingly carry hazardous materials, such as tar sands oil. Although pipelines are a relatively safe means of transportation, they are subject to aging and spills. For thousands of miles, they pass through Indian Country. All transportation facilities and infrastructure are potentially liable to terrorism but—due to their length and location—pipelines are relatively unprotected, especially if they are above ground. When spills occur, they can contaminate land and water and create downstream problems that flow into Indian Country.

ADEQUATE ACCESS TO HEALTH CARE

Inadequate transportation infrastructure makes it difficult for tribal community residents to travel to hospitals, stores, schools, and employment centers. Tribal roads and bridges are often in such disrepair that children cannot attend school, sick and injured people are prevented from reaching hospitals or other health care providers, and emergency responders are delayed in providing timely assistance to people in need. The poor condition of roads, bridges, and transit systems jeopardizes the health, safety, security, and economic well-being of tribal members and the traveling public.

Evaluating Railroads of the Future through the Lens of Historical Experience

Typically, in the past, transportation planning has paid too little attention to externalities or the negative effects of transportation. When evaluating the

[4] For details, visit https://www.govinfo.gov/app/details/FR-2021-01-08/2021-00175.

effects of high-speed rail that would likely travel between major cities, sometimes crossing Indian Country but making few-to-no stops there, it makes one question what benefits—if any—will be brought to the tribes by high-speed rail.

High-speed rail is the 21st century manifestation of the transcontinental railroad. As White notes in *Railroaded: The Transcontinentals and the Making of Modern America*, the transcontinental railroads of the 19th century had severe adverse effects on many Indian tribes. Acquiring this historical land and cutting railroads through it brought European settlers and diseases, making it easy for these outsiders to slaughter the buffalo on which the tribes of the Plains Indians depended (*1*).

Today, there are more protections against taking property; however, the unfortunate history of such takings requires consideration of how future high-speed rail initiatives will avoid adverse effects on low-income communities and Indian Country, including avoiding the creation of physical barriers to integration, movement, and community cohesion. For example, in Southern California, some of the proposed high-speed rail routes run through or next to existing parks and Native American lands.

In California, the High Speed Rail Authority included environmental justice in its environmental analyses (*2*). In some transportation environmental impact analyses and environmental impact statements, environmental justice has been covered. The coverage is often uneven; in part, because the basis is environmental laws, but civil rights laws provide the actual legal protections. Environmental law generally does not prevent civil rights violations, but government transportation entities and the officials who create environmental assessments and environmental impact statements are responsible for upholding civil rights imperatives.

Technical assistance is available through federal sources such as FHWA. Under Section 106 of the National Historic Preservation Act of 1966, FHWA can help a tribe pay for certain expenses related to environmental justice.[5] When a state requests, FHWA may participate in eligible, project-specific consultation costs and expenses incurred by a tribal historic preservation officer or designated tribal representative.

California High Speed Rail Authority

California's multibillion-dollar high-speed rail project, envisioned to connect Sacramento and San Diego through hundreds of miles of land, raises environmental and economic issues.

Cumulative Risks to Community Cohesion

For tribes, multiple and cumulative risks and impacts cannot be separated from the historical legacy of land loss. Indigenous nations in the United States have lost 98.9 percent of their historical land base since European settlers began colonizing the continent. EPA has begun to explore issues of cumulative risks and impacts in the Native American context through what are sometimes called "tribal traditional lifeways." Tribal traditional lifeways include cultural resources (aquatic and terrestrial), tribal health (physical and cultural), cultural lifeways, and tribal phenology (i.e., the study of cyclic and seasonal natural phenomena, especially in relation to climate and plant and animal life). Tribes have raised concerns that EPA's programs, risk methodologies, and regulatory approaches are not sensitive to their way of life and do not give a comprehensive view of the health of the people or their environment. EPA is involved in transportation issues, in part, because of pollution.

Cumulative impact analysis can become important in a transportation context when roads either are built through the same corridors repeatedly or create new or repeated pollution and noise. Typically, cumulative impact analysis includes the following factors:

- Cumulative public health risk to an affected populace;
- Historical patterns of exposure to environmental hazards;
- Physical sensitivity of the affected populace;
- Disruption of the community structure associated with the proposed action;
- Nature and degree of the impact on the community's physical and social structure;
- Proximity of the project site to an EPA Superfund site;
- Percentage of low-income residents, people of color, and indigenous peoples;
- Percentage of children with childhood lead poisoning, asthma, or other

[5] Visit https://www.gsa.gov/real-estate/historic-preservation/historic-preservation-policy-tools/legislation-policy-and-reports/section-106-national-historic-preservation-act-of-1966.

environmentally related health problems;

- Number of air quality alert days for dangerous air quality for sensitive populations;
- Number of heavily trafficked highways and streets;
- Direct and indirect effects of the project on a given resource, ecosystem, and affected populace;
- Affected populace's capacity to accommodate additional effects of a proposed project; and
- Accumulation of similar environmental, socioeconomic, and public health effects on an affected population.

A lack of cumulative impact analysis adversely affected the African-American community in Salisbury, Maryland, where Jersey Heights, a predominantly Black residential neighborhood, would have been directly affected by a proposed US-50 bypass in the 1990s (*3*). Repeatedly, over the course of several decades, the African-American community was divided by Maryland State Highway Administration road construction.

Gray Areas: Defining Environmental Justice and the Importance of Cultural Artifacts

Any and all tribal environmental justice issues become important in an environmental process, especially when multiple cultural resources or activities are affected or potentially affected. Tribal environmental justice issues are not always well defined, since social, cultural, and spiritual components are not easily assessed and are rarely adequately considered during environmental processes. Road- and bridge-building may uncover archeological sites and artifacts that may be of significant importance to tribes. The historical and archeological sites may be well outside the present boundaries of reservations, rancherías, or Alaskan Native corporations. This can create problems for transportation planners who are focusing directly on areas with tribal jurisdiction. But from the tribal perspective, the whole

Jimmy Emerson, DVM, Flickr, CC BY-NC-ND 2.0

A hand-painted sign conveys the fight against environmental injustice on the Pine Ridge Indian Reservation in South Dakota and Nebraska. Home to the Oglala Lakota tribe, it is the poorest reservation in the United States. Repeated instances of environmental injustices since the 19th century likely contributed to today's 80 percent unemployment, a suicide rate four times the national average, and some of the shortest life expectancies of any group in the Western Hemisphere.

United States was once occupied by tribes, and there are ensuing sensitivities. Additionally, over time, the area inhabited by tribes has changed and largely decreased, and historical research may be necessary to avoid impinging on historical sites not presently occupied. This difficulty occurred when a bridge in Port Angeles, Washington, was inadvertently placed on an Indian burial ground and the site of an ancient village. A map was available in the town library that showed the site from the mid-1800s, but the contractors performing the work had not consulted it.

Generally, there are two kinds of projects where tribal participation, with an emphasis on environmental justice, is most likely to occur. Federal-level executive orders require that transportation projects conducted on Indian-owned or partially owned land should always be conducted with the direct participation of the relevant tribes. Tribal participation is also required when transportation projects have the potential to affect historic, cultural, or sacred resources on lands used by Native Americans in the past. Because all of the United States was once owned and used by tribes, transportation planners must be ready to consult with the appropriate tribal governments even when tribal historical resources are found far from any present-day tribal settlements. These issues were brought out in the recent litigation over the Dakota Access Pipeline,[6] where several tribes and many tribal members objected to the location of the pipeline even though it was not passing through a reservation. In *Standing Rock Sioux Tribe v. U.S. Army Corps of Engineers,* the court found that the Army Corps of Engineers had to engage in more consultation with the nearby tribe to ascertain and address their concerns. The court stated in part, "the Corps will have to reconsider those sections of its

[6] See the United States Court of Appeals document at https://www.cadc.uscourts.gov/internet/opinions.nsf/3FEF9DA2426A19048525866900562121/$file/20-5197-1881818.pdf.

environmental analysis upon remand by the court."[7]

Challenges

Environmental justice concerns for tribes encompass more than access to and the use of traditional cultural properties or items of cultural patrimony. It is important for federal and state transportation agencies to be knowledgeable, sensitive, and aware of the needs and heritage of tribes and to incorporate that understanding into their activities.

While the required government-to-government relationship between recognized tribes and federal, state, and local transportation entities is long-standing, some practitioners have not fully implemented these requirements. An example is the recent litigation about the Dakota Access Pipeline, where the federal courts ruled that the U.S. Army Corps of Engineers had not adequately considered tribal concerns and remanded the case for that consideration. Tribal concerns included possible downstream effects of pipeline leaks that would flow into the tribe's reservation and foul its drinking water. As sovereign governmental entities, federally recognized tribes have a range of interests that can extend to sacred sites, cultural practices, upstream effects, and traditional lands outside the borders of reservations.

Proactive tribal participation in statewide transportation planning is being successfully promoted in some states but has not been a priority in others. Examples of successes include Arizona, California, and Washington. Efforts to involve tribes in the early stages of transportation planning have sometimes been hampered by a lack of interest—sometimes on the part of agencies, sometimes on the part of tribes—knowledge, resources, or trust. Many tribes, especially smaller ones, do not have the resources or the administrative infrastructure needed to be effective partners in the transportation planning process. Programs, such as the Tribal Governance Program at Evergreen State College in Olympia, Washington, have been created to help fill this knowledge gap.

Pax Ahimsa Gethen, Wikimedia, CC BY-SA 4.0

The Dakota Access Pipeline has created concerns that groundwater could be contaminated if leaks in the pipeline occur near groundwater sources. Protests like this 2016 march before City Hall in San Francisco, California, have been held across the United States.

Even if a state has no tribal reservations within its borders or a reservation is far from a project location, there may still be historic resources—such as traditional cultural properties—associated with a tribe. It is the federal and state agencies' responsibility to identify and contact such tribes.

Steps Forward

How can tribes and other interested parties fruitfully advance these interests in the transportation aspects of environmental justice? The Biden Administration is pursuing some of these issues under its Justice40 Initiative, led by the Council on Environmental Quality. The Justice40 Initiative is a part of the administration's whole-of-government approach to advancing environmental justice. The Biden Administration has promised that 40 percent of all benefits from infrastructure investment will go to vulnerable and marginalized communities. Efforts include development of a screening tool to determine which communities are most in need of investment.

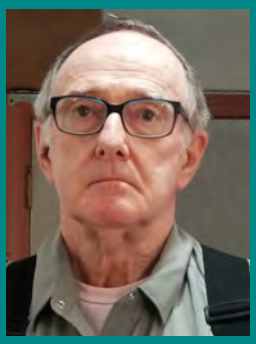
Many social justice and environmental advocacy groups now include environmental justice as part of their mission. Some advocacy organizations are pursuing a litigation strategy by filing lawsuits under NEPA. Recently, a housing advocacy group in Berkeley, California, used the California Environmental Quality Act for a housing issue involving the University of California at Berkeley. Several states have state versions of the federal NEPA and a few have explicit environmental justice protections and statutes. Interested parties can file administrative civil rights complaints alleging environmental justice discrimination under Title VI of the Civil Rights Act of 1964 with U.S. DOT, EPA, and other involved federal agencies.

Title VI covers recipients of federal financial assistance, which includes many entities in the transportation sector. Tribes can ask for involvement in transportation planning processes under executive orders and federal and state public participation directives. Research

[7] For details, see https://www.govinfo.gov/app/details/USCOURTS-dcd-1_16-cv-01534.

and tools are currently being developed by academics, advocacy groups, states, and federal agencies. These tools include EPA's EJScreen, which uses data, mapping, geographic information systems, and demographics to help determine what areas and demographic groups may be adversely affected by transportation and other infrastructure projects. These screening tools are expected to help prevent new and continued adverse impacts on vulnerable and marginalized groups. Future projects will need to address environmental justice concerns more directly and broadly than previously, plan on early community engagement, consult with legal and technical advisors, and use screening tools (such as EJScreen) to find creative, productive, and protective solutions for project approval and implementation, while meeting the needs and concerns of tribes. Major steps in this direction include transportation planners' advance knowledge of tribes in their service area, tribal contacts, and tribal concerns.

About the Author



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Nic Y-C, Unsplash

How Do Transit Agencies Use Social Media?

SUBASISH DAS

The author is an associate research scientist at the Texas A&M Transportation Institute in College Station.

During the height of the COVID-19 pandemic, transit agencies leveraged social media to communicate quickly with passengers like this rider preparing to board a train. Establishing and maintaining a rapport with customers, marketing transit services or products, boosting client satisfaction, building brand image, and getting service alerts to riders in near real-time are all possible with social media. But how do transit agencies optimize this relatively new tool?

The enormous growth of social media has made it simple to create and issue content that can instantly reach millions of people worldwide via the Internet. Social media sites like Twitter and Facebook; media-sharing sites such as Instagram, TikTok, YouTube, and Twitch; and professional networking sites like LinkedIn have ushered the world into a new era of connectivity. The profound impact of social media on the user community has motivated companies, including transit agencies, to establish a communication channel with their customers, market their services or products, boost client satisfaction, build brand image, and encourage equity. The past several years have fostered a radical shift in how transit agencies use social media platforms. Transit agencies use social media as a tool to communicate with present and potential riders while collecting passenger data and feedback. This enables a transit agency to personalize services and present their public persona as a platform of cooperation and customer-generated innovation.

Although *Transit Cooperative Research Program (TCRP) Synthesis 99: Uses of Social Media in Public Transportation* provides valuable insights, it is more than a decade old (*1*). There have been many changes in social media platforms since the publication of this synthesis—some older social media platforms shut down (e.g., Klout), and new platforms (such as TikTok, WeChat, and Telegram) have emerged. Smartphone ownership has grown rapidly during the intervening years, as well. An updated report, *TCRP Synthesis 156: Uses of Social Media in Public Transportation*, was published in 2022 to provide comprehensive understanding of existing work on recent social media use by transit agencies (*2*). This synthesis presents

- A thorough review of the existing literature on social media use by transit agencies;
- A nationwide survey to understand social media use in terms of timely

updates and crisis information, public education and awareness, public engagement, transit promotion, and support for and influence over organizational goals; and

- Case examples from diverse (size, geographic location, and use of social media) transit agencies.

This article highlights the findings in TCRP Synthesis 156 on how transit agencies use social media.

Methodology

The study agenda was designed to reveal social media use patterns by transit agencies. This work included a detailed literature review, survey design and analysis, and distinct case examples. Forty-six transit agencies (80 percent of those responding) were selected for inclusion in the synthesis based on regional location and relative size or service.

The survey questionnaire included sections on social media platforms, agency considerations, challenges and barriers, lessons learned, and future needs. This study aimed to learn about the social media structure of the agencies, by asking

- Which platforms do agencies use?
- How many hours and staff members do transit agencies invest for social media use?
- At what frequencies do agencies use social media and for what purposes?
- How do agencies measure their social media program outcomes?
- How are agency policies designed to help users and employees?

Forty-six agencies completed the survey, providing 47 complete survey responses (a social media strategist and a marketing manager from the same agency participated), and seven participated in the case examples (Figure 1).

Survey Analysis

SOCIAL MEDIA PLATFORMS

All responding transit agencies indicated some level of social media presence. According to the survey results, the following social media platforms were reported to be used frequently by the indicated percentage (rounded) of agencies:

- Facebook and Twitter (each 83 percent),
- YouTube and Instagram (each 63 percent), and
- LinkedIn (53 percent).

No agencies serving smaller urban areas and few agencies active in both rural and urban areas reported investing more than 40 hours per week in managing social media activities. However, more than 22 percent of responding large urban agencies indicated this level of management investment.

FIGURE 1 Participating transit agencies. (Source: TCRP Synthesis 156.)

AGENCY CONSIDERATIONS

Most agencies that allocate staff resources for managing social media employed their marketing staff to create and circulate posts on various social media platforms. Many agencies distributed the responsibilities for managing social media among senior management, customer service staff, administrative staff, and information technology staff. The survey, which measured how often transit agencies used social media for sharing specific information, found that transit agencies used social media to share real-time service information (such as a delay, out-of-service notice, or emergency event), general or static service information (such as information about weekly or daily schedules), and agency promotional material several times a day. There was a tendency among the agencies to match the type of content with the social media platforms used. For example, two-thirds of the respondents shared real-time service alerts only through Twitter, but frequently used Twitter and Facebook to provide other types of information such as service information, emergency alert and crisis information, agency news and projects, press releases, and statements (Table 1).

To further understand which factors or considerations determine transit agencies' social media use, this study identified a series of common goals based on the literature review and practical knowledge and asked the survey participants about each goal's importance in social media use. To compare these goals, a weighted average was calculated for the importance and effectiveness of each goal using a four-point scale (*not important/effective at all* equaled one point and *very important/very effective* equaled four points). The respondents scored the considerations according to their perspectives

TABLE 1 Type of Information Provided by Agencies via Major Social Media Platforms

Type of Information	Facebook	Twitter	YouTube	Instagram	Other
Static service information	78.7%	70.2%	8.5%	23.4%	4.3%
Real-time service information	23.4%	66.0%	0.0%	4.3%	6.4%
Emergency alert and crisis information	66.0%	70.2%	0.0%	17.0%	10.6%
Agency news and projects	76.6%	66.0%	36.2%	44.7%	21.3%
Other news	61.7%	59.6%	23.4%	40.4%	19.1%
Press releases and statements	61.7%	55.3%	2.1%	6.4%	21.3%
Agency promotion	72.3%	57.4%	42.6%	48.9%	14.9%
Feature stories	66.0%	51.1%	42.6%	55.3%	14.9%
Meeting and event notices	72.3%	59.6%	6.4%	14.9%	8.5%
Job listings	51.1%	34.0%	2.1%	10.6%	34.0%

Note: Multiple responses were allowed. Responses are expressed as a percentage of the 47 completed surveys.

on the effectiveness of achieving them through social platforms. According to the weighted scores, *communicate with current and prospective riders* ranked highest. In contrast, *recruit and keep staff* was considered least important (Figure 2).

Regarding measuring social media metrics, the survey results indicated that the 46 responding transit agencies relied on users'

- Engagement (63.8 percent), estimated by likes, comments, shares, and clicks;
- Awareness (61.7 percent), measured through impressions and reach; and
- Customer care success (38.1 percent), reflected by response rates and time.

When asked about social media policies (e.g., rules on public post contents) and employee conduct policies (such as being polite when responding to a post or a reply as an agency employee), 43 percent of the participating agencies had policies for employee conduct in action, 13 percent had an employee conduct policy in development, and 26 percent had none. Fewer agencies (21 percent) had an existing social media strategy policy. However, 28 percent of agencies reported having a social media policy in development.

Many responding agencies (64 percent) coordinated social media with their marketing and communications plan. This was expected since according to the survey, marketing staff had the responsibility of creating and circulating posts in most of the agencies. Slightly more than half of the responding agencies said that they used their social media platforms for real-time service alerts and just under half of the agencies combined real-time service alerts with service advisories.

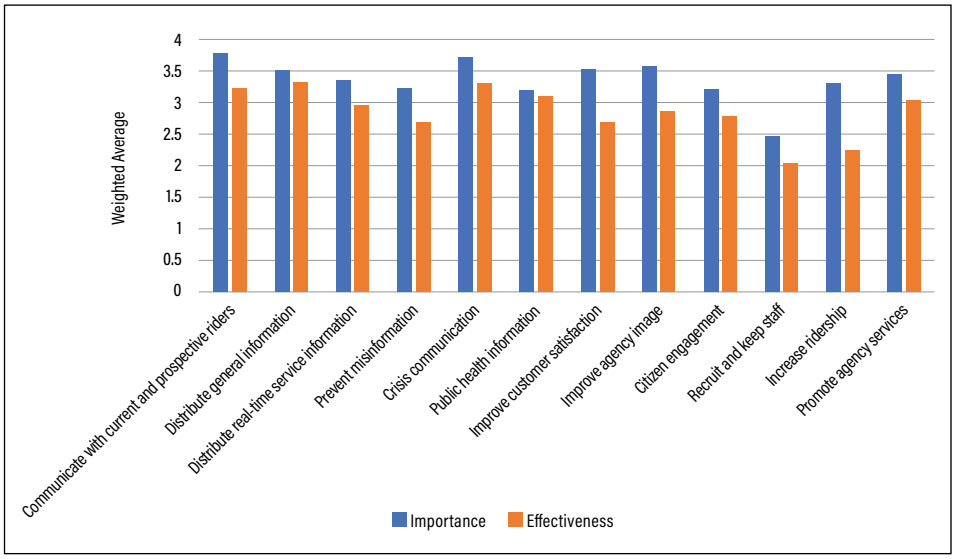

FIGURE 2 Agency goals in social media use.

SOCIAL MEDIA USE DURING THE COVID-19 PANDEMIC

Especially during the early days of COVID-19, transit agencies' social media platforms played an important role. It is anticipated that social media algorithms could help agencies handle planned and unplanned traffic events. Similar methods can be applied to use social media data to disseminate social-distancing protocols for managing public gatherings. Moreover, the survey results showed that transit agencies' social media accounts could help the agencies spread emergency news and alerts, press releases, and real-time information and prevent misinformation, which can be highly impactful during a crisis. Since this survey reflected that the COVID-19 pandemic influenced current agency goals, the type of information shared on social media platforms, and future goals, survey respondents were asked if they made any changes regarding information sharing during the COVID-19 pandemic. Nearly all (96 percent) of the respondents reported increasing their social media activity during the pandemic. To reassure their passengers, a smaller group of agencies (23 percent) shared information regarding on-site safety protocols during the

Patrick Carey, NYC Transit, Flickr, CC BY 2.0

A New York City Transit Authority worker sanitizes a public bus in June of 2020. The pandemic hit the Big Apple hard with some of the nation's highest infection and mortality rates. Images of the disinfection process reassured passengers, many of whom were essential workers.

pandemic. Some used their social media accounts to show the disinfection process, rear-door boarding, seating capacity limitations, regulations on masking, and other safety improvements. Shifting social media activities to spread awareness about COVID-19 also boosted business marketing and helped many agencies promote a positive public image.

Case Examples

After the survey was complete, seven agencies (six from the United States and one from Canada) were selected as case examples. Selection was based on the agency's size, geographic location, and use of social media. Three of the seven case examples [Bay Area Rapid Transit (BART), CapMetro, and CyRide] consisted of guided interviews with agency staff to gather further details from the survey responses. Table 2 lists the case example agencies, including their key focus areas and specific interests.

Leslee, Flickr, CC BY-NC-ND 2.0

A kiosk provides a passerby with some quick reading for the journey. Short story dispensers like this one in Boston, Massachusetts, make the trip more relaxing.

TABLE 2 Case Examples

Agency	Location	Service Area	Principal Modes	Annual Ridership in 2019	Focus Areas/Specific Interests
San Francisco Bay Area Rapid Transit (BART) District	Oakland, Calif.	Large urbanized area (population over 200,000)	Heavy rail/subway	14,990,092	• Timely updates and crisis information • Public engagement • Employee conduct policy • Social media policy • Short story dispenser
Miami–Dade Transit (MDT)	Miami, Fla.	Large urbanized area (population over 200,000)	Bus, light rail, heavy rail/subway, paratransit services	81,600,000	• Timely updates and crisis information • Public engagement • Employee conduct policy • Social media policy • Time allocation for social media posts and interactions
CyRide	Ames, Iowa	Small urbanized area (population 50,000–200,000)	Bus	4,577,482	• Public education and awareness • Disabled person mobility • Free transportation to COVID-19 vaccination site
Transit Authority of Northern Kentucky (TANK)	Fort Wright, Ky.	Small urbanized area (population 50,000–200,000)	Bus	2,482,528	• Support and influence organizational goals • Employee conduct policy • Disabled person mobility • Free transportation to COVID-19 vaccination site
Central Midlands Regional Transit Authority (the COMET)	Columbia, S.C.	Both rural and urbanized areas are served	Bus, streetcars and trolleys, vanpool, paratransit services	2,300,000	• Public engagement • Transit promotion • Time allocation for social media posts and interactions • Food delivery for nonprofit organizations
Capital Metropolitan Transportation Authority (CapMetro)	Austin, Tex.	Large urbanized area (population over 200,000)	Bus, light rail, heavy rail/subway, paratransit services	22,798,913	• Employee conduct policy • Time allocation for social media posts and interactions • Disabled person mobility
Halifax Transit	Halifax, Nova Scotia, Canada	Large urbanized area (population over 200,000)	Bus, paratransit services	30,400,000	• Timely updates and crisis information • Employee conduct policy • Social media policy

The case examples show that Twitter and Facebook were the critical social media platforms that agencies used to share information and provide customer support. Agencies occasionally preferred Twitter due to its short text format. Service alerts were the predominant type of information shared frequently by agencies.

COVID-19 significantly impacted the nature of information distribution. Being more innovative out of necessity, agencies used social media more frequently and efficiently, not only to impart service-related information but also to raise public awareness on health and safety issues. Some agencies promoted specific interests, such as short story dispensers, free rides to COVID-19 vaccine locations, and disabled rider assistance. One responding agency suggested that leadership should be engaged in social media posting to maintain the quality and consistency of content sharing. Data archiving seems difficult even for the agencies selected as case examples.

Conclusions

The global reach of popular social networking sites is astounding. Almost every business, organization, and agency curates an official identity on social media. Transit agencies are using social media to share information and understand public sentiments and attitudes about their services. TCRP Synthesis 156 gives readers a glimpse of transit agencies' most used social media practices and which platforms they trust to deliver specific types of information.

It is noteworthy that several transit agencies expressed concerns that when the social media feed is not delivered in real-time (such as in a weekly digest), it reduces the relevance and timeliness of information posted. Readers lose interest when their comments, feedback, complaints, and queries do not receive timely responses. The agencies emphasized the importance of employing a designated social media manager and spokesperson to communicate via social media effectively and efficiently. Agencies emphasized the value of hiring trained personnel with strong experience in public relations and good writing skills.

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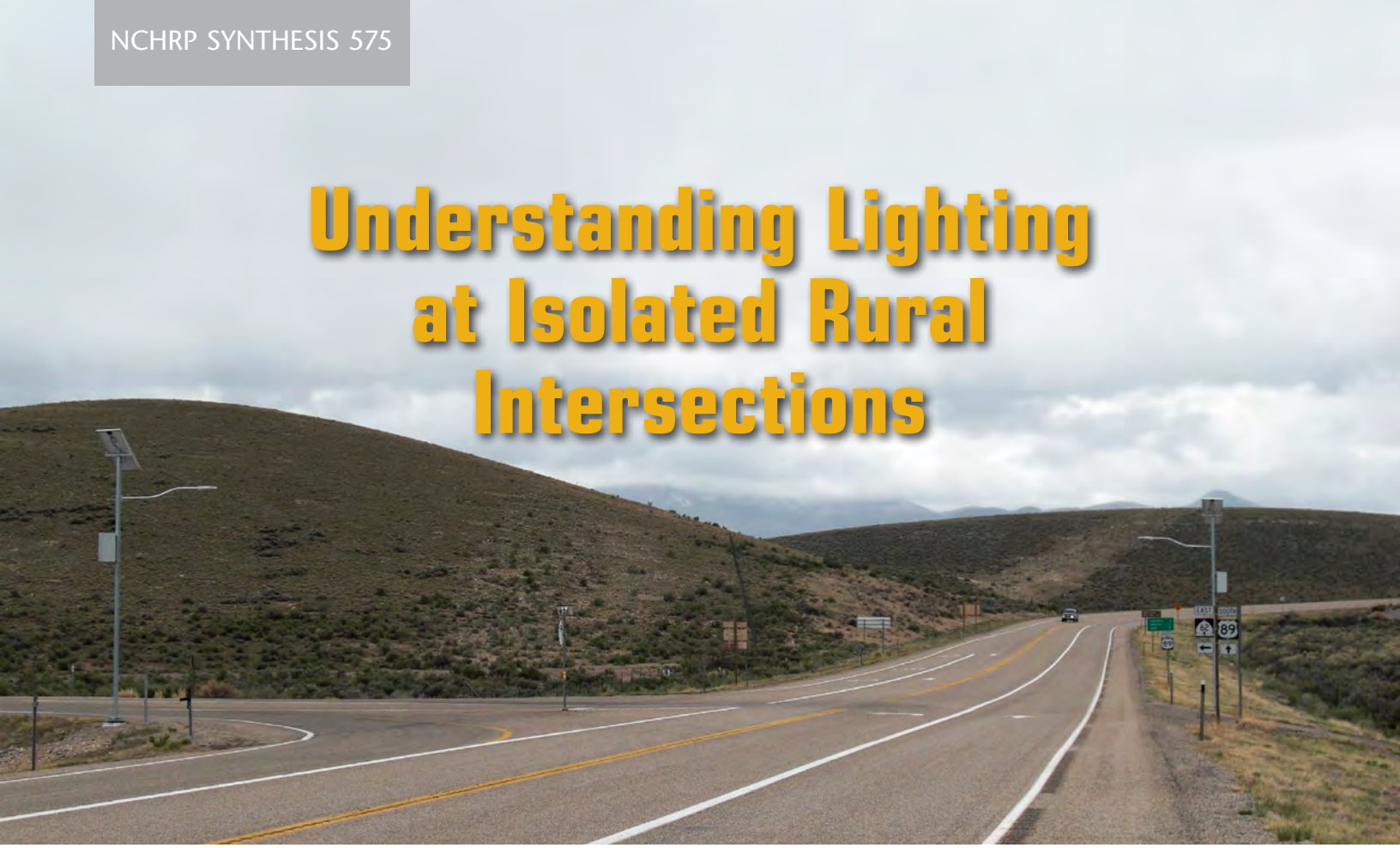
VOLUNTEER VOICES

"Looking 100 years into the future, I believe our industry will pivot away from talking in terms of *transportation* and will be fully focused on *mobility*. The word *transportation* has always implied the harder side of our business—cars, trucks, asphalt, and concrete. *Mobility* is a broad term that encompasses the softer side of our industry. Mobility focuses on the outcome—getting from Point A to Point B. Transportation is how it happens. Perhaps we will be state departments of mobility, reinvented with greater balance toward multimodal activities. Perhaps the Transportation Research Board will be the Mobility Research Board, again highlighting the broader focus on how people and things move. Our good fortune will be the rich history and knowledge base that will continue to be developed by TRB over the next century!

—DIANE GUTIERREZ-SCACCETTI
Commissioner
New Jersey Department of Transportation
Trenton

Understanding Lighting at Isolated Rural Intersections



FHWA

JOHN D. BULLOUGH

The author is a program director in Population Health Science and Policy at the Albany, New York, Light and Health Research Center, part of the Icahn School of Medicine at Mount Sinai.

Storm clouds and rolling hills shroud a lone vehicle traveling along open road. With darkness—and possible bad weather—on the horizon, effective lighting at isolated intersections can make the difference between an accident and a safe arrival.

Although only 19 percent of the U.S. population lives in rural areas, 45 percent of all U.S. roadway fatalities occur along rural roads and nearly 30 percent of all intersection-related fatalities occur in rural locations (*1*). This overrepresentation of fatalities at rural intersections has spurred interest in countermeasures for reducing crashes at these locations. Among those countermeasures is fixed, pole-mounted roadway lighting (*2*). Because roadway lighting can be a relatively expensive proposition, especially at isolated intersections where access to nearby electrical power is often absent, transportation agencies need to be able to weigh the potential benefits and costs of lighting to decide if and when it would best serve the public.

To address this need for objective information, the National Cooperative Highway Research Program (NCHRP) published *NCHRP Synthesis 575: Lighting Practices for Isolated Rural Intersections* (*3*). State departments of transportation (DOTs) across the country were interviewed, research studies and standards reviewed, and case examples of isolated rural intersection lighting and alternatives documented. The resulting synthesis provides a current state of practice for lighting at these locations. Lessons learned are summarized in this article.

When Is Lighting Warranted?

It is widely accepted that intersection lighting benefits safety, and evidence bears this out (*4*). Nonetheless, transportation agency resources are limited and not all isolated rural intersections can be lighted as a result. About 70 percent of the state DOTs surveyed for this synthesis have policies or guidance for determining where and how to implement lighting at these locations. The warranting factors identified in the review of standards and practices include traffic volume, roadway geometry, existing nighttime crash

TABLE 1 Warranting Factors for Isolated Rural Intersection Lighting and Criteria Used by State DOTs

Warranting Factor	Example Criterion
Traffic volume	High traffic volume (e.g., >3,500 vehicles/day)
Road geometry	Complex alignment
Nighttime crash frequency	High frequency (e.g., >2.4 crashes/year in 3 consecutive years)
Pedestrian activity	High pedestrian activity
Weather	Recurring nighttime fog
Signalization	Unsignalized intersections generally do not warrant lighting
Aesthetic appearance	To maintain rural character, lighting might not be installed
Request from locality	Lighting may be installed if the locality is willing to pay for it

frequency, and the level of pedestrian activity (Table 1).

Alternatives to lighting isolated rural intersections that state DOTs can consider include the following:

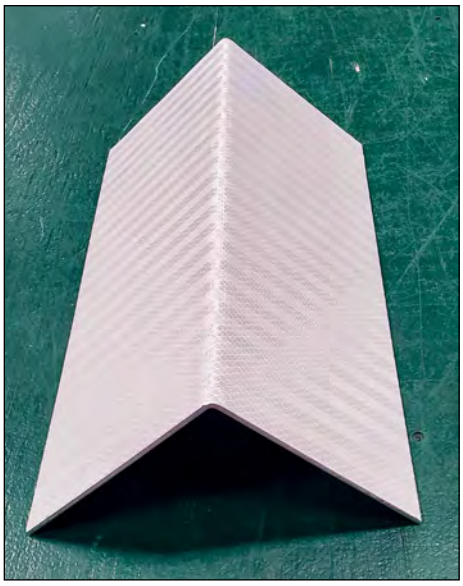
- Supplementary pavement markings,
- Rumble strips,
- Flashing light signals,
- Intersection conflict warning systems,
- Dedicated turning lanes (when there is sufficient area), and
- Signage and reflective delineation.

For instance, Maine DOT installed oversized angled delineators along a shoulder adjacent to a rural intersection (Figure 1). Drivers reported that these delineators helped when navigating through the intersection by making the geometry of the intersection and its approaches easier to see and understand.

How Is Isolated Rural Intersection Lighting Designed?

Until recently, most roadway lighting standards consulted by state DOTs—such as those from the Illuminating Engineering Society (IES) and AASHTO—only provided design criteria for continuous roadway lighting systems like those found along many urban roads and highways. Current IES and AASHTO standards provide light-level recommendations for isolated intersections found in many rural locations, but these are not always incorporated into state DOT lighting specifications.

In addition, nearly half of state DOTs sometimes install delineation, destination, or beacon lighting, in which a low-wattage fixture is erected near the conflict point of an isolated rural intersection (Figure 2). The fixture is meant to be seen by approaching drivers as a visual cue for the intersection's presence, rather than to provide useful illumination to help drivers see hazards at the intersection. Despite the logic of



Maine DOT

FIGURE 1 Maine DOT mounted these reflective panels, bent at 90 degrees to reflect light in both traffic directions, at headlight height. They provide delineation to rural intersections and provide drivers with additional visual information about the approaching roadway geometry.

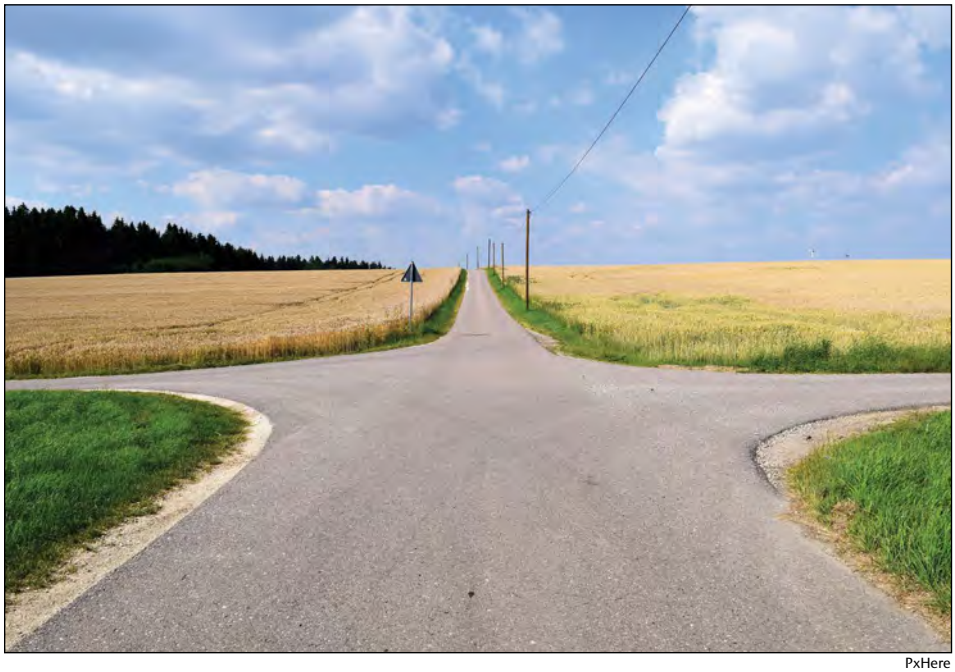


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FIGURE 2 Isolated rural intersections would be safer if illuminated by a single light fixture. This common practice in such areas not only improves safety but also minimizes light pollution and maintains rural character.

delineation lighting of this type, its benefits have not been widely investigated.

A growing concern for light pollution has resulted in two trends evident in the design of isolated rural intersection lighting. Both trends are examples of attempts to minimize glare, effects on wildlife and insects, and possible disruptions of human sleep–wake circadian cycles. First, most state DOTs specify fixtures that produce little-to-no direct upward and high-angle light, commonly called cutoff fixtures, and more recently defined by an IES system called the BUG Rating, described as follows:

- **B** = backlight directed behind a fixture, possibly toward nearby residential windows;
- **U** = upward light that can create sky glow; and
- **G** = glare produced by high-angle light from a fixture (*5*).

Second, in newer installations using light-emitting diode (LED) sources, some state DOTs are beginning to use fixtures with low correlated color temperatures of 3000 Kelvin (a warm white appearance) rather than 4000 Kelvin (neutral to cool white).

One approach to isolated rural intersection lighting that, to date, has not been widely implemented is the use of adaptive lighting control. Adaptive lighting systems use different light levels, based on expected or observed traffic activity. For example, the four busiest hours of the night carry more traffic (*6*). Using 7 p.m.–7 a.m. as "night" and 7 a.m.–7 p.m. as "day," the four busiest hours of the night were 7–8 p.m., 8–9 p.m., 9–10 p.m., and 6–7 a.m. Sixty-one percent of the night traffic occurred during those four hours and the remaining 39 percent of traffic occurred during the other eight hours.

Reducing light levels during the less busy period would have relatively minimal effects on safety but would reduce operating costs, energy use, and light pollution for much of the night. IES road lighting standards have begun to permit adaptive control, but more trials will be needed before state DOTs will become comfortable with adaptive control of lighting.

How Well Does Isolated Rural Intersection Lighting Work?

Less than a third (29 percent) of the state DOTs surveyed reported that they kept track of whether their isolated rural intersection lighting installations had beneficial effects on safety. Research studies have suggested that this type of lighting does indeed reduce nighttime crashes, although the reported crash reduction percentages vary widely from 1.5 percent (*4*) to 70 percent (*7*). Isolated rural intersections are so unique in terms of factors like pedestrian activity and geometric layout that it is difficult—if not impossible—to assign a single crash reduction percentage value to this type of lighting.

At one isolated rural intersection in Vermont, where a high number of nighttime single-vehicle crashes occurred, the Vermont Agency of Transportation installed a single LED fixture at an intersection to help prevent vehicles from running through it at night (Figure 3). The agency also added a reflective panel to the post of the stop sign at the intersection. Because the light fixture was installed in fall 2019, formal crash analyses are not yet possible. However, no nighttime crashes had occurred there as of the publication of NCHRP Synthesis 575. One issue with this project was that the intersection was not close to any electrical power lines, which doubled the lighting installation cost.

Vermont Agency of Transportation

FIGURE 3 A light fixture installed on a utility pole at a rural intersection in Vermont aims to keep everyone safe in a sparsely lit area.

Utah DOT installed solar-powered LED light fixtures—similar to the one shown in Figure 4—at several rural intersections and rail crossings to overcome the limitations of having no nearby electrical power.

Argonne National Laboratory, Flickr, CC BY-NC-SA 2.0

FIGURE 4 These hybrid solar- and wind-powered streetlights at Argonne National Laboratory in Washington, DC, are completely off the grid, with a small solar panel and wind turbine powering the LED light atop the fixture. The light can store energy in batteries for up to three days without sun or wind.

Anecdotal reports suggest that drivers were less likely to miss turns at the intersections after the lighting was installed in 2016. The photovoltaic panels providing power have worked well, but it is estimated that the batteries used to store power will need to be replaced after 10 years.

Remaining Questions

Overall, state DOT experiences suggest that isolated rural intersection lighting can be beneficial, especially when it is installed at locations with previous crash histories. However, it is not always possible to predict the safety benefits precisely. The possible incremental benefits of adaptive lighting control at rural intersections have not been investigated widely. When state DOTs were asked what information they lack that would help them make decisions about installing isolated rural intersection lighting, the most common response—by nearly 60 percent of survey respondents—was a need for information about funding sources to help pay for lighting at these locations. When it comes to rural intersection lighting, the economic challenges of budgeting will remain difficult to navigate. NCHRP Synthesis 575 is intended to help state DOTs overcome some of these challenges and improve safety at isolated rural locations.

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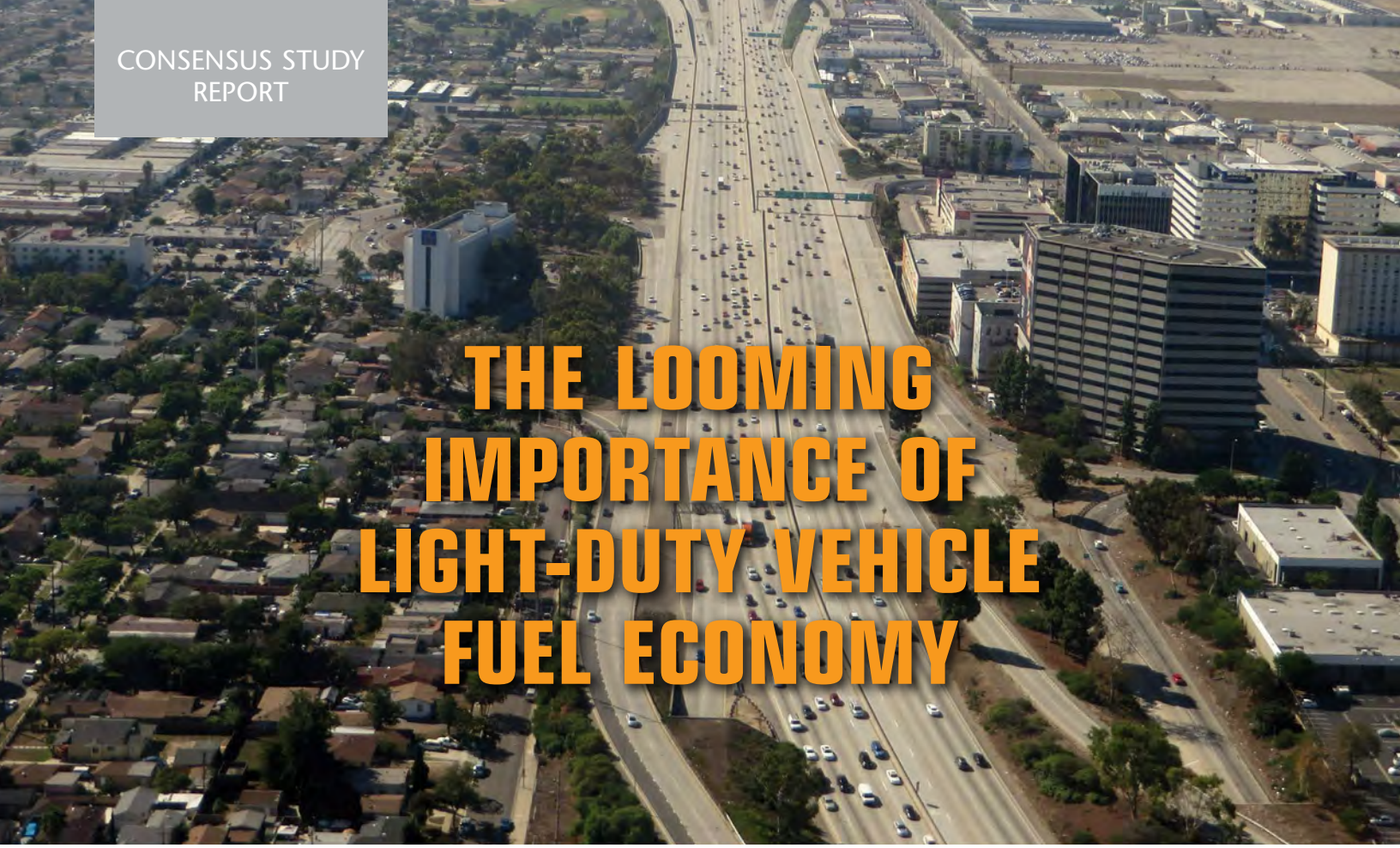
VOLUNTEER VOICES

“TRB definitely has supported my professional development and career—but my experience is different from that of most TRB members. As a transportation journalist, my schooling didn’t include any transportation courses, so TRB has been a great source of education. As a podcast host, I’ve been privileged to interview several TRB executive directors, as well as other staff. Through TRB and its Annual Meeting, I’ve been introduced to countless professionals in the transportation field. My role has also allowed me to share news and information about TRB with a wide audience.

—BERNIE WAGENBLAST
Editor, Transportation Radio
Cranford, New Jersey

CONSENSUS STUDY REPORT



THE LOOMING IMPORTANCE OF LIGHT-DUTY VEHICLE FUEL ECONOMY

Ken Lund, Flickr, CC BY-SA 2.0

ELIZABETH L. ZEITLER AND GARY E. MARCHANT

Zeitler is associate director of the Board on Energy and Environmental Systems at the National Academies of Sciences, Engineering, and Medicine in Washington, DC. Marchant is a Regents Professor of law and director of the Center for Law, Science, and Innovation at Arizona State University in Tempe.

A critical Los Angeles highway for commuters and commerce, I-405 is a major source of Southern California's air pollution, noise, and greenhouse gas emissions. Fuel economy that meets future emissions requirements requires the most efficient technologies.

The decade from 2025 through 2035 will bring fundamental changes to the cars and trucks driven, from the growing market share of electric vehicles to the deployment of automated vehicle technologies to increasingly globalized markets and a priority to reduce greenhouse gas emissions. These developments will transform how

- Automakers design, manufacture, and market vehicles;
- Businesses sell, service, and refuel them;
- Consumers buy and use their vehicles; and
- Federal, state, and local governments regulate and plan for future transportation infrastructure.

At the request of Congress and the U.S. Department of Transportation (U.S. DOT), the National Academies of Sciences, Engineering, and Medicine, through its Board on Energy and Environmental Systems[1] in the Division on Engineering and Physical Sciences[2] evaluated how internal combustion engine, hybrid, battery electric, fuel cell, non-powertrain, and connected and automated vehicle technologies could contribute to vehicle efficiency from 2025 to 2035, and the effects of these technologies for consumers, manufacturers, and vehicle regulations. The report, *Assessment of Technologies for Improving Light-Duty Vehicle Fuel Economy—2025–2035,* provides cost and effectiveness estimates for future fuel efficiency technologies and recommends updates to the current Corporate Average Fuel Economy (CAFE) standards to reflect new technical, economic, and policy developments (*1*). Key

[1] Find out more about the Board on Energy and Environmental Systems at https://www.nationalacademies.org/bees/board-on-energy-and-environmental-systems.
[2] To learn more about the Division on Engineering and Physical Sciences, visit https://www.nationalacademies.org/deps/division-on-engineering-and-physical-sciences.

report findings are in the areas of technology futures, increasing deployment of zero-emission vehicles, encouraging consumer acceptance, test cycles and life cycle emissions, and coordinating agencies and CAFE standards (Figure 1).

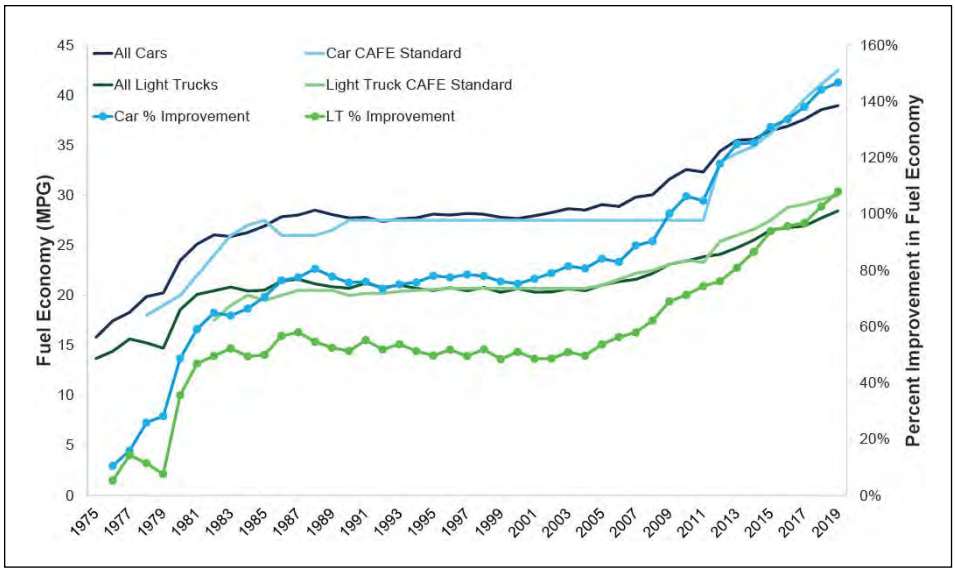


FIGURE 1 U.S. fleet fuel economy standard, achieved fuel economy in miles per gallon (MPG), and vehicle energy efficiency as percent improvement in fuel economy (LT = light truck). (Source: National Academies of Sciences, Engineering, and Medicine.)

Projecting Technology Futures

INTERNAL COMBUSTION ENGINE VEHICLES

Conventional internal combustion engine vehicles will continue to play a significant role in the new vehicle fleet from 2025 to 2035. Manufacturers will continue to develop and deploy technologies to further improve the efficiency of conventional powertrains, with the greatest potential coming from electric hybridization.

BATTERY ELECTRIC VEHICLES

Those battery electric vehicles with longer electric range (e.g., 300 miles) may reach cost parity with comparable internal combustion engine vehicles by 2030, primarily due to projected reductions in battery cost. From 2025 to 2035, lithium-ion batteries will be the dominant battery technology and highly efficient wide bandgap devices are expected to be used in power electronics. Wide bandgap devices incorporate semiconductor materials like silicon carbide and gallium nitride, which enable them to operate at higher voltages, temperatures, and frequencies, and with lower on-resistance leading to increased device efficiency.

Green Energy Futures, Flickr, CC BY-NC-SA 2.0

Battery electric vehicles are powered by electricity charged from the grid and stored in batteries on board the vehicle. Battery electric vehicle sales experienced over 80 percent growth in 2021 relative to 2020.

FUEL CELL ELECTRIC VEHICLES

A few major automakers are prioritizing fuel cell electric vehicles to take advantage of their long ranges and short refueling times relative to battery electric vehicles. Fuel cell electric vehicles could reach parity with internal combustion engine vehicles in total cost of ownership from 2025 to 2035 if aggressive efficiency and cost targets are met.

NON-POWERTRAIN TECHNOLOGIES

Continued improvement will occur in fuel economy for non-powertrain technologies through further advances in mass reduction (or decreases in vehicle weight), aerodynamics, and reducing rolling resistance. From 2025 to 2035, automakers will implement mass reduction to improve drivability and reduce fuel consumption in all vehicles, and to increase driving range in battery electric vehicles and fuel cell electric vehicles. Mass and geometric disparity in the fleet may

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The National Renewable Energy Laboratory uses solar energy to make hydrogen that powers this electric vehicle. Through its Wind to H2 Project (H2 means lower-cost hydrogen), fuel to power hydrogen fuel cell vehicles and buses is created completely from renewable energy.

increase or decrease due to electrified powertrains, new architectures, advanced driver assistance systems, and a shift from sedans to crossovers, sport utility vehicles, or pickup trucks. Improvements in crash compatibility will reduce the adverse effect of mass and geometric disparity on crash safety for all road users.

VEHICLE CONNECTIVITY AND AUTOMATION TECHNOLOGIES

These technologies could improve the fuel efficiency of internal combustion engine vehicles by up to 9 percent in city driving and up to 5 percent on the highway by detecting upcoming conditions and adjusting acceleration and powertrain operation accordingly. Fully automated light-duty vehicles will be deployed in some ride-hailing, delivery, and closed-campus fleets by 2025. More widespread adoption of automated technologies will require ensuring safety under all conditions, resolving cybersecurity issues, developing appropriate regulations, and gaining consumer acceptance of a radically different driving experience.

Increasing Deployment of Zero-Emission Vehicles

The greatest opportunity and uncertainty for light-duty vehicle energy efficiency from 2025 to 2035 will be the increasing penetration of zero-emission vehicles. The price of the vehicles, fueling infrastructure, performance attributes, and consumer interest in and comfort with the technology will be major determinants in their uptake. Automakers are predicting deployment of tens of millions of zero-emission vehicles globally during 2025 to 2035, with leading jurisdictions (e.g., California, China, and Europe) aiming to achieve 50 to 100 percent zero-emission vehicle sales by the decade 2025 to 2035. High penetration of zero-emission vehicles will involve profound changes to the vehicle fleet, charging and fueling infrastructure, business models for dealers, driver behaviors, repairs, emergency response, materials, and battery recycling.

The key recommendations of the report for increasing deployment of zero-emission vehicles included the following:

- Agencies should use all their delegated authority to drive the development and deployment of zero-emission vehicles because they represent the long-term future of energy efficiency, petroleum reduction, and greenhouse gas emissions reduction in the light-duty vehicle fleet. Vehicle efficiency standards for 2035 should be set at a level consistent with market dominance of zero-emission vehicles at that time, unless consumer acceptance presents a barrier that cannot be overcome by public policy and private-sector investment. At the same time, maximum feasible fuel economy of petroleum-fueled vehicles

Gregory Varnum, Flickr, CC BY-SA 2.0

Zero-emission vehicles are becoming increasingly available worldwide and they comprise more of the light-duty vehicle fleet. They also represent the long-term future of energy efficiency, petroleum reduction, and greenhouse gas emissions reduction in the light-duty vehicle fleet.

should be pursued. The pathway to zero emissions should be pursued so one technology is not prioritized over another.

- The U.S. federal purchase subsidies for battery electric vehicles, plug-in hybrid electric vehicles, and fuel cell electric vehicles should be continued until financial and psychological consumer barriers to purchasing such vehicles have been overcome. Examples of psychological barriers include lack of understanding of how electric vehicles work, where they can be serviced, how much electric vehicles cost to operate, and worries about how drivers will recharge their vehicle. However, they should be changed to point-of-sale rebates to increase effectiveness and lower fiscal burdens for the consumer. Income eligibility for rebates should be considered for both equity and effectiveness.
- U.S. DOT, EPA, and the Department of Energy (DOE) are advised to coordinate to facilitate electric charging and hydrogen refueling infrastructure deployment with relevant stakeholders, including state and local government agencies, business associations, and entities. Congress is advised to appropriate funds for, and the agencies should create, a national public–private partnership to lead this coordinating effort.

Encouraging Consumer Acceptance

New vehicle purchasers select vehicles with a variety of factors in mind, including fuel economy. Many consumers initially resist new technologies that disrupt current practices and lifestyles, or create novel risks or uncertainties, even if the technology provides net benefits to them. Because consumer resistance to novel technology is a significant issue in market penetration and acceptance of new technologies, the report recommended that policy interventions beyond purchase subsidies may be needed to address these barriers. Such policies may include investment in charging and refueling infrastructure, or consumer education and exposure to the new technology and its benefits.

Department of Energy, NREL, CC BY-NC 2.0

Charging stations, like this solar-powered electric station for plug-in hybrid or all-electric vehicles in Orlando, Florida, and other current charging infrastructure will be improved to meet future demand.

Test Cycles and Life Cycle Emissions

The current test procedures to determine CAFE fuel economy compliance are insufficient to test electric vehicle range and connected and automated vehicle operation, and they do not adequately reflect modern driving patterns of light-duty vehicles. Furthermore, there is no representatively sampled, empirical measure of on-road fuel consumption or greenhouse gas emissions for the U.S. light-duty fleet, but such a statistically valid and relevant dataset is increasingly possible to assemble using on board diagnostics and available customer data.

The key recommendations of the report related to test cycles and life cycle emissions include the following:

- U.S. DOT, EPA, and DOE (the agencies) are advised to conduct a study on how well current driving patterns and new vehicle technology impacts are reflected by current vehicle certification test cycles. The results of this study should then be used to propose new light-duty vehicle test cycles, or to re-adopt or revise the weighting of the existing five-cycle test.
- The agencies may implement a program that measures fuel consumption and greenhouse gas emissions from the light-duty vehicle fleet in use. The in-use program's purpose should be to evaluate and improve the CAFE program's effectiveness, not for year-by-year enforcement against individual manufacturers. Currently, vehicle manufacturers are responsible for meeting on board per-mile fuel efficiency and emissions requirements. Neither NHTSA nor EPA account for full fuel-cycle emissions or energy use to incentivize zero-emission vehicles, which have no greenhouse gas emissions at the tailpipe but some upstream emissions and energy use associated with generating electricity, hydrogen, or other zero-emissions fuels. Life cycle assessments would more fully capture total greenhouse gas emissions and energy consumption and enable easier comparison between vehicles using different fuels.
- In the longer term, it makes sense to address the full fuel-cycle emissions of all vehicles, including zero-emission vehicles, especially as they become a progressively larger portion of the light-duty vehicle fleet.

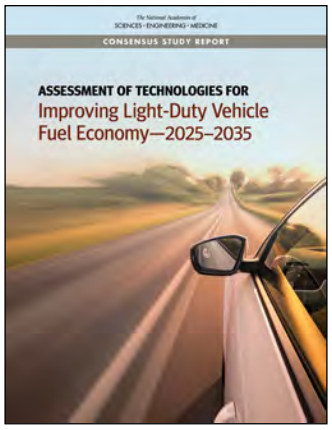
Agency Coordination and CAFE Standards

The efforts of NHTSA and EPA to coordinate their fuel economy and greenhouse gas emission standards since 2010 have been beneficial and are recommended to be continued to the extent feasible. However, separate agency standards may now diverge because of the growing availability and benefits from zero-emission vehicles and the agencies' different statutory authorities. For NHTSA to fulfill its statutory mandate of obtaining the maximum feasible improvements in fuel economy, the consensus study report recommended NHTSA consider the fuel economy benefits of zero-emission vehicles in setting future CAFE standards. The simplest way to accomplish that would be for Congress to amend the statute by deleting the prohibition against considering the fuel economy of dedicated alternative fueled vehicles when setting CAFE standards.

Rethinking Fuel Economy Regulations from 2025 to 2035 and Beyond

Given the projected changes to vehicle technology, national goals for vehicle efficiency and emissions, and other changes to the light-duty vehicle transportation system from 2025 to 2035, the existing CAFE program will need to be updated between 2025 and 2035 for legal, scientific, policy, technological, and economic reasons. When the CAFE program was adopted, its primary objective was to enhance energy security by reducing reliance on petroleum imports. Today, while energy security concerns remain relevant, addressing climate change has risen in importance, and this should be expressly recognized in the CAFE program. It is increasingly likely that the United States will and must adopt an economywide national program to reduce greenhouse gas emissions across all sectors before or during 2025 to 2035.

Thus, the most important large-scale and longer-term issue is how the CAFE program—as well as greenhouse gas emissions from light-duty vehicles in general—fit within a broader national strategy to combat climate change. Regardless of the structure of any such strategy, it will almost certainly intersect with the CAFE program, given the significant contributions from the transportation sector to overall U.S. greenhouse gas emissions. The breadth of expected changes in mobility and transportation over the coming decades suggests that interagency coordination will be required to adequately address the many facets of sustainable transportation, from new vehicle technologies and ownership models, to fuel supply and infrastructure needs, to justice and fairness impacts.



According to this report, the 2025–2035 decade could bring the most fundamental transformation in the history of the automobile.

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VOLUNTEER VOICES

"I hope to impact transportation infrastructure by improving the tools and techniques with which pavements are tested and for these tools and techniques to better harmonize design and construction. While working in this arena, I hope to be an ambassador for the profession, to show those in the field—and the public at large—that construction matters to our quality of life.

—ISAAC HOWARD

Director, Richard A. Rula School of Civil and Environmental Engineering
Mississippi State University
Starkville

Effective Landscape Strategies Can Unlock Co-Benefits of Transportation Stormwater Management

Ann Hartell

ROGER KILGORE, ALAN LEAK, AND MAURA FLIGHT

Kilgore is principal of Kilgore Consulting and Management and Leak is principal of RESPEC Company, both in Denver, Colorado. Flight is principal of IEc in Cambridge, Massachusetts.

Increasingly recognized for their importance in managing runoff, trees and their leaf canopies reduce erosion caused by falling rain. They also provide surface area where rainwater lands and evaporates. Roots take up water and help create conditions in the soil that promote infiltration.

Stringent requirements for stormwater quality and quantity management led state departments of transportation (DOTs) to seek collaboration with regulatory agencies and other potential external stakeholders and partners to solve problems. Watershed-based implementation of landscape strategies that possibly offer co-benefits include wetlands restoration; forest uplands restoration and creation; steady restoration and improvement; and agricultural practices, modification, and conversion.

Higher peak flows, less infiltration (more runoff), and more rapid runoff can lead to erosion, channel instabilities, flooding, and loss or adverse change in aquatic habitat. Engineers, scientists, and planners use traditional, well-accepted techniques—including best management practices—to achieve stormwater quantity and quality mitigation of transportation impacts in-kind. In-kind mitigation counterbalances a transportation project's negative effects with a positive effect measured by the same metric. For example, if the impact is an increase in the loading of nutrients measured in pounds per year, then in-kind mitigation relieves the loading of nutrients in pounds per year. Similarly, if the impact is increased peak runoff of the 10-year event, measured in cubic feet per second, then the peak runoff is decreased and measured in cubic feet per second.

Watershed-Based Implementation of Landscape Strategies

Engineers, scientists, and planners typically apply these stormwater correction techniques at a project site but may apply them offsite. An example of an off-site, in-kind best management practice is a regional stormwater management pond that reduces runoff from many parts of a watershed. In-kind stormwater methods may provide ecosystem services, in addition to the primary hydrologic benefits. The benefits associated with ecosystem

services, known as co-benefits, either are not associated with the in-kind correction or are not assessed.

Out-of-kind methods counteract the negative impact of a transportation project by using the same metric applied to quantify the impact while providing co-benefits by improving a different but related watershed function. In some cases, its most attractive purpose could be its co-benefits, rather than reduction of the project's hydrologic impact. Out-of-kind correction is typically located offsite.

Many out-of-kind corrective techniques can be characterized as landscape modifications because they change the landscape characteristics that make up the watershed. These techniques tend to be new. They are less well accepted, with insufficient documentation of their effectiveness.

NCHRP Project 25-60, "Watershed Approach to Mitigating Hydrologic Impacts of Transportation Projects" (*1*), focused on out-of-kind mitigation techniques applied offsite rather than traditional on-site/in-kind mitigation. The techniques included in this project were

- Wetland restoration and creation,
- Forest restoration and creation,
- Stream restoration and improvement,
- Uplands restoration, and
- Agricultural practices modification and land conversion.

These corrective techniques all have the potential for co-benefits. A common characteristic is that they alter the landscape, thereby changing the runoff and infiltration characteristics of a watershed. Numerous other techniques exist, and NCHRP Project 25-60 provides a general overview of other out-of-kind mitigation techniques, as well as more traditional on-site mitigation techniques.

The project developed procedures and resources for analyzing the hydrologic impacts of transportation projects, as well as the hydrologic benefits and co-benefits of out-of-kind mitigation techniques using a watershed approach. Co-benefits include stormwater mitigation, in addition to the primary hydrologic objectives (such as improvements to recreation opportunities or enhancement of climate resilience of water supplies). Co-benefits are created by providing ecosystem services that contribute to human health, wealth, and well-being by natural ecosystems.

Roger Kilgore

Southeast of Denver, Colorado, the Cherry Creek Watershed wetland restoration exemplifies a landscape modification that addresses runoff from adjacent roadways and other land uses in the watershed. Runoff endangers the environment by carrying pollutants onto adjacent land, as well as into watercourses and drains. Organizations risk reputational damage or litigation if highway pollution affects their land or water supply.

The research expanded the perspective for evaluating landscape mitigation for stormwater management beyond the transportation corridor to the larger watershed. This perspective offers additional opportunities for locating mitigation measures upstream or downstream of the transportation projects, but within the same watershed. This perspective also provides the opportunity for mitigation to address the effects of multiple projects within a watershed, as well as the development of projects over a period of a decade or more.

The potential for achievement of co-benefits from landscape mitigation measures can offer significant incentives for approaches that achieve goals beyond meeting hydrologic regulatory goals. Conventional onsite mitigation (e.g., a stormwater management pond) can achieve specific peak flow reduction requirements to mitigate increased flow from a transportation project. However, a stormwater management pond rarely offers benefits beyond meeting the specific hydrologic requirements. By contrast, landscape measures such as reforestation, wetland recreation, stream restoration, uplands restoration, and the modification of agricultural practices can generate additional co-benefits in addition to mitigation of peak flow. These measures produce the co-benefits by changing the environment (Figure 1).

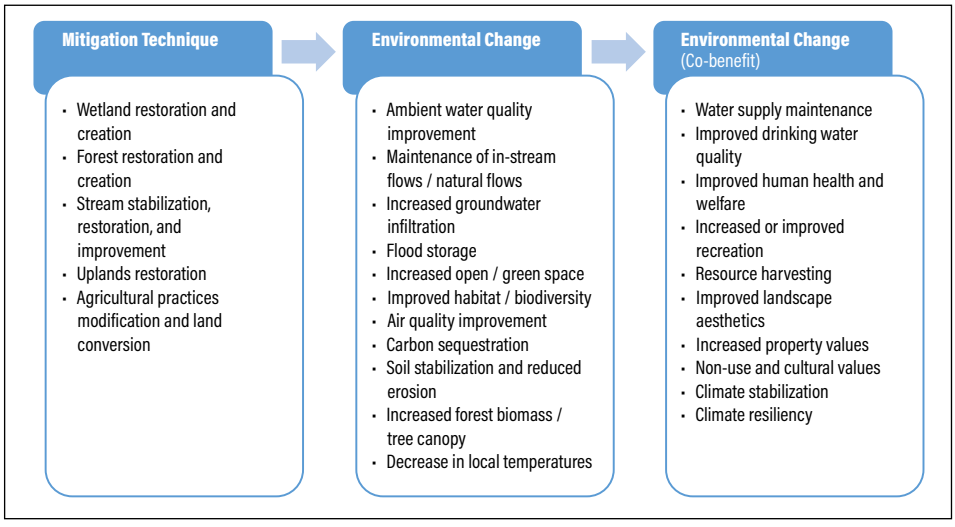

FIGURE 1 Examples of mitigation techniques, environmental changes, and ecosystem services.

These co-benefits, in turn, offer transportation agencies the opportunity to partner with stakeholders who may value one or more of the co-benefits of the stormwater mitigation measure. Because of co-benefits, the stakeholders may become supporters of the transportation project and could provide personnel and/or financial resources to support implementation of the landscape-based stormwater mitigation measure.

Transportation and Watershed Benefits

A watershed approach to the mitigation of stormwater impacts from transportation projects benefits both the transportation project and the watershed. The potential benefits to the transportation project include

- More flexibility in the location of stormwater mitigation by looking at the larger watershed rather than just the transportation right-of-way;
- Larger scale of mitigation measure implementation that could address multiple projects in a watershed over time, resulting in a lower unit cost of mitigation;
- Addition of project stakeholders that support mitigation measure implementation because of the value placed on one or more co-benefits; and
- More effective mitigation of increased stormwaters' flows.

The benefits to the watershed and its stakeholders include

- Development or improvement of ecosystem services, such as improved water quality, improved habitat, increased open space, and others provided in Figure 1;
- Realization of co-benefits, such as increased recreation opportunities, climate resiliency, and increased property values; and
- Collaboration on the mitigation of transportation impacts on the watershed.

The watershed approach also may lead to opportunities for mitigation banking of reforestation, stream restoration, and other landscape mitigation analogous to wetland banking. This may provide the transportation agency with opportunities to either create or buy in to banks that benefit the watershed, as well as the transportation project.

Implementing the Watershed Process

An overall decision framework is critical for a successful state DOT outcome when implementing a watershed approach to mitigate the hydrologic impacts of transportation projects. Figure 2 provides an overview of a high-level decision framework that describes the primary implementation steps. The steps are flexible and may shift in importance with the transportation project, the transportation agency and potential stakeholders, and the watershed context.

The process can be simplified by considering the following phases:

- **Phase 1: Preliminary planning and assessment.** Steps 1 through 5 lay the groundwork for implementation of the watershed approach by articulating objectives, identifying stakeholders, and defining the scope of watershed and potential mitigation measures.
- **Phase 2: Mitigation portfolio screening.** Steps 6 through 9 represent the development of a portfolio of mitigation measures under consideration by the transportation agency and stakeholders and the screening assessment of the hydrologic performance of the mitigation and the presence of co-benefits.
- **Phase 3: Mitigation detailed analysis.** Steps 10 through 12 provide for detailed analysis of the hydrologic performance of the mitigation and the presence of co-benefits if the screening analysis (Phase 2) did not yield actionable information.

These three phases can lead to actionable watershed-based mitigation measures that the transportation agency and stakeholders implement. The research team developed tools that facilitate the screening analysis of the landscape-based

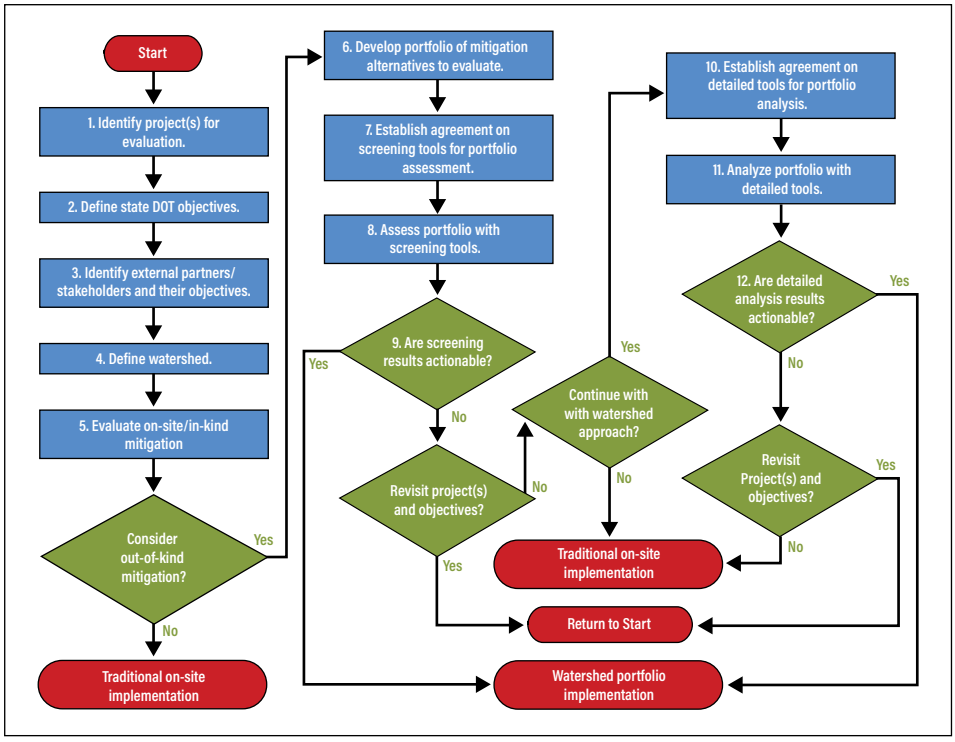

FIGURE 2 Decision framework.

mitigation measures and their potential co-benefits.

Based on a series of watershed modeling analyses for watersheds across the United States, the research team developed mitigation ratios that indicate the quantity of mitigation needed to address the increase in peak flow or runoff volume per acre of transportation impact under a range of conditions. For example, the screening tool estimates that 1.3 to 4.0 acres of forest creation is needed to offset the hydrologic effects of one acre of transportation project impact, depending on the relevant hydrologic metric, for mitigation located downstream in the watershed from the highway project. The hydrologic screening tool provides these mitigation amounts for wetlands, forest, and uplands restoration or creation on an acre-per-acre basis. The tool also provides mitigation amounts for stream restoration on a stream length per acre of impact basis.

To support screening of potential co-benefits of stormwater mitigation measures, the research team developed a series of generic causal chains. These causal chains identify common environmental changes that would result from implementation of landscape-based mitigation and the potential ecosystem service co-benefits that could be expected from those environmental changes. Using these generic causal chains, the transportation agency and potential stakeholders can identify the most likely or dominant possible outcomes for a specific mitigation measure in a watershed.

To support the detailed analyses of Phase 3, the research team identified and explained several tools available for hydrologic and co-benefits analyses of landscape-based mitigation measures. The objective of both the screening and detailed analyses is to generate an actionable basis for implementing mitigation measures that satisfy hydrologic requirements and generate valuable co-benefits to stakeholders.

Use of landscape-based stormwater mitigation measures such as wetlands, reforestation, uplands restoration, and stream restoration within a watershed gives transportation agencies additional options for meeting increasingly stringent stormwater management requirements. It also unlocks the potential co-benefits that are generally not available using conventional on-site stormwater management strategies. In addition, broader stakeholder engagement enhances the performance of transportation projects and provides for win–win project development.

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VOLUNTEER VOICES

"When I was a kid, I would make roads in the sandbox and in my mashed potatoes. I drew roads for fun and, as a high school student, I was called *Roadmaker*. I like to think that roads and transportation are in my DNA. I pursued a degree in civil engineering at the University of Buffalo and got a job with the New York State Department of Transportation. I have been designing roads ever since. What keeps me here is my love of transportation and my desire to help safely and efficiently move people and goods in our community. My "career project" was creating a new signature bridge for Rochester, New York. This project is part of our community's fabric and I am so proud to have contributed to that.

—HOWARD RESSEL
Senior Design Engineer
Popli Design Group
Penfield, New York

ELECTRIC BICYCLES

EVOLUTION, RESEARCH, AND THE MOVE FORWARD

Cathy Frye, Flickr, CC BY 2.0

PRASANTA SAHU, MOHAMMED ZABIULLA, AND BANDHAN MAJUMDAR

Sahu is an assistant professor and Zabiulla is a PhD candidate at Birla Institute of Technology and Science—Pilani in Hyderabad, India. Majumdar is an assistant professor at the National Institute of Technology in Durgapur, India.

E-bikes are meeting a demand for micromobility options in cities and suburban areas around the globe. The public mindset changed during the COVID-19 pandemic, which resulted in a surge in electric bike share programs and advances in e-bikes.

One of the widely regarded solutions for mitigating traffic-related air pollution is to replace existing fossil-fueled vehicles with electric vehicles. Among electric vehicles, electric bicycles—or e-bikes—are gaining popularity around the world due to their numerous advantages over other vehicles. Such assets include riding over hilly and flat terrain without effort, discharging zero carbon emissions, reducing automobile traffic congestion, traversing overcrowded urban roads with ease, and improving health by providing physical exercise through motor-assisted pedalling. E-bikes are conventional bicycles fitted with an electric motor and a battery to keep up with the greater distances and higher speeds required to travel in rapidly developing cities. This article highlights the evolution of e-bikes over the past 30 years and provides an overview of research and policies practiced worldwide.[1]

[1] Find more TRB e-bike publications at http://trid.trb.org.

E-bikes are of three types: pure e-bikes (throttle only), pedal-assisted bicycles (pedelecs), and a combination of pedal-assist and throttle-mode bicycles. Pure e-bikes can run solely on the electric motor using a throttle when the rider tires of pedalling. Cranking up the throttle activates the motor and pushes the bicycle forward (*1*). While this and other types of e-bikes are useful on uphill roads to keep up to speed with the traffic flow without any delay, anxiety over a limited 15- to 20-mile range—depending on battery capacity and throttle usage—remains one of the major barriers associated with adoption of pure e-bikes.

Pedal-assisted bicycles—or pedelecs—use an electric motor to get an extra push while pedalling, which fosters effortless pedalling. In this case, initial pedalling is mandatory for the motor to start and subsequently provide assistance in pedalling. The motor assists the pedalling to a certain speed limit (15.5 miles per hour for most countries) and then turns off if the bicycle speed exceeds that limit.

Galen Crout, Unsplash

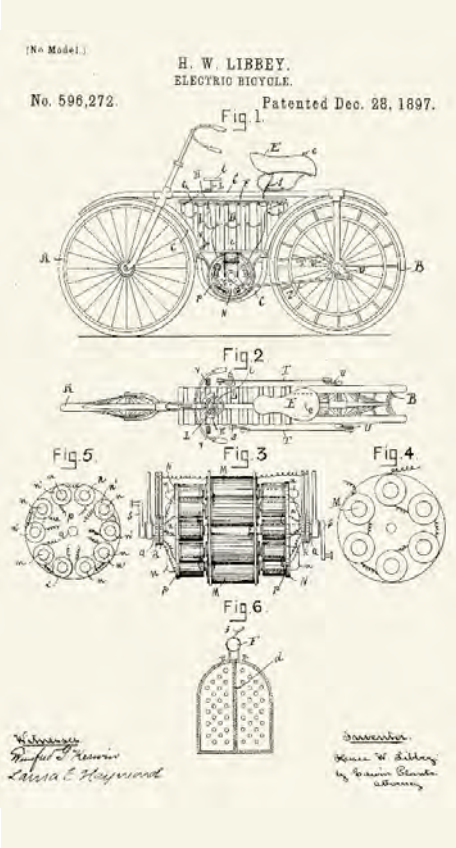
The Tern GSD pedelelec e-bike's motor uses three sensors to gauge how much assistance to provide the rider. If the rider is pedalling hard going uphill, the motor provides more assistance than on the downhill where gravity helps.

Providing an opportunity to exercise in a less strenuous way and offering more range through different pedal-assist levels for a single charge is an added benefit for using pedelecs, in comparison to pure e-bikes.

History and Evolution of E-Bikes

The earliest models of e-bikes were first patented in the 1890s in the United States. In 1895, Ogden Bolton, Jr., designed the first e-bike model as a battery-powered bicycle with a rear-wheel direct current hub motor with no pedals (*1*). This design of an integrated battery fitted inside the main triangle of the bicycle frame was an inspiration to many of today's e-bike models on the market. In 1897, Hosea W. Libbey invented a mid-drive (motor placed between the pedals) double electric motor that offered high torque and propelled the cycle effortlessly. Mid-drive e-bikes are popular, particularly for off-road trails and adventure riding due to their supreme balance, lighter weight, and power capabilities; yet they are more expensive than hub-drive (motor mounted on the rear hub) e-bikes.

Subsequently, several inventors in the 1990s patented various e-bike designs. Some of these models were remarkable, and some were ineffective. Stefanos Argyris's viable configuration of a cylindrical electric motor was mounted in the center and in line with the chain, providing a better pedal assist and preventing backward propelling of the motor during a power cut. In the early 2000s, inventors from Japan and Taiwan introduced torque and pedal force sensors that detect riders' pedal force and offer effective assistance to pedalling. Thereafter, many significant technology advancements—such as lithium-ion batteries (integrated and detachable), brushless direct current motors, mid-drive motor systems, power electronics, foldable frames, digital display, smartphone app connectivity, and radio frequency identification locks for security—improved the e-bike's operating performance and increased its global sales in the mid-2000s.


[No Model.]
H. W. LIBBEY.
ELECTRIC BICYCLE.
No. 596,272. Patented Dec. 28, 1897.
Fig. 1.
Fig. 2
Fig. 5
Fig. 3
Fig. 4
Fig. 6

Wikimedia, CC BY-SA 3.0

Hosea W. Libbey's mid-drive electric bicycle received a U.S. patent in 1897. The Boston, Massachusetts, inventor described his invention as "a bicycle to be propelled by electricity generated by primary batteries and in motors therefor."

E-BIKE REVOLUTION IN CHINA: LESSONS LEARNED

China witnessed an e-bike market boom at the beginning of the 21st century with the skyrocketing sales of all types of e-bikes. The attempts of Chinese local governments to ban motorcycles in city centers to reduce traffic congestion and air pollution sparked this rise in e-bike sales. Moreover, low- and middle-income families adopted e-bikes because they were economical, easy to use, nature-friendly, highly efficient, and did not require a driver's license. Soon these electric vehicles occupied public roads in large numbers and created two-wheel traffic chaos, violating the traffic rules and increasing injury crashes in the city due to their higher speeds. This prompted the Chinese government to impose a ban on e-bikes in major cities and set some mandatory safety technical standards to differentiate and prohibit bike riders who were noncompliant with rules on the roads.

In 2016, traffic police in Shenzhen City launched a campaign to forbid the use of unlicensed e-bikes, which resulted in the seizure of around 18,000 e-bikes (*2*). At the same time, many Chinese cities also faced the problem of bike-share oversupply. City streets were packed

with unpowered rental bicycles, and unused abandoned bicycles were piled up in bicycle graveyards (*3*). As a result of city-imposed e-bike and regular bike-share bans, many private bicycle manufacturing companies and start-ups went bankrupt and were shut down. Today, major companies are focusing on e-bike–sharing systems and are experiencing sustainable growth in the market.

Scientific Research and Development

TRB continues to make progress in transportation innovation and advancement through research and information exchange. Its Standing Committee on Bicycle Transportation is concerned with all aspects of bicycling, bicyclists, and criteria for bicycle facilities to assure that the bicycle rider has safe, convenient, and efficient travel. The committee discusses ways to include biking into multimodal transportation systems, as well as transportation and land use planning, policy, and engineering in general. TRB extended its involvement in the research of pedestrian and bicycle transportation with collaborative support from research programs such as the National Cooperative Highway Research Program (NCHRP) and Transit Cooperative Research Program (TCRP). For example, *NCHRP Synthesis 597: Micromobility Policies, Permits, and Practices* focuses on the functioning of state departments of transportation (DOTs) concerning micromobility, policies and regulations, challenges, and opportunities. In this case, micromobility relates to any small, personal vehicle that travels at a speed of less than 20 to 30 miles per hour (*4*). *TCRP Research Report 230: Transit and Micromobility* describes the overall benefits and effects of micromobility on public transportation in transit-rich markets, as well as in medium-size and smaller cities (*5*).

When looking at how electric bicycle research has evolved over the past 40 years, a search of Elsevier's Scopus database yielded 1,842 documents. Figure 1 shows the evolution of scientific research over this period, with a notable increase in interest in scientific research on electric bicycles in 2008. Figure 2 shows the number of publications by different countries.

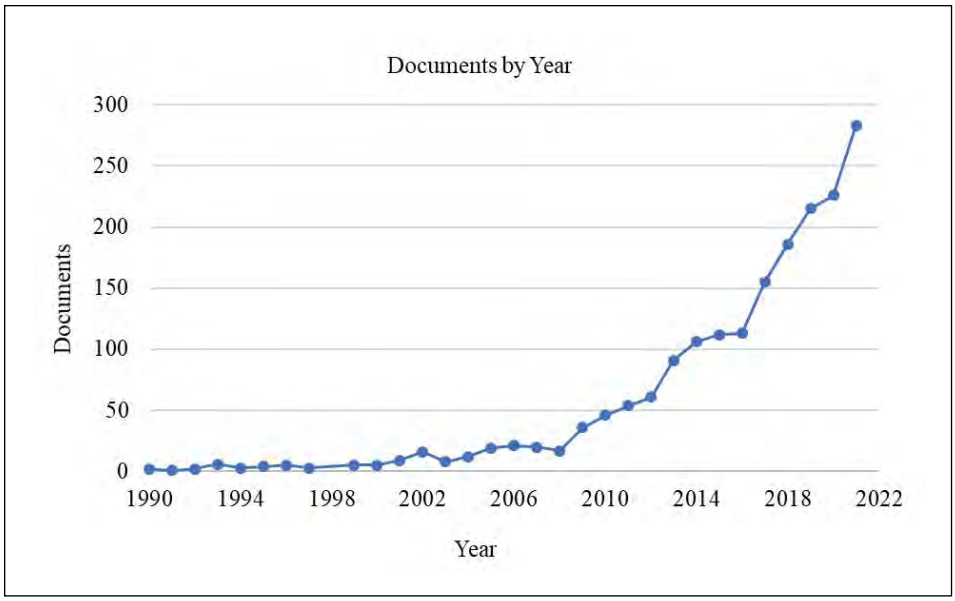


FIGURE 1 Scientific research on electric bicycles between 1990 and 2022. (Source: Elsevier Scopus Database.)

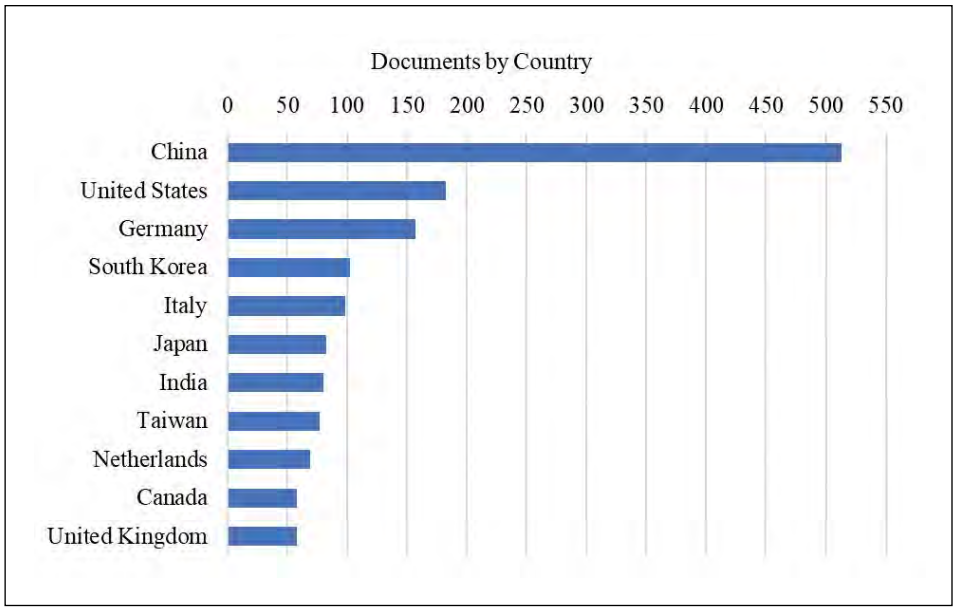


FIGURE 2 Publications on electric bicycles by country. (Source: Elsevier Scopus Database.)

Adoption, Growth, and Deterrents

Globally, the electric bicycle market is expected to grow at a compound annual rate of 9.92 percent to reach $62.25 billion by 2030, up from $26.51 billion in 2021 (*6*). Currently, China stands first in the adoption and use of electric bicycles in the world. In 2020, the Asia Pacific region had the largest electric bicycle market, with China accounting for 97 percent of the region's total volume. India, Japan, South Korea, and Taiwan are expected to be potential future markets. Elsewhere, electric bicycle markets are likely to grow rapidly in Eastern Europe, Latin America, the Middle East and Africa,

KBO Bike, Unsplash

Whether for leisure, commuting, or commercial delivery, e-bikes allow for longer, faster, less strenuous trips. The detractors—weight, high cost, limited range, and short battery life—are evolving as bikes use better or multiple batteries and other advancements are made.

Western Europe, and North America. The United States experienced a slow growth rate in the beginning but gained popularity in the last 10 years. The Netherlands also has seen a substantial increase in its electric bicycle fleet in recent years. A recent study from the Light Electric Vehicle Association reveals how enthusiastically the Dutch have welcomed electric bicycles; one out of every three adults in the Netherlands rides one (*7*).

The purchase and use of electric bicycles rely mostly on the perceived usefulness of the mode of transportation, according to the needs of the commuter. Many studies show that electric bicycles are popular among older adults to run errands and for leisure and recreational trips *(8)*. Also, people who are environmentally conscious and advocates of physical activity tend to use electric bicycles (*9*). A 2013 online survey conducted in Australia among electric bicycle owners indicated that about 60 percent of participants purchased bicycles to replace using their cars, while around 50 percent of participants wanted a riding experience with less effort (*10*). A similar survey in North America showed that the major reasons for purchasing electric bicycles were to replace car commutes and save fuel and money (65 percent), to improve their active health standards and fitness (52 percent), and to overcome hilly terrains with less effort (60 percent) (*11*).

There are many reasons and motivations to purchase an electric bicycle, but there also are some barriers to electric bicycle usage. The same survey found that many users report the weight of the electric bicycle as the main deterrent, followed by high cost, limited range, and short battery life. Moreover, studies on the effects of mode substitution have shown that electric bicycles replace not only bus and car trips but also substitute active health-promoting transportation modes like conventional bicycling and walking, further reducing the physical activity of the commuter (*12*). Other deterrents include speeding, risk of theft, insufficient charging and bicycling infrastructure, and inclement weather conditions. However, the priority and significance of these barriers differ from person to person and from place to place. One possible solution for tackling these issues is the introduction of a shared electric bicycle system.

ELECTRIC BICYCLE SHARING SYSTEM

Solving the problems of conventional bicycle sharing systems, an electric bicycle sharing system (EBSS) encourages long-distance bicycle commutes, particularly in hilly terrains (*13*, *14*). Compared with public transit and taxi services, shared electric bicycles can be a good option for overcoming first- and last-mile connectivity gaps and avoiding delays caused by traffic congestion.

Similar to the factors affecting adoption of conventional bicycle sharing systems, use of an EBSS for commuting is influenced by factors such as commuter sociodemographics (e.g., gender, age, income, and education), pro-environmental attitudes, perceived compatibility with hilly terrains and long-distance commutes, urban morphology and topography, weather conditions, cycling and charging infrastructure, location of EBSS stations, and the quality of the prevailing transit services. The cost-effective dockless EBSS can attract low- and middle-income groups and increase bicycle ridership in the city. A survey conducted in four districts in Beijing, China, confirmed that although the service was attractive to limited

Cody Engel, Unsplash

In 2018, Santa Cruz, California, partnered with JUMP bikes and welcomed the first bike share program in the country. The program was successful and active until March 2020 but started to collapse when JUMP was first acquired by Uber and later handed to another bike share company, Lime.

sociodemographic groups, the majority used the EBSS to replace bus trips and long-distance trips, even in hot temperatures and polluted environments (*15*).

HURDLES OF EBSS DEVELOPMENT

Despite the enormous benefits of an EBSS, there are certain negative externalities associated with its acceptance and practice in cities where micromobility systems are likely to emerge. Electric bicycles are a more rational choice than cars in utilizing road space. However, they are not as efficient as buses in moving passengers (*13*).

Similarly, the promoted benefit of zero emissions from electric bicycle use can be deceptive; electric bicycle batteries discharge more emissions than fossil-fueled vehicles. Moreover, the process of generating electricity for electric vehicles in general indirectly adds to vehicular emissions, depending on how that electricity is produced for charging electric vehicle batteries (e.g., from fossil fuel thermal power plants).

One of the reasons China banned electric bicycles was to control increasing electric bicycle accidents due to their higher speeds (*16*). Statistics for 2019 reported by the Chinese Ministry of Transport showed that 8,639 people died and 44,677 people were injured in electric bicycle–related accidents. Another safety risk associated with electric bicycles is batteries exploding or catching fire due to overcharging or age. Though news of casualties and such incidents are rare, these occurrences are still a potential deterrent for individuals considering the purchase and use of an electric bicycle. Compared to the conventional bicycle-sharing systems, an EBSS requires charging stations that can provide a safe and reliable source of energy, such as an electric utility connection to charge the batteries. This increases installation cost and also makes site selection of station locations difficult.

THE FUTURE AND CONTINUING NEEDS

Electric bicycles are modern-day, sustainable, micromobility transportation options useful for short and middle-range trips. Considering the fluctuating fuel prices, electric bicycles can be a great alternative to gasoline-powered vehicles. Though EBSSs are just starting to be launched in some cities, researchers, transportation planners, and policymakers expect successful EBSS adoption to address transportation-related concerns such as traffic congestion, air pollution, and first- and last-mile connectivity.

Electric bicycles are likely to be the next preferred mode of delivery for e-commerce platforms in smart cities. Called e-cargo bikes, they are electric bicycles developed to deliver goods within a radius of two to three miles. Compared with conventional internal combustion engine two-wheelers and vans, e-cargo bikes provide considerable

Mark Stosberg, Unsplash

This Indiana family is biking home using a pair of e-cargo bikes filled with children and weekend camping supplies. Family cargo bike use is outpaced by e-commerce and food delivery companies, particularly in cities, and creating rising demand for these bikes.

potential for expanding per day shipment capacity and achieving cost optimization for last-mile service providers. Several major companies have already started using electric bicycles for making deliveries in big cities. As with EBSSs, the development of adequate charging infrastructure for e-cargo bikes remains a challenge.

The advent of electric bicycles has made cycling an ever-growing part of the future, but—in a way—it's also a return to the past. A century-old invention with modern technological advances has an important role to play in developing a healthier and more environmentally friendly future for people and the communities in which they live.

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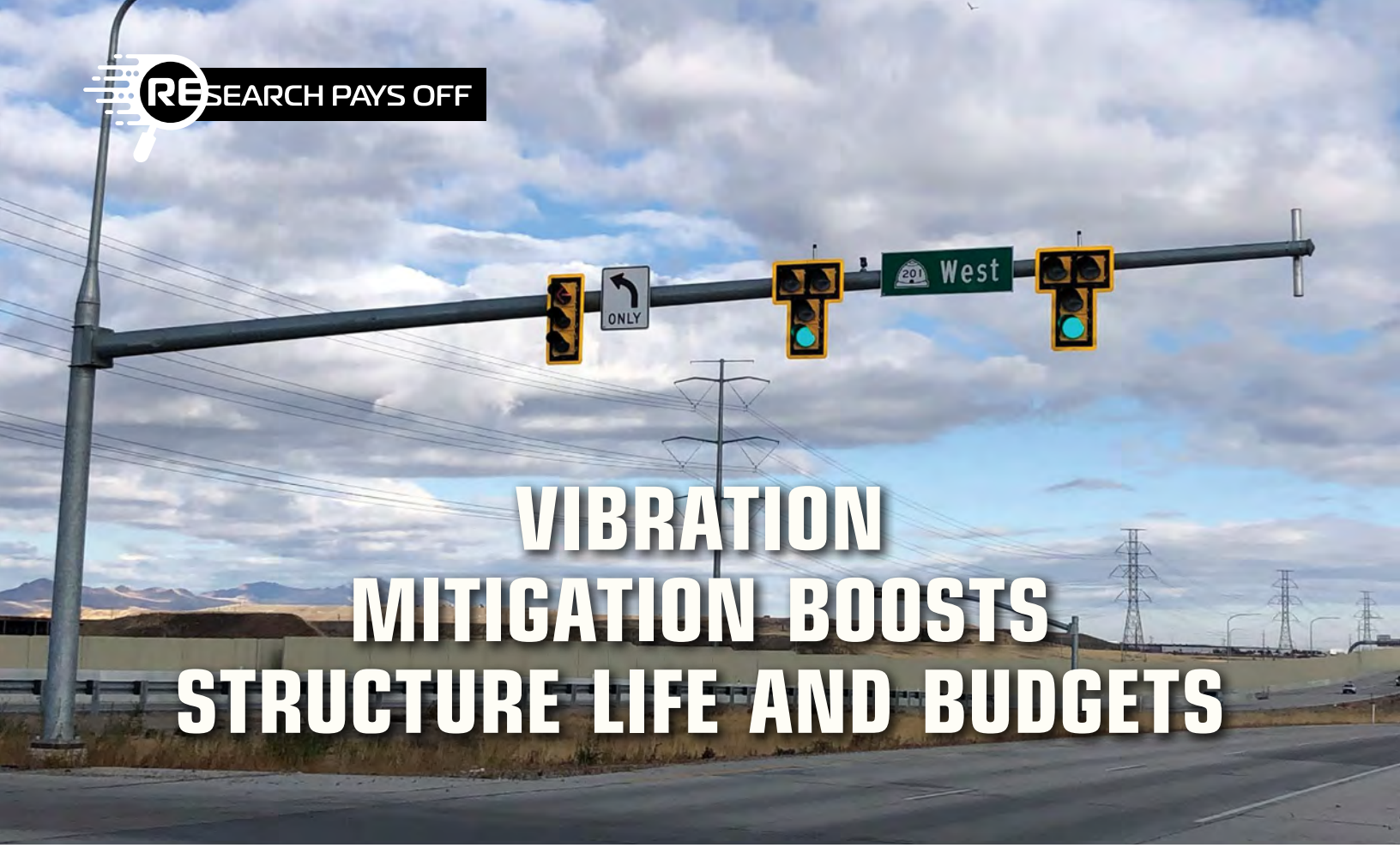
VOLUNTEER VOICES

"I hope I will be able to make a significant contribution to the transportation industry, specifically in the area of structural rehabilitation. TRB is helping me reach this goal and make this impact by connecting me with other engineers with similar interests and giving me the opportunity to present and submit on this subject matter.

—JOSEPH STRAFACI
Project Manager
HNTB Corporation
Boston, Massachusetts



Mark Taylor

VIBRATION MITIGATION BOOSTS STRUCTURE LIFE AND BUDGETS

CARL J. MACCHIETTO AND MARK TAYLOR

Macchietto is vice president of product development and management at Valmont Industries, Inc. in Valley, Nebraska. Taylor is a traffic signal operations engineer at the Utah Department of Transportation in Salt Lake City.

When traffic signals or mast poles move repeatedly in the wind, traffic engineers call this *galloping*, during which the structure withstands vibrational stress that can cause premature fatiguing. In lieu of more costly solutions, adding a vibration damper stabilizes the structure, reduces fatigue, and improves structure lifespan.

The Valmont TR1 Mitigator vibration damper was designed using vibration theory and innovative damping technologies to reduce vibration stress from wind excitation and increase the fatigue life of a sign and traffic signal structure. The damper's technology built upon the knowledge and understanding presented in National Cooperative Highway Research Program (NCHRP) Innovations Deserving Exploratory Analysis (IDEA) research performed as part of NCHRP IDEA-141, "Signal Head Vibration Absorber for Traffic Signal Support Structures" (*1, 2*). Use of this device has resulted in more efficient traffic signal and sign support structures by

- Creating a more economical design;
- Improving safety for the traveling public;
- Extending the life of new and existing structures;
- Lowering maintenance, inspection, and repair costs; and
- Reducing mast arm movement, thus improving vehicle detection by cameras and radar systems.

The Problem with Vibrations

Traffic signal support structures have been increasingly observed to be susceptible to vibrations resulting from both normal and extreme wind conditions. Types of wind loading—including galloping, vortex shedding, natural wind gusts, and truck-induced gusts—can result in vibration of these structures. AASHTO defines galloping as large amplitude resonant oscillations in a plane normal to the direction of wind flow, usually limited to structures with nonsymmetrical cross-sections, such as sign and traffic signals mounted to an arm. AASHTO defines vortex shedding as the shedding of wind vortices on alternate sides of a member that results in resonant oscillations in a plane normal to the wind direction. Vibrations can lead to stress variations

that can significantly reduce the fatigue life of these structures.

AASHTO's *LRFD Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals* and subsequent interim revisions[1] address fatigue loading caused by wind-induced vibrations and truck gusts for traffic signal structures and strive to make our streets safer (*3, 4*). In many cases, to adhere to these revisions, the cost of traffic signal installations have doubled in the past decade. Key contributing factors are the added cost of bulkier steel poles and mast arms, larger foundations, and higher costs of labor.

A New Approach

The Valmont TR1 Mitigator vibration damper is a self-contained unit weighing approximately 35 pounds. It is easy to handle and mount. A reciprocating steel mass is suspended in the tube by a stainless steel extension spring. Magnets located on the reciprocation mass moving through the aluminum tube create eddy currents (electricity), which provide damping and are extremely effective in damping low- or high-amplitude motion. Specially designed bearings on the top and bottom of the steel mass provide proper pneumatic damping (air resistance), which is more effective at larger amplitudes (Figure 1).

Laboratory and field testing were completed to determine the TR1 Mitigator's efficacy as an alternative to larger poles, more steel, larger foundations, or other previous remedial measures aimed at minimizing the galloping of mast arms. Specifically, the research objective was to determine whether the vibration damper sufficiently reduces wind-induced vibration oscillations while keeping structure size and costs manageable and adhering to the minimum AASHTO fatigue design recommendations.

The laboratory tests were conducted at the University of Connecticut on cantilever mast arm configurations of different lengths, diameters, and added masses,

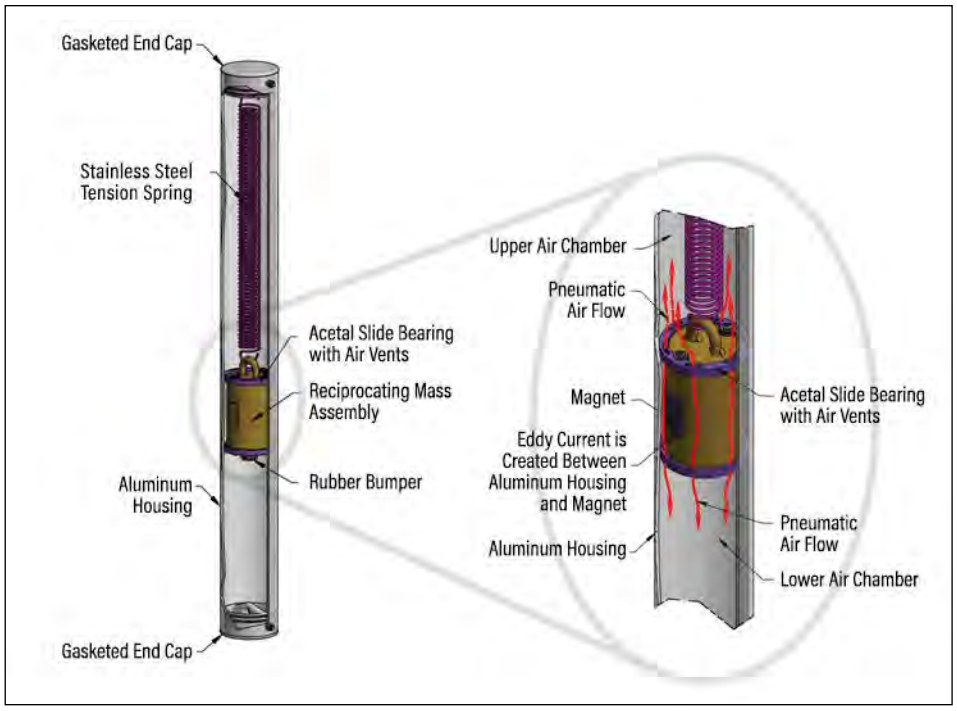


FIGURE 1 Internal view of the TR1 Mitigator vibration damper.

to simulate a range of signal and sign structures. Free vibration (displacing the arm by a certain distance and letting it go) and force vibration (applying a steady continuous impulse force to the arm at the structure's natural frequency) tests were performed and measured with both strain gauges and accelerometers. These tests showed that the device effectively mitigates vibration movement on a wide variety of pole configurations and frequencies. The numerical model of the damper makes it possible to accurately—mathematically—predict the performance of the TR1 Mitigator while mounted on any traffic and sign structure. The free vibration tests conducted on 50-foot mast arms showed that the TR1 Mitigator reduced vibration amplitude by 97 percent to 99 percent (Table 1).

Table 1 Free Vibration Testing of 50-Foot Mast Arm at the University of Connecticut

Mast Arm Base OD & Wall Thickness (in.)	Natural Frequency (Hz)	Added Weight (lbs.)	Inherent Structural Damping (%)	Damping with TR1 Mitigator Damper (%)	Vibration Amplitude Response Reduction (%)
12.5 OD 0.2391 Wall	1.2	48.34	0.09	2.70	97
12.5 OD 0.2391 Wall	0.99	173.34	0.07	3.20	98
10.0 OD 0.1793 Wall	0.95	48.34	0.08	9.50	99
10.0 OD 0.1793 Wall	0.69	173.34	0.07	2.50	97

NOTE: OD = outside diameter on the large end of the tube. "Added Weight" refers to the extra weight (not including the Mitigator) used to change the structure's frequency and dynamic mass.

[1] LRFD stands for load and resistance factor design.

Table 2 TR1 Mitigator Field Tests

Date	Location	Mast Arm Length (Feet)
6/16/2016	City of Omaha, Nebraska	70
8/3/2016	State of Utah	40, 45, 50, 70, and 75[a]
11/10/2016	City of Seattle, Washington	65
5/24/2017	City of Harford, Connecticut	55
6/28/2017	State of Nevada	45
10/20/2017	Doha, Qatar	68[b]
12/20/2017	State of Colorado and City of Brighton, Colorado	65
6/14/2018	State of Arizona	40
11/20/2018	City of Fort Worth, Texas	50
2/12/2019	Clark County, Nevada	85
9/22/2021	Waterloo and Dubuque, Iowa	50
4/26/2022	State of Kansas	70

Note: [a]Three 75-foot mast arms. [b]Two 68-foot mast arms.

Some TR1 Mitigator installations in the United States and abroad have undergone field testing (Table 2). Measured performance from these field tests showed a reduction of vibration amplitude from 85 percent to 94 percent and further validated the laboratory developed mathematical performance model that gave calculated results within 1.5 percent of the measured results.

Putting This Research in the Field

Since 2016, the Utah Department of Transportation (DOT) has installed more than 1,200 of the devices and reported that it takes only a few minutes for installation. The TR1 Mitigator is standard for new traffic signal installations and Utah DOT is both pleased with the device's performance and impressed by its aesthetics because it blends in nicely with the other devices on the mast arm.

In March 2017, a Nevada standard flashing signal railroad crossing mast arm failed from metal fatigue near Reno, due to wind-induced vibration. The mast arm failed across the road, risking safety of the public, disrupting traffic flow, and causing a costly quick replacement. In June 2017, the State of Nevada replaced the signal arm and installed a TR1 Mitigator. The measured performance from a field-conducted test was 91 percent vibration response reduction. One other similar structure near this site also was retrofitted with a TR1 Mitigator to safeguard it from possible future failure. The State of Nevada now includes the TR1 Mitigator in their standard state plans for all related structures of this type.

Benefits

The TR1 Mitigator is expected to last as long as the structure on which it is placed. It provides a budget-friendly alternative for state DOTs and agencies looking to use resources more effectively through proactive preservation of the steel infrastructure. This allows state DOTs to better balance costs and the need to meet the most recent AASHTO wind-loading standards.

When an effective vibration mitigation device is used, the AASHTO specifications for 2013 or later allow the reduction from Fatigue Category I to Fatigue Category II and do not include the galloping fatigue loading case because it should no longer occur (*5*). This results in smaller and more economical traffic signal structures that are less likely to encroach on the compact right-of-way demands of the intersection. Because the TR1 Mitigator lessens signal movement, it

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At more than 1,200 intersections like State Route 85 and State Route 171 in Utah's West Valley City, Utah DOT has pioneered the use of the TR1 Mitigator (the vertical device visible toward the end of the mast pole) on new and existing inventory.

Carl Macchietto

Carl Macchietto

Wind-induced vibration brought this flashing signal railroad crossing mast arm down across the road near Reno, Nevada (*left*). Shortly after the failure, it was moved to the side of the road. Metal fatigue (*above*) sheared the arm off its connector to the pole.

- Improves motorist visibility of traffic signals,
- Increases vehicle detection when cameras and radar are used,
- Heightens surveillance camera imagery by reducing motion,
- Lowers maintenance costs,
- Increases public safety, and
- Limits liability risk.

Acknowledgments

The authors thank Richard Christenson of the University of Connecticut for his research on vibration damping, performed as part of NCHRP IDEA-141.

To learn more, watch the video at https://www.valmontstructures.com/products-solutions/product-catalog/us/accessories/mitigator-tr1-traffic-damper.

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VOLUNTEER VOICES

"Definitely the most memorable experience is my first presentation at the TRB Annual Meeting in 1989. It was my first-ever international presentation in English and at a conference where I had never visited before. Moreover, there were *too* many colleagues in the audience, giving more pressure to succeed. But everything went fine!

—VESA MÄNNISTÖ
Senior Advisor, Asset Management
Finnish Transport Infrastructure Agency, Helsinki

Crashing Through COVID-19

How FHWA Kept Its Outdoor Impact Laboratory Going

FHWA, Federal Outdoor Impact Laboratory

EDUARDO ARISPE

The author is a research highway safety specialist at the Turner–Fairbank Highway Research Center of FHWA in McLean, Virginia.

This moment of impact from a slow-motion video shows a crash test vehicle colliding with a stone-faced concrete barrier at the Federal Outdoor Impact Laboratory (FOIL) on the grounds of FHWA's Turner–Fairbank Highway Research Center in McLean, Virginia. At the FOIL, COVID-19 brought these tests to a wider, virtual audience.

Office work environments during the COVID-19 pandemic presented many challenges for those converting to full-time telework, especially for laboratories where onsite work still had to be performed. At the FHWA Federal Outdoor Impact Laboratory (FOIL), the ability to still perform crash tests and communicate those results with its partners was imperative for its research to continue.

The FOIL research facility, which is accredited by the International Organization for Standardization (ISO), is used to support FHWA's safety research and development programs and other federal security initiatives. Researchers use this facility to extend their understanding of crash events and acceleration forces that occur during impacts. One way this goal is accomplished is by staging controlled, high-speed motor vehicle collisions into other vehicles or roadside hardware (e.g., guardrails, sign supports, cable barriers, and concrete safety shapes) to evaluate effectiveness. Researchers primarily use this facility to either generate data to formulate mathematical models or confirm the accuracy of computer-generated crash predictions.

Retooling During COVID-19

To be able to continue work at the FOIL during the pandemic, two main challenges had to be addressed: social distancing and the ability to communicate with partners. Because the FOIL is an outdoor facility, the social distancing aspect could be easily resolved by careful planning and assigning duties that could physically separate employees. However, this also meant that external partners, who would have normally visited the facility, would have to do so virtually. Using already available equipment, the FOIL crew was able to set up a system that would accommodate everyone's needs, to the point where it will most likely become part of normal operating procedure after the pandemic. For many

years, FHWA has provided its employees with computer software meant to facilitate online meetings, and although this was not intended for an outdoor lab environment, the team set out to find a way to take advantage of it. Using digital still photography cameras available at the FOIL and a readily available collaboration and communication software platform, the team was able to set it up so that FOIL partners could get a live, multiple-perspective view of crash tests. This includes a pretest question and answer session and a posttest close-in view of the test damage. Initial tests were conducted with only research partners in attendance. However, it has now evolved into a live viewing that includes researchers and practitioners from all over the world, sometimes with up to 150 attendees.

The first test at the FOIL was conducted in July 2020 in collaboration with Eastern Federal Lands and the National Park Service to determine if safety hardware devices meet the safety performance criteria set forth in the AASHTO *Manual for Assessing Safety Hardware* (*1*). This project's goal was to evaluate the impact performance of safety hardware devices when cost, maintenance, and compatibility with the local setting is important and it is all done without sacrificing the safety hardware devices' aesthetic effect. In this test, a mid-size crossover vehicle weighing 3,851 pounds, traveling at 62 miles per hour impacted a preliminary stone-faced concrete bridge rail design at a 25-degree angle. This test was one in a series aimed at calibrating computer models that were used in the development of the barrier.

harry_nl, Flickr, CC BY-NC-SA 2.0

On display at the Computer History Museum in Mountain View, California, a crash-tested 2008 Ford Taurus is part of an exhibit about the use of computers for calculating the possible effect of car crashes.

An Unforeseen Challenge

As part of its testing procedures, the FOIL is accredited to ISO Standard 17025, which ensures the competence of testing and calibration laboratories. As part of this accreditation, an assessor would normally visit the facility and inspect procedures and results documentation, as

FHWA, Federal Outdoor Impact Laboratory

Before its crash test at the FOIL, a mid-sized vehicle is positioned to show the impact point it will have during the stone-faced concrete barrier test.

FHWA, Federal Outdoor Impact Laboratory

Frontal damage can be seen—and assessed—after impact with the stone-faced concrete barrier. The FOIL full-scale crash tests are documented with real-time and slow-motion video, as well as pretest and posttest photos.

well as the facility and testing instruments themselves. The same technology used to show a live view of tests was again modified so that it could be mobile, moving around the facility as if the assessor were performing a live inspection. The first assessment during the COVID pandemic took place on August 2020 and lasted two days, after which the FOIL received its accreditation.

An Unforeseen Benefit

The FOIL researchers are considering ways to expand their capabilities to reach a greater audience so that they can better communicate test results with their partners. The current system's setup will only allow for two live camera views. However, through the purchase of specialized equipment, the research team is looking for ways to add more views, as well as the capability to instantly show slow motion and still photos of the tests.

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Did You Know?

Jaywalking, that frowned-upon and—in the United States—largely illegal practice of crossing the street between controlled intersections, got its name from Midwestern slang for a country person considered "an empty-headed chatterbox, like a bluejay," says Peter Norton, an associate professor of history in the University of Virginia's Department of Engineering and Society.

According to Norton, the word was first used to describe such people who were so dazzled by city lights and large display windows that they repeatedly stopped and got in the way of other pedestrians.

Norton, author of *Fighting Traffic: The Dawn of the Motor Age in the American City*, cites the earliest known reference to jaywalking as December 1913, when a Syracuse, New York, department store hired a Santa Claus. They positioned him outside with a microphone, where he proceeded to call people jaywalkers for improperly crossing the street. The term stuck, and by the 1920s, it was entrenched in urban vocabulary.

Journey through the Motor Age in Peter Norton's book at https://mitpress.mit.edu/9780262516129/fighting-traffic/.

—Cassandra Franklin-Barbajosa
Senior Editor, *TR News*

Library of Congress Work Projects Administration Poster Collection

PROFILE

Arlyn Purcell

Director of Aviation Environment and Sustainability (Retired), Port of Seattle, Washington

Arlyn Purcell looks to the future and sees "many of the basic solutions to reduce greenhouse gas emissions are already known—transition to solar and wind power, use of electric vehicles and sustainable aviation fuel, integration of low-carbon materials into construction projects. But there is a gap between knowing what to do and achieving it." Her cautionary advice is that, like that phrase found in the London Undergound, we had better *mind the gap*.

With more than 35 years' experience as an environmental and sustainability planner and a master's degree in regional planning with a transportation planning emphasis from Harvard University's Kennedy School of Government, Purcell recently retired as the director of Environment and Sustainability for the Seattle–Tacoma International Airport. She describes the team she led as "engaged, smart, and terrific professionals who performed cutting-edge work in sustainability, environmental compliance, and airport noise." She is particularly proud of her team's development and implementation of a sustainable evaluation framework for capital projects. The framework integrates sustainability into the capital design process and helps decision makers understand the cost and environmental benefits of sustainability options.

Although retired, Purcell plans to stay active in work related to sustainability and addressing climate change. She is mentoring a student through the Milgard Women's Initiative Mentorship Program at the Milgard School of Business of the University of Washington in Tacoma. She also has enrolled in climate action training through the Harvard Alumni for Climate and the Environment. Last June, she gave the sustainability lecture during the airport systems planning and design short course at the University of California, Berkeley.

Purcell has an excellent track record for staying involved. "While I was at the Port of Seattle," she explains, "I sponsored several Capstone Projects—term-long studies students conduct

"No one starting out in the field should be worried about what they don't know—please just jump in and help."

for a real-world client—for Columbia University's Sustainability Management Program." From embedded carbon in airport construction projects to using solid waste to create sustainable aviation fuel, the topics were fresh and innovative. "I'm grateful for the ideas and energy young professionals bring to the table," Purcell admits, quickly adding. "No one starting out in the field should be worried about what they don't know—please just jump in and help."

Sustainability has been Purcell's focus for most of her career. Before assuming her position at the Port of Seattle, she was an aviation regional planning supervisor for airport environmental programs at the Port Authority of New York and New Jersey. For some of the world's busiest and biggest airports, she managed the sustainability program, advocated for the trial use of alternative jet fuel, coordinated with staff on performance-based energy contracting and sustainable design guideline implementation, and oversaw a study on how sea-level rise affects critical assets. Her management of an aviation system capacity study provided valuable knowledge of airports, increasing her effectiveness in airport sustainability.

Purcell currently chairs the TRB Standing Committee on Environmental Issues in Aviation and was a member of the Standing Committee on Aviation System Planning. She served on several Airport Cooperative Research Program (ACRP) project panels and chaired two panels: Integrating Airport Sustainability Plans with Environmental Analyses and Quantifying Emissions Reductions at Airports from the Use of Alternative Jet Fuels. She was a member of the ACRP Synthesis of Information Related to Airport Practices project panel and participated on a special panel addressing implementation of the *ACRP Strategic Plan*. With her accreditations from the American Institute of Certified Planners in the early 1990s and the United States Green Building Council in 2004, she has had an informed front-row seat to the looming climate crisis.

She recognizes that "airports are increasingly challenged to demonstrate they have *a social license to operate*." Purcell recalls first hearing this phrase and thinking, "Of course, airports should operate. They are essential to the movement of people and goods." Today, she foresees, "climate change will force difficult conversations about the role of air travel in our society." While some advocates call for less flying or more trains as the solution, Purcell notes, "the answers are more complex. Research helps airports understand what can be done, as well as best practices for how. Decisions grounded in data and science help to gain public and stakeholder trust." Although she sees research as a key tool, she wonders "how can we make those solutions happen for transportation?" As a society, we can no longer just *mind* the gap, but we need to figure out how to *fill* the gap so concept and implementation flow as one process.

INFLUENCER

John C. Andoh

John C. Andoh is the mass transit administrator and general manager of the County of Hawai'i Mass Transit Agency. Since assuming this position in January 2022 after a six-month period as interim administrator, he is becoming known as an innovative thinker with a passion for using transit to connect people to community. A TRB member since 2014, he is co-chair for the Transit Cooperative Research Program (TCRP) project panel on the Analysis of Public Transportation Health Impacts and Benefits.

What is your role as mass transit administrator and general manager?
I am the chief executive officer for the transit agency in Hawai'i County. The agency is responsible for providing all islandwide public transportation services across 4,200 square miles on the island of Hawai'i. We operate fixed-route bus, paratransit, shared-ride taxi, vanpool, bikeshare, rural dial-a-ride and—soon—microtransit services. The County of Hawai'i Mass Transit Agency also is a regulatory agency for taxicabs and other transportation means on the island.

How did this role change during the COVID-19 pandemic?
Our public bus system, Hele-On (which means travel on), has faced declining ridership for the past seven years. The pandemic caused it to further decline to the point where public transit services were not cost effective. Fortunately, a *Transit and Multi-Modal Transportation Master Plan* was sitting on the shelf partially implemented. I was hired to rebuild the transit system and start implementing the many options within this plan. As a result of these efforts, we saw a 62 percent increase in trips made on the public transit system between the various modes that we are operating. I feel I have become the architect of a new public transit system that will provide great value to Hawai'i County residents and visitors.

What do you think is helping you to be successful as co-chair of the TCRP project panel on the Analysis of Public Transportation Health Impacts and Benefits?
I am able to take health impacts into consideration and understand how health influences transit passengers, as well as their quality of life. We have to change our ways regarding how people interact on public transit systems—from cleaning to proper space considerations and barriers to ensure the safety and the welfare of employees. Furthermore, there is an active component to public transportation that we sometimes overlook: Walking and biking can lead to healthy lifestyles and to a well-balanced, active public transportation system.

How has TRB influenced your career so far?
I have served on six TRB project panels since 2017 and it has been amazing. TRB has taught me a lot of best practices that I have been able to implement at the transit systems I have led. In reviewing reports, I have been able to share good insights so other transit systems can benefit from these research efforts. I look forward to more active participation in TRB to make a difference in the overall U.S. transportation network.

Transportation Influencer highlights the journey of young professionals active in TRB. Have someone to nominate? Send an e-mail to TRNews@nas.edu.

Let's Hear from You!

In each issue, we pose a sometimes light and fun transportation-related question that allows you to share your thoughts with other readers. To answer, **click here** or e-mail us at **TRNews@nas.edu** and follow these simple steps:

1. In the subject line, include **"Volunteer Voices: [the question you're answering]";**
2. Answer the question thoughtfully, but keep it brief—up to about 150 words;
3. Add whether you are a TRB member or volunteer, and list the committees you are involved with; and
4. Add TRNews@nas.edu to your contacts so we avoid your spam folder when we tell you you're going to be published.

That's it! Like all *TR News* content, your response may be edited for grammar, length, and TRB style. When the issue with your quote is published, you'll get a PDF of the page featuring your response and photo.

Now that you have the details, here's the question:
What is today's biggest challenge in transportation, and how would you resolve it?

For the People and the Mission

In June 2021, the National Academies of Sciences, Engineering, and Medicine created the Office of Diversity and Inclusion and selected Laura Castillo-Page as its first chief diversity and inclusion officer. Karen Febey, TRB senior report reviewer, spoke with her to learn more about her work and diversity, equity, and inclusion (DEI) objectives at the Academies.

What is your professional background, and what did you do before you came to the Academies?

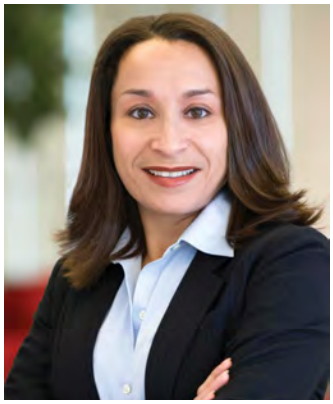
I currently serve as the chief diversity and inclusion officer for the Academies. After completing my doctorate, I began a career as a research scientist as well as a faculty member focused on DEI topics. Prior to joining the Academies, I worked at the Association of American Medical Colleges as senior director for DEI, where I led a portfolio of work to advance learning and workplace environments focused on achieving an inclusive culture.

What are the reasons that you decided to accept the position as the Academies' chief diversity officer?

I was drawn in by the people and the mission. Of course, I knew about the great work of the Academies—it often guided my own work. I was attracted to the organization's mission and by the opportunity to contribute to that mission from a DEI perspective. Ultimately, the staff, members, and volunteers that I would be able to work with collaboratively to advance DEI greatly influenced my decision to accept this position.

You started your position during the pandemic. How do you see the pandemic affecting the Academies' DEI work?

It was certainly an interesting experience to start working with people before many of us had even met in person. Although we have all been challenged by so many issues in the past few years, we have been able to move forward with our DEI work. In fact, the COVID-19 pandemic, along with the systemic societal inequities raised in the past few years, further highlighted the importance of advancing DEI—now more than ever—within our organizations and society.



Laura Castillo-Page (*above*), the Academies' first chief diversity and inclusion officer, shared her thoughts with Karen Febey, TRB senior report review officer.

What do you see as the biggest steps forward in the Academies' DEI work since you have started this position?

One big step was to, first and foremost, establish an infrastructure within the organization to lead this work. Once we formed our first Office of Diversity and Inclusion and the DEI Council, we established the mission, which is to foster a culture that values DEI at the Academies, as well as across the science, technology, engineering, and mathematics fields, through inclusive practices and evidence-based DEI strategies. This is the culture that will strengthen the Academies' ability to meet its mission of providing independent, objective analysis and advice to inform public policy decisions and help solve some of society's most complex problems.

What are your short- and long-term priorities moving forward?

We are getting ready to launch our first DEI Action Plan, which will support the broader DEI goals in the Academies Strategic Plan. Our plan will highlight the efforts we undertake as an organization to address the six pillars of our DEI strategy.

What do you like to do when you are not working?

I am a wife, mother of two amazing kids, and a dog mom. When I'm not at work, I simply love spending time with them, and I also enjoy running, cooking, and just being out in nature.

More information on DEI work at the Academies can be found in the Office of Diversity and Inclusion's annual report, available at https://nap.nationalacademies.org/catalog/26711/office-of-diversity-and-inclusion-annual-report-2021-2022-building.

The National Academies Diversity, Equity, and Inclusion Pillars

1. Build an infrastructure and develop capacity;
2. Foster a culture of inclusion and belonging;
3. Examine and refine hiring and advancement policies and practices;
4. Apply a DEI lens to programs and initiatives;
5. Enhance policies, processes, and practices to diversify academy members, volunteers, contractors, and local partnerships; and
6. Increase accountability, communication, and data transparency.

Meet TRB's New Executive Director Victoria Sheehan

On December 5, 2022, TRB welcomed Executive Director Victoria Sheehan. Sheehan, who was born in Ireland and initially came to New Hampshire to work at a summer camp, moved to the United States after receiving a master's degree in structural engineering and architecture from the University of Edinburgh in Scotland. She spent 10 years at the Massachusetts Department of Transportation (DOT) leading strategic planning and highway performance, managing the bridge consulting program, and overseeing an eight-year $3 billion Accelerated Bridge Program. She joined the National Academies after seven years as the commissioner of New Hampshire DOT, where she was responsible for an operating budget of more than $650 million, oversight of a staff of more than 1,600 employees, and honing the mindset that "transportation impacts the quality of life for everyone in our state," as she led the development of New Hampshire's Ten-Year Transportation Plan.[1]

Concurrently, while Sheehan was AASHTO vice president in 2019–2020, she led a panel on asset management at the 99th TRB Annual Meeting with the goal of helping state DOTs see the value in "preserving what we have" as opposed to building new infrastructure. Her approach was to gain consensus, calm concerns, and promote change by, as she commented in an AASHTO interview, showing that "this is not some monumental task—there are intermediate steps to bring results immediately—the DOTs can take things on in bite-size amounts."[2] At the end of her term, Sheehan was elected as AASHTO's 2020–2021 president. During her presidency, she emphasized two goals: articulating the value of transportation and taking a hard look at looming workforce challenges. In May 2021, she addressed the U.S. Senate Committee on Finance as the voice of AASHTO, outlining the need to provide all state DOTs with the security of long-term federal funding. Concise but detailed projections informed Congress that "to simply maintain the current Highway Trust Fund spending levels adjusted for inflation" would require "$74.8 billion in additional revenues for a five-year bill through 2026," and paved the way for the $110 billion in additional funding authorized for a five-year period by the Infrastructure Investment and Jobs Act.[3, 4]

With this view of Sheehan's past accomplishments, it is easy to ponder—with more than a little excitement—just where the new executive director will lead TRB.

New Hampshire DOT

Victoria Sheehan meets with New Hampshire Department of Transportation staff to discuss emergency repairs after flooding in 2017.

AASHTO

Victoria Sheehan addressed the AASHTO Board of Directors during the AASHTO 2021 Annual Meeting.

[1] Read *NH Business Review's* Q&A with Transportation Commissioner Victoria Sheehan at https://www.nhbr.com/qa-with-transportation-commissioner-victoria-sheehan/.
[2] Watch the full AASHTO interview at https://www.youtube.com/watch?v=5TSF9axOgEA.
[3] Find AASHTO President Sheehan's full testimony to Congress at https://www.finance.senate.gov/imo/media/doc/Testimony%20-%20Victoria%20Sheehan.pdf.
[4] More information on the transportation benefits of the Infrastructure Investment and Jobs Act may be found at https://www.whitehouse.gov/bipartisan-infrastructure-law/#roadsandbridges.

ZUMA Press, Inc., Alamy

Then New Hampshire DOT Commissioner Victoria Sheehan introduced President Joe Biden, who spoke on the recently passed Infrastructure Investment and Jobs Act. This legislation will fund repairs to this bridge over the Pemigewasset River in Woodstock, New Hampshire, on which they were standing.

"Throughout my career I have been a passionate advocate for investment in safe and efficient transportation solutions that improve quality of life, provide access to opportunity for individuals, and support economic vitality. The passage of the Bipartisan Infrastructure Law provides an unprecedented level of investment in transportation. To ensure those dollars are used effectively, as TRB executive director, I am committed to promoting the work of TRB, so that it is leveraged by those making investment decisions today, while continuing to provide research that supports the transportation sector in making sound decisions in the future."

COVID-19's Effects on State Transportation Funding and Finance

JAIME RALL

The author is the principal at J. R. Rall Consulting and has been the lead investigator for all three editions of *Transportation Governance and Finance*.

Andy Atzert, Flickr, CC BY 2.0

When all but nonessential workers were told to stay home during the COVID-19 pandemic, transit revenues plummeted and stations like this one at the World Trade Center in New York were eerily empty.

How has the COVID-19 pandemic affected state transportation funding and finance so far, and how might it be expected to continue to do so in the coming years? These are two of the questions hundreds of state survey respondents were asked for the third edition of *Transportation Governance and Finance: A 50-State Review of State Legislatures and Departments of Transportation,* a unique NCHRP 20-24 project that examines how all 50 states and the District of Columbia pay for and manage their transportation systems.

Across the states, respondents unsurprisingly concurred that the pandemic had an early negative effect on state transportation revenues. Motor and aviation fuel taxes, tolls, and transit fares (which are typically local or regional revenues but are also collected by a few states) were hit especially hard. These effects can be attributed to stay-at-home orders, shifts to telework, travel restrictions, and a reluctance to use shared transportation modes.

However, remarkable variations were reported in the size of those effects and how quickly collections were recovering.

Dale Cruse, Flickr, CC BY 2.0

As travel and commuting to work start to pick up again, toll plazas across the nation are generating revenue and seeing an increased stream of customers.

StartupStockPhotos, Pixabay

Stay-at-home orders made many workers adjust their living spaces to include efficient workspaces, as well. Although this was not easy at first, now that workers have made the adjustment, will they want to leave the house? If employers see a way to downsize office space, will they want to continue to provide workers with dedicated, on-site office space or will they trim expenses?

While many states indicated that revenues had already returned to or exceeded pre-pandemic levels as of January 1, 2022, others projected continued reductions some years into the future. Washington State, for example, did not expect certain revenue sources to bounce back until later this decade. Ohio recalled its experience with the economic downturn that started in 2007 and 2008, when fuel taxes took almost 10 years to recover and believed that a similar pattern might play out this time as well. Delaware projected a return to pre-COVID levels by FY 2023 but estimated that growth rates would be affected up to FY 2028.

COVID-19 is not, of course, the only major disruptor to the transportation sector with which states are having to deal. Pennsylvania, while taking the broader situation into account, observed that, "Fuel tax revenues are not projected to return to pre-pandemic levels for at least the next five years and, with growing fuel efficiency and the adoption of electric vehicles, likely never will."

In some states, while some revenues fell, others stayed steady or even increased. For example, in Iowa and Michigan, registration fees and taxes helped offset fuel tax reductions, as did vehicle sales taxes in South Carolina and Vermont. Montana and Oregon saw growth in trucking-related revenues due to increased freight movement. In Nebraska and New Jersey, statutory fuel tax rate adjustments more than made up for initial losses.

To respond to dips in transportation revenues, states acted to both increase available dollars and cut costs. To raise revenues, Colorado created new fees on transportation network companies and online deliveries—both of which grew in use due to the pandemic. Delaware and Rhode Island issued bonds. Federal relief funds from the Coronavirus Aid, Relief, and Economic Security Act, the Coronavirus Response and Relief Supplemental Appropriations Act, and the American Rescue Plan Act also helped cover state shortfalls.

State efforts to cut spending included reducing operating expenses, delaying construction projects, cutting back on routine maintenance, adjusting or deferring state aid to cities and counties, refinancing debt, and using fund balance reserves. Connecticut slowed its state DOT hiring and decreased public transit service levels, and Missouri purchased only essential items and began a shared work and salary reduction program to reduce personal service and fringe benefit costs.

Respondents described many other effects on transportation funding and finance so far. In terms of revenues, Colorado, Illinois, Iowa, and Oregon

Oregon Department of Motor Vehicles, Pixabay, CC BY 2.0

At the start of the COVID-19 pandemic, Oregon closed all Department of Motor Vehicles offices until further notice under Governor Kate Brown's Stay Home, Save Lives Executive Order. The goal was to limit the spread of COVID-19 by protecting both workers and customers. The closure, from March 18, 2020, to June 2, 2020, ended with a limited number of offices opening by appointment for certain transactions and enforcement of social distancing and masking.

David Mark, Pixabay

Some states were able to save on cutbacks during the COVID-19 pandemic. The suspension of tourism meant that passenger trains like this Amtrak double-decker Superliner saved money for states like Vermont and the federal government.

reported distortions or delays to vehicle fee collections due to Department of Motor Vehicles office closures. On the expenditures side, many observed that supply chain disruptions and shortages of materials and labor had led to increased construction costs and delays. At the same time, in Hawai'i and New Jersey, lower traffic volumes allowed certain road projects to be accelerated; in New Jersey, this kind of work is typically much more expensive because congestion requires it to be performed at night and on extended timelines. In Vermont, the suspension of Amtrak service saved state and federal dollars.

Other repercussions were also expected over the longer term. Some respondents expressed concerns about persistent reductions in transit ridership, which in some cases may lead to a greater state share of transit operating expenses. In Minnesota, a recently enacted law requires the state DOT to coordinate a study on post-pandemic public transit, including an examination of anticipated changes in revenues and expenditures. Other predictions included ongoing cost increases, supply chain disruptions, and labor shortages. Many respondents reflected on the possible lasting effects on travel patterns, but these are by no means certain. Will an enduring shift toward telework mean less vehicle travel, lower gasoline sales, and reduced fuel tax collections moving forward? Or, as one respondent suggested, is any decrease in commuter travel likely to be offset by overall economic growth, which could boost online deliveries and travel for leisure activities while opening opportunities for other types of taxes to help pay for transportation investments? There's no crystal ball, but what is certain is that these are trends to watch.

For more information, visit https://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=5077.

Raman Oza, Pixabay

Tourism saw a dramatic decrease during the COVID-19 pandemic. Although some parts of the industry are on the rise—cruises, for example, are only back to 2006 levels—national parks have seen tourism rise as well. However, some parks, such as Yellowstone—most of which is in Wyoming, but spills into neighboring Montana and Idaho—experienced flooding and other extreme weather events that limited visits. The future of tourism remains hard to predict.

AASHTO's Transportation Governance and Finance: A 50-State Review of State Legislatures and Departments of Transportation

JAIME RALL

The author is the principal of J. R. Rall Consulting and has been the lead investigator for all three editions of *Transportation Governance and Finance*.

The third edition of *Transportation Governance and Finance: A 50-State Review of State Legislatures and Departments of Transportation*, is the culmination of a unique National Cooperative Highway Research Program (NCHRP) Project 20-24 examining how all 50 states and the District of Columbia pay for and manage their transportation systems. Published by AASHTO, this edition of the report updates its 2011 and 2016 predecessors of the same title.

Until about a decade ago, there was no one-stop, 50-state compendium about state-level transportation governance and finance. If an organization

or state agency had a question about what all the states were doing to govern, oversee, fund, or finance their transportation programs, they often had to do their own research from scratch, either by searching for relevant state laws or reaching out to their counterparts across the states.

In 2011, AASHTO partnered with the National Conference of State Legislatures to fill that gap. The team used in-depth survey research to find out what each state was doing to govern and pay for its transportation systems and integrated the resulting data into one navigable reference tool, designed to answer state stakeholders' most-asked questions. The final report described those who participate in state transportation matters (at all levels of government and beyond), how state legislatures and departments of transportation (DOTs) interact when making policy and overseeing programs, and funding and finance approaches across the states. The report contained a nationwide synthesis with cross-jurisdictional comparisons, accompanied by detailed state-by-state profiles.

NCHRP INVOLVEMENT

NCHRP Project 20-24, which supports studies of particular interest to senior leadership of state DOTs, funded a second edition of the report in 2016 to reflect how the environment for transportation changed as a result of federal legislation (notably, the Moving Ahead for Progress in the 21st Century Act and the Fixing America's Surface Transportation Act), as well as innumerable state actions. In response to user feedback on the first report, the second edition made the following improvements:

- Clarified whether each funding and finance option was only authorized in law or actually in use;
- Explored new topics, such as state roles in local transportation funding; and
- Added legal citations throughout to support readers in doing their own follow-up research.

THE UPDATED EDITION

The third edition, released in 2022, provides another fresh update that reflects how the transportation governance and finance landscape has continued to evolve both in the states and nationally. Since 2016, several states have revised their transportation governance models, at least 35 states and the District of Columbia have raised their transportation revenues, and several states have been actively considering how to restructure or even replace gasoline taxes to ensure sustainable funding into the future. States are also reckoning with the impacts of shared, electric, autonomous, and connected vehicles on transportation programs, as well as the repercussions of the COVID-19 pandemic. At the federal level, enactment of the Infrastructure Investment and Jobs Act in 2021 provided historic funding for transportation infrastructure while creating new policies and programs that will shape the roles and responsibilities of state partners for years to come.

In addition to thoroughly updating the information from the previous edition, the current publication again presents new topics of interest. These include emerging jurisdictional issues for state DOTs, transportation-related revenues that are being used for nontransportation purposes, state actions to optimize available funding and increase local flexibility, the effects of COVID-19 on transportation governance and finance, and the current rates of every state's fuel taxes and vehicle registration fees. The survey research achieved a 100 percent response rate, in that at least one response was received for each survey from every state and the District of Columbia. Drawing on the survey respondents' enormous wealth of knowledge and experience, the report also features practical strategies and lessons learned from across the states.

For more on this AASHTO publication, see Page 50.

COOPERATIVE RESEARCH PROGRAMS NEWS

WINTERTIME PAVEMENT MAINTENANCE PRACTICES

CTC & Associates received a $55,000, 18-month contract [National Cooperative Highway Research Program (NCHRP) Synthesis 20-05/Topic 54-18] to create a synthesis report that documents current state department of transportation (DOT) practices for reactive winter pavement maintenance. Information will be gathered through a literature review, a survey of state DOTs, and follow-up interviews with selected DOTs for the development of case examples. Information gaps and suggestions for research to address those gaps will be identified.

For further information, contact Jo Allen Gause, TRB, at 202-334-3826 or JAGause@nas.edu.

TRUCK PARKING INFORMATION MANAGEMENT SYSTEMS

Cambridge Systematics was awarded a $499,911, 22-month contract (NCHRP Project 08-140) to develop a guide that presents rational practices for truck parking information management systems. The guide should be a resource for state DOTs in implementing information management practices that address commercial vehicle parking needs, thereby reducing the challenges associated with the search for safer parking options.

For further information, contact Amir Hanna, TRB, at 202-334-1432 or AHanna@nas.edu.

Chris Sharkman, Pixabay

Truck parking demand exceeds the available supply in many public rest areas and private truck stops across the nation. A new NCHRP report will investigate the application of information management practices to ease this problem.

PUBLIC TRANSIT AND RIDE SHARING BEST PRACTICES

Texas A&M Transportation Institute received a $250,000, 24-month contract (NCHRP Project 08-130) to create a report and implementation guidebook on innovative applications for integrating public transportation in less-populated areas with shared-use mobility services and providers. For this research, shared-use mobility services include ride sharing, car sharing, ride hailing, microtransit, mobility on demand, and vanpooling services/systems. The report will include case studies of urban, rural, and frontier partnerships, and highlight challenges and solutions.

For further information, contact Christopher McKenney, TRB, at 202-334-2218 or cmckenney@nas.edu.

DIGITAL TWINS FOR AIRPORTS

InterVISTAS Consulting received a $350,000, 18-month contract [Airport Cooperative Research Program (ACRP) Project 03-66] to provide a guidebook for airports to understand the concept of digital twins and the potential stakeholder benefits, as well as to develop a roadmap for implementation of a digital twin program. The guidebook and roadmap should be scalable to airports of all sizes and accompanied by an executive summary for airport leadership.

For further information, contact Matthew J. Griffin, TRB, at 202-334-2366 or MJGriffin@nas.edu.

EQUITY IN PEDESTRIAN AND BICYCLIST MOBILITY, SAFETY, AND HEALTH: IMPACT OF RACIAL BIAS

The RAND Corporation received a $500,000, 28-month contract [Behavioral Traffic Safety Cooperative Research Program (BTSCRP) Project BTS-21] to assess the nature and magnitude of racial disparities in traffic safety-related policing involving pedestrians, bicyclists, and micromobility users. The steps communities are taking to address the effects of biased enforcement, such as community-led programs, technology-based systems, organizational or policy changes, changes to traffic-related laws, training and education of police officers, or other interventions will be described. A framework to evaluate the impacts and equity outcomes of these approaches will be developed and applied to establish recommendations for mitigating inequities in enforcing traffic-related laws.

For further information, contact Richard Retting, TRB, at 202-334-2418 or RRetting@nas.edu.

Erica Fischer, Flickr, CC BY 2.0

A pair of New York City pedestrians risk jaywalking across a busy street, a common—but largely illegal—practice throughout the United States. BTSCRP research will examine racial disparities in the enforcement of traffic laws—including jaywalking—upon pedestrians, bicyclists, and micromobility users.

MEMBERS *ON THE MOVE*

Michael Brooks joined TRB as a senior program officer for the National Cooperative Highway Research Program (NCHRP). Previously, he was a senior analyst for Noblis, Inc.

Alexandra Briseno, former TRB senior librarian, became the archivist for the National Academies of Sciences, Engineering, and Medicine in December 2022.

Rich Cunard, senior program officer of traffic and operations, retired from TRB's Technical Activities Division after 33 years of service on December 31.

Paula Hammond, WSP senior vice president and multimodal national market leader, is the first woman elected chair of the American Road and Transportation Builders Association.

Tony Opperman, former Virginia Department of Transportation preservation program manager, member of several NCHRP project panels, and past chair of TRB's Committee on Historic and Archaeological Preservation in Transportation, retired.

Commuting in America 2021: The National Report on Commuting Patterns and Trends—Brief 21.3. The Evolution of Households

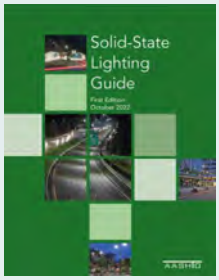
AASHTO. ISBN 978-1-56051-793-1. To download this free PDF, go to https://store.transportation.org/Item/PublicationDetail?ID=5027.

This AASHTO brief explores the evolution of households as related to commuting. The household has been the basic unit of analysis in trip generation and travel demand estimation since the beginning of regional modeling. Provided is a summary of how the composition and characteristics of households have changed over time, and how those changes have affected travel demand. This analysis focuses on the time since 1995, when the growth in travel rates started to slow. Since the turn of the millennium, U.S. travel rates have declined. Population growth is fueling increases in road traffic, but not greater amounts of travel per person.

Commuting in America 2021: The National Report on Commuting Patterns and Trends—Brief 21.4. Emerging Modes and How to Measure Them

AASHTO. ISBN 978-1-56051-797-9. To download this free PDF, go to https://store.transportation.org/Item/PublicationDetail?ID=5028.

Transportation planners face considerable uncertainty regarding the development and deployment of emerging transportation technologies. The impacts of emerging technology on mobility and the expected resulting changes call for data and research to support planning, policy, and operations. This AASHTO brief provides a summary of emerging modes of travel, including ride hailing, ride sharing, micromobility, car sharing, connected and autonomous vehicles, and telemobility. It also introduces the data available for analyzing each of these modes and provides suggestions for future datasets and methodologies to shed light on their use.



Solid-State Lighting Guide, 1st Edition

AASHTO. ISBN 978-1-56051-792-4. To purchase this downloadable PDF, go to https://store.transportation.org/Item/CollectionDetail?ID=238.

AASHTO's *Solid State Lighting Guide* offers guidance on design standards and methods of implementing solid-state lighting technology. This publication explains the differences between solid-state lighting systems and traditional lighting systems and provides guidance on design, electrical systems maintenance, operations, and environmental impacts. This guide also identifies areas where additional research is needed.

Transportation Governance and Finance: A 50-State Review of State Legislatures and Departments of Transportation, 3rd Edition

AASHTO. ISBN 978-1-56051-796-2. To download the PDF, go to https://store.transportation.org/Item/PublicationDetail?ID=5029.

Based on survey data from state department of transportation personnel and other transportation stakeholders, this AASHTO report is a comprehensive, up-to-date reference regarding how the 50 states and the District of Columbia provide and pay for their transportation systems. The report details all transportation funding sources and finance tools that are now in use for every mode, in every state. This third edition of the report integrates survey respondents' lessons learned and on-the-ground experiences.

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

TRB PUBLICATIONS

Transportation Research Record 2676, Issue 9

Factors influencing roundabout performance, first and last miles by cargo bikes, the potential for U.S. rail safety statistics to undercount suicides, the safety performance of unsignalized median U-turn intersections, and other topics are examined in this issue.

Transportation Research Record 2676, Issue 10

This issue includes research on e-scooter safety regulations, construction of a composite pavement, fare capping policies in the United States, a curb space evaluation tool, teen driver distractions, understanding crash risk, and the 2022 research that won the Pyke Johnson Award, Fred Burggraf Award, and William W. Millar Award.

Transportation Research Record 2676, Issue 11

This issue includes research on injury severity analysis for large truck–involved crashes, procurement benchmarks for major transportation projects, a dynamic routing algorithm for hazmat transportation problems, and other topics.

Transportation Research Record 2676, Issue 12

Real-time crash-risk optimization at signalized intersections, classification of flexible pavements based on texture data, effects of cooperative adaptive cruise control on traffic stability, in-depth understanding of near-crash events through pattern recognition, and other topics are examined in this issue.

SAGE is the publisher of the Transportation Research Record: Journal of the Transportation Research Board (TRR) series. To search for TRR articles, visit http://journals.sagepub.com/home/trr. To subscribe to the TRR, visit https://us.sagepub.com/en-us/nam/transportation-research-record/journal203503#subscribe.

Guidelines for the Development and Application of Crash Modification Factors
NCHRP Research Report 991

This report provides guidelines for developing and applying crash modification factors (CMFs) in road safety practice and interactive tools to support their use. CMFs provide transportation professionals with the quantitative information they need to make decisions regarding where to invest limited safety funds.

2022; 404 pp.; TRB affiliates, $88.50; TRB nonaffiliates, $118. Subscriber categories: highways, operations and traffic management, safety and human factors.

Use of 0.7-in. Diameter Strands in Precast Pretensioned Girders
NCHRP Research Report 994

This report presents the design methodology for precast pretensioned girders using 0.7-in. diameter strands based on comprehensive analytical and testing programs. The use of 0.7-in. diameter strands would help bridge designers extend the spans of existing girder shapes.

2022; 160 pp.; TRB affiliates, $68.25; TRB nonaffiliates, $91. Subscriber categories: bridges and other structures.

Automated Data Collection and Quality Management for Pavement Condition Reporting
NCHRP Synthesis 589

This synthesis documents the experiences, challenges, and state-of-the-practice solutions used by state DOTs that are either amid transition or have transitioned to automated and semiautomated processes for collecting pavement data. Data for state and federal reporting requirements, such as Transportation Asset Management Plans and the Moving Ahead for Progress in the 21st Century Act also are summarized.

2022; 118 pp.; TRB affiliates, $60.75; TRB nonaffiliates, $81. Subscriber categories: highways, data and information technology, pavements.

Toward a Touchless Airport Journey
ACRP Research Report 241

This report is a quick reference guide for all types and sizes of airports and their third-party vendors. The report identifies readily available touchless technology features, near-term solutions, and best practices to allow a safe and efficient journey. For each solution, the current level of readiness, barriers to implementation, and specific tips on getting started are described.

2022; 68 pp.; TRB affiliates, $49.50; TRB nonaffiliates, $66. Subscriber categories: aviation, passenger transportation, terminals and facilities.

Airport Parking Pricing Strategies
ACRP Synthesis 118

This synthesis provides information that airport staff and others require to select and implement rate-making strategies that serve their airports' needs. This information was gathered through a comprehensive literature review and in-depth surveys of the staff directly responsible for parking operations and rates at 30 participating airports ranging in size from large hubs to non-hubs across all nine FAA regions.

2022; 52 pp.; TRB affiliates, $46.50; TRB nonaffiliates, $62. Subscriber categories: aviation.

Behavioral Traffic Safety Messaging on Variable Message Signs
BTSCRP Research Report 3

This report provides an evidence-based approach to help guide behavioral traffic safety message design and display on variable message signs.

2022; 82 pp.; TRB affiliates, $54.75; TRB nonaffiliates, $73. Subscriber categories: highways, operations and traffic management, safety and human factors.

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MEETINGS, WEBINARS, AND WORKSHOPS

February

28 **TRB Webinar: Pavement Foundations with Conventional and Unconventional Stabilizers**

March

2 **TRB Webinar: Strategies to Reduce Highway Traffic Noise**

April

11–12 **Workshop on Building More Resilient Supply Chains**
Washington, DC
For more information, contact Scott Babcock, TRB, 202-334-3208, SBabcock@nas.edu.

May

9–10 **TRB's International Conference on Road Weather and Winter Maintenance***
Washington, DC
For more information, contact Stephen Maher, TRB, 202-334-2955, SMaher@nas.edu.

15–18 **11th National Aviation System Planning Symposium**
For more information, contact Christine Gerencher, TRB, 202-334-2970, CGerencher@nas.edu.

17–19 **11th Young Researchers Seminar***
Lisbon, Portugal
For more information, contact Bill Anderson, TRB, 202-334-2514, WBAnderson@nas.edu or Bernardo Kleiner, TRB, 202-334-2964, BKleiner@nas.edu.

June

4–6 **Innovations in Travel Analysis and Planning**
Indianapolis, Indiana
For more information, contact Claire Randall, TRB, 202-334-1391, CRandall@nas.edu.

*TRB is co-sponsor of the meeting.

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VOLUNTEER VOICES

"My first TRB Annual Meeting was in 2013 when I was on an internship in Northern Saskatchewan with the provincial Ministry of Transportation. I needed to get out of the cold northern Canadian winter and wrote a paper on the history of commuter rail for submission to TRB. The doorman at the Dupont Circle Hotel was quite confused by my great pleasure with the "tropical" weather. It was snowing and just below freezing. I had a lot of fun with the doormen that year. I once asked where I could get dinner and was immediately directed to a fast-food chain. Clearly, I was radiating my status as a poor student!

—JASON HAWKINS
Assistant Professor
Department of Civil and Environmental Engineering
The University of Nebraska–Lincoln

INFORMATION FOR CONTRIBUTORS TO TR NEWS

TR News welcomes the submission of articles for possible publication in the categories listed below. All articles submitted are subject to review by the Editorial Board and other reviewers to determine suitability for *TR News*; authors will be advised of acceptance of articles with or without revision. All articles accepted for publication are subject to editing for conciseness and appropriate language and style. Authors review and approve the edited version of the article before publication. All authors are asked to review our policy to prevent discrimination, harassment, and bullying behavior, available at https://www.nationalacademies.org/about/institutional-policies-and-procedures/policy-of-harrassment.

ARTICLES

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

MINIFEATURES are concise feature articles, typically 1,500 words in length. These can accompany feature articles as a supporting or related topic or can address a standalone topic.

SIDEBARS generally are embedded in a feature or minifeature article, going into additional detail on a topic addressed in the main article or highlighting important additional information related to that article. Sidebars are usually up to 750 words in length.

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

RESEARCH PAYS OFF highlights research projects, studies, demonstrations, and improved methods or processes that provide innovative, cost-effective solutions to important transportation-related problems in all modes. Research Pays Off articles should describe cases in which the application of project findings has resulted in benefits to transportation agencies or to the public, or in which substantial benefits are expected. Articles (approximately 750 to 1,000 words) should delineate the problem, research, and benefits, and be accompanied by the logo of the agency or organization submitting the article, as well as one or two photos or graphics. Research Pays Off topics must be approved by the RPO Task Force; to submit a topic for consideration, contact Nancy Whiting at 202-334-2956 or nwhiting@nas.edu.

OTHER CONTENT

TRB HIGHLIGHTS are short (500- to 750-word) articles about TRB-specific news, initiatives, deliverables, or projects. Cooperative Research Programs project announcements and write-ups are welcomed, as are news from other divisions of the National Academies of Sciences, Engineering, and Medicine.

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

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- **Articles** submitted for possible publication in *TR News* and any correspondence on editorial matters should be sent to the *TR News* Editor, Cassandra Franklin-Barbajosa, cfranklin-barbajosa@nas.edu, 202-334-2278.
- Submit **graphic** elements—photos, illustrations, tables, and figures—to complement the text. Photos must be submitted as JPEG or TIFF files and must be at least 3 in. by 5 in. and 2 megabytes with a resolution of 300 dpi. Large photos (8 in. by 11 in. with a minimum of 4 megabytes at 300 dpi) are welcome for possible use as magazine cover images. A detailed caption must be supplied for each graphic element.

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