TR NEWS

April–June 2024

NUMBER 349

TRB 103rd Annual Meeting

PLUS

Rehabilitating Culverts

Design–Build Skills

Electric Vehicles in Rural America

NATIONAL ACADEMIES *Sciences Engineering Medicine*

TRB TRANSPORTATION RESEARCH BOARD

NATIONAL ACADEMIES *Sciences Engineering Medicine*

The **National Academy of Sciences** was established in 1863 by an Act of Congress, signed by President Lincoln, as a private, non- governmental institution to advise the nation on issues related to science and technology. Members are elected by their peers for outstanding contributions to research. Dr. Marcia McNutt is president.

The **National Academy of Engineering** was established in 1964 under the charter of the National Academy of Sciences to bring the practices of engineering to advising the nation. Members are elected by their peers for extraordinary contributions to engineering. Dr. John L. Anderson is president.

The **National Academy of Medicine** (formerly the Institute of Medicine) was established in 1970 under the charter of the National Academy of Sciences to advise the nation on medical and health issues. Members are elected by their peers for distinguished contributions to medicine and health. Dr. Victor J. Dzau is president.

The three Academies work together as the National Academies of Sciences, Engineering, and Medicine to provide independent, objective analysis and advice to the nation and conduct other activities to solve complex problems and inform public policy decisions. The National Academies also encourage education and research, recognize outstanding contributions to knowledge, and increase public understanding in matters of science, engineering, and medicine.

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The Transportation Research Board is one of seven major program divisions of the National Academies of Sciences, Engineering, and Medicine. The mission of the Transportation Research Board is to mobilize expertise, experience, and knowledge to anticipate and solve complex transportation-related challenges. The Board's varied activities annually engage about 8,500 engineers, scientists, and other transportation researchers and practitioners from the public and private sectors and academia, all of whom contribute their expertise in the public interest. The program is supported by state transportation departments, federal agencies including the component administrations of the U.S. Department of Transportation, and other organizations and individuals interested in the development of transportation.

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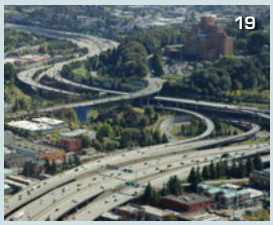

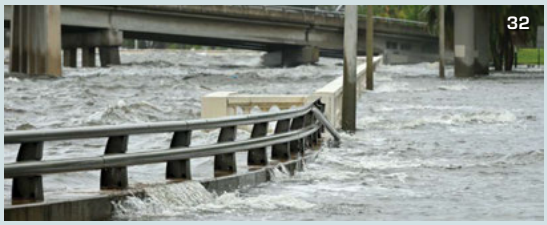

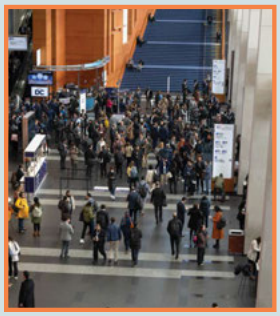

Risdon Photography

COVER Transportation professionals, academicians, and students gather at the Walter E. Washington Convention Center in Washington, DC, for the 103rd TRB Annual Meeting.

Coming Next Issue

The July–September 2024 issue of *TR News* features a diverse selection of articles. Authors look at the challenges presented by oil spills and the advances in oil spill science; guidance in evaluating the historic significance of post–World War II commercial properties; and the uncertainty of federal funding in state, local, and regional departments of transportation.

Courtesy of the Bureau of Safety and Environmental Enforcement

Flanked by orange collection booms, an oil spill response vessel sweeps surface water during a deployment training in Lake Charles, Louisiana. Improved preparedness and industry training have helped reduce the impact of oil in marine environments.

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.

***TR News* is produced by the Transportation Research Board**

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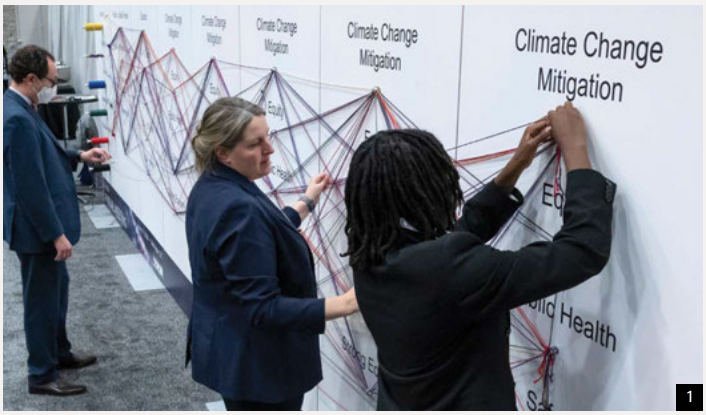
Examining Critical Issues in Transportation

For another year, Washington, DC, was abuzz as transportation professionals from around the world convened for the 103rd TRB Annual Meeting. From January 7 to 11, 2024, some 13,600 attendees gathered for committee meetings, poster and lectern sessions, award presentations, and a fireside chat on mental health in the construction and transportation industries, followed by closing remarks from U.S. Department of Transportation Secretary Pete Buttigieg.

Sessions and workshops addressed topics of interest to policy makers, administrators, practitioners, researchers, and students—many focused on artificial intelligence; electric vehicle infrastructure; and the role of transportation in addressing critical issues such as road safety, public health, and equity and inclusion. Environmental science and policy expert Susan Handy delivered the 2024 Thomas B. Deen Distinguished Lecture, "Reflections on the Role of Research in Shaping the Ideas That Shape Transportation."

Details and highlights appear on the following pages.

Annual Meeting photographs by Risdon Photography, except where indicated.



1 Attendees string yarn on the Critical Issues Wall to indicate the importance of transportation-supported societal goals.

2 U.S. Department of Transportation Secretary **Pete Buttigieg** delivered closing remarks about the infrastructure package and other transportation initiatives and concerns during the Chair's Plenary Session.

3 **Sharareh (Sherri) Kermanshachi** of Pennsylvania State University at Harrisburg weighs in on occupational suicide during the Chair's Plenary Session, co-hosted by TRB Executive Committee Chair **Diane Gutierrez-Scaccetti** (*right*) and Vice Chair **Carol Abel Lewis** (*left*). Other guest panelists are (*left to right*) **Travis McCarthy**, Sundt Construction; and **Peter Tateishi**, Associated General Contractors of California.

Intersections

1 At one of several spots for taking selfies, attendees (*left to right*) **Guocong Zhai**, **Xuting Wang**, and **Fengjiao Zou** have their moment.

4 Members of the TRB Executive Committee exchange double fist bumps during a break from proceedings. They are (*left to right*) **Diane Gutierrez-Scaccetti**, Commissioner of the New Jersey DOT and Executive Committee chair; **Carol Abel Lewis**, Professor of Transportation Studies at Texas Southern University and Executive Committee vice chair; **Leslie S. Richards**, General Manager of the Southeastern Pennsylvania Transportation Authority; **Susan Shaheen**, Professor and Co-Director of the Transportation Sustainability Research Center at the University of California, Berkeley; and **Victoria Sheehan**, TRB Executive Director.

5 19 students from 14 schools attended the Annual Meeting as participants in the 2024 TRB Minority Student Fellows Program, with college majors ranging from civil engineering to computer science to geospatial sciences. Pictured are (*left to right*) **Karen Febey**, TRB Senior Report Review Program Officer and Minority Student Fellows Program Manager; **Karen Bobo**, Director of the FHWA Center for Transportation Workforce Development; **Cipriano De Luna Gutierrez**; **Brian Castaneda**; **Byron Hall**; **Zaria Bullard**; **Robert Valencia**; **Elise Russ**; **Daniel Frolich**; **Ibrahima Fall**; **Olivia Tafoya**; **Ty Holliday**; **Joyce Alicea-Hernandez**;

2 **Ramond Robinson** of the Bureau of Transportation Statistics shares information with an attendee at the Careers in Motion Networking Fair.

3 **Christian Torres-Ortiz** of the University of Puerto Rico at Mayagüez and a visiting student at the University of New Mexico joins the discussion at the Minority Student Fellows Luncheon.

Barron Allison; **Leandro Addarich**; **Victoria Lanier**; **Christian Torres-Ortiz**; **Marielly Rodriguez Gauthier**; **Darius Dale**; **Victoria Sheehan**, TRB Executive Director; and **Santiago Martinez Contreras**. Not pictured is **Deyana Thomas**.

6 The Technical Activities Council (TAC) oversees the organization and activities of TRB's standing committees. Members are (*front row, left to right*) **Jane Lin**, **Tom Hickey**, TAC Chair **Avery Grimes**, **Gloria Jeff**, TRB Technical Activities Division Director **Ann Brach**, and **William Eisele**. Standing (*left to right*) are **Robert Bertini**, **Fred Wagner**, **Jeff Borowiec**, **Pasi Lautala**, **Niloo Parvinashtiani**, **Robert Hazlett**, Technical Activities Division Deputy Director for Program Content **Stephen Maher**, and **Tara Cavalline**.

Sessions & Workshops

1 Assistant Secretary for Aviation and International Affairs **Annie Petsonk** joins a panel discussion on the "Department of Transportation Activities in Advanced Air Mobility."

2 Associate Professor of Urban and Regional Planning at Eastern Washington University and Spokane tribal member, **Margo Hill** presents to attendees at "Health for All: Addressing Gender Disparities in Accessing Health Care and Other Critical Destinations."

3 **Ivory Carter**, U.S. Transportation Command, shares in a lectern session discussion on cyber-resilient transportation.

4 **Zaria Bullard** of Tennessee State University presents her research on crash frequencies at railroad highway crossings in Tennessee at the Minority Student Fellows Poster Session.

5 **Beverly Kuhn** (*left*) joins other participants in the "Freeway Operations Student Research Needs Challenge."

Committees

1 In a session of TRB's Standing Committee on Transportation Asset Management, **William Johnson** of Colorado DOT and **Tashia Clemons** of FHWA look over *Applying Transportation Asset Management to Traffic Signals: A Primer*.

Blue Ribbon for Best Practices

TAC Chair **Avery Grimes** presents Blue Ribbon Awards for best practices of outstanding technical activities committees in the following categories:

1 *Identifying and Advancing Ideas for Research*: Standing Committee on Steel Bridges, chaired by **Jamie Farris** (accepted by **Duncan Paterson**);

2 *Attracting and Preparing the Next Generation of Professionals and Scholars in TRB*: Subcommittee on Young Members—Aviation, chaired by **Ryan Dittoe**;

3 Transportation Resilience Section, chaired by **Anne Strauss-Wieder** (*right*); and Subcommittee on Young Members—Sustainability and Resilience, chaired by **Brittney Gick** (*left*) and **Stephen Wong**; *Moving Research Ideas into Transportation Practice*: Standing Committee on Accessible Transportation and Mobility, chaired by **Todd Hansen** and **Judy Shanley** (not pictured);

Stephen Maher, TRB

4 *Contributing to Improving the Management and Operation of TRB Committees*: Standing Committee on Research Innovation Implementation Management, chaired by **Emily Parkany**; and Standing Committee on Artificial Intelligence and Advanced Computing Applications, chaired by **Yinhai Wang** (not pictured);

5 *Increasing the Diversity of Committee Membership and Friends*: Standing Committee on Freight Transportation Planning and Logistics, chaired by **Sushant Sharma**;

6 Standing Committee on Highway Traffic Monitoring, chaired by **Ioannis Tsapakis**; and

7 Standing Committee on Design and Rehabilitation of Asphalt Pavements, chaired by **Leslie Myers**.

2 TRB Executive Director **Victoria Sheehan** participates in a discussion with members of TRB's Special Committee on Diversity, Equity, and Inclusion.

3 **Rebecca Kiriazes** of Catholic University of America in Washington, DC, discusses how to be a TRB paper reviewer during a meeting of the Subcommittee on Public Transportation Group Young Members.

4 **Yinhai Wang** of the University of Washington in Seattle leads a discussion with fellow members of the Standing Committee on Artificial Intelligence and Advanced Computing Applications.

5 **Mia Held** summarizes the Aviation Young Members Council "Call to Action" exercise during their meeting.

Paper Awards

The Fred Burggraf Award is presented to researchers under age 35. TRB Executive Director **Victoria Sheehan** (*right*) presented the Paper Awards to recipients, who are shown from left to right.

1 **Gabriel Walton**, **Adam Malsam**, **Nicole Oester Mapes**, and **Brett Arpin** received the Burggraf Award on Transportation Infrastructure for *Forecasting and Mitigating Rockfall Based on Lidar Monitoring: A Case Study from Colorado*.

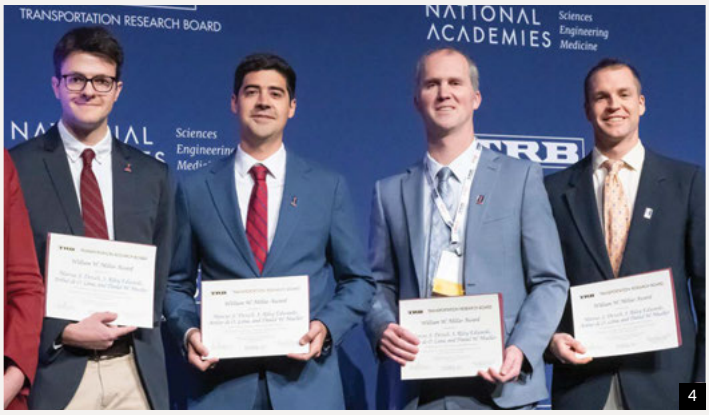
2 **Hao Xu** received the Pyke Johnson Award for *Curbside Parking Monitoring with Roadside LiDAR*. Not pictured: **Zhihui Chen**, **Junxuan Zhao**, and **Hongchao Liu**.

3 **Tanja Niels** and **Klaus Bogenberger** received the D. Grant Mickle Award for *Modelling Vehicle Flocking in Lane-Free Automated Traffic*. Not pictured: **Majid Rostami** and **Simone Weikl**.

Paper Awards
(continued)

4 **Daniel Mueller**, **Arthur de Oliveira Lima**, **J. Riley Edwards**, and **Marcus S. Dersch** received the William W. Millar Award for *Development of a Real-Time Wheel Load Quantification System for the Transit Environment*.

5 **Egemen Okte, Imad L. Al-Qadi**, and **Angeli Jayme** received the K. B. Woods Award for *Environmental and Economic Efficiency of Stone-Matrix Asphalt with Surface Micro-Milling*.



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6 **Nathan McNeil** and **Keith Bartholomew** received the Charley V. Wootan Award for *Transportation Academies as Catalysts for Civic Engagement in Transportation Decision-Making*.

5

6

Major Awards

1 Distinguished Professor of Environmental Science and Policy and director of the National Center for Sustainable Transportation at the University of California, Davis (UC Davis), **Susan Handy** is the recipient of the 2024 Thomas B. Deen Distinguished Lectureship. Her academic service has spanned more than 30 years, during which she has focused on strategies for reducing automobile dependence, including bicycling as a mode of transportation. Her research is motivated by the goal of a more sustainable transportation system—one that meets needs across all segments of society while minimizing environmental and societal harms now and into the future. Also chair of UC Davis' graduate program in transportation technology and policy, Handy is recognized for her contributions to the advancement of knowledge on travel behavior and to the practice of transportation planning and education.


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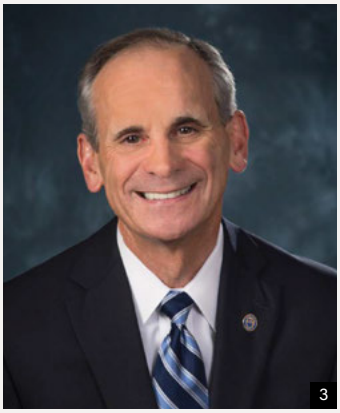
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2 **Imad L. Al-Qadi**, the Grainger Distinguished Chair in Engineering at the University of Illinois at Urbana–Champaign and the founding director of the Illinois Center for Transportation, is the 2023 recipient of the Roy W. Crum Distinguished Service Award. Named for TRB's former director, who served from 1928 until his death in 1951, the award recognizes outstanding leadership in transportation research or research administration. Al-Qadi is recognized for his diverse and distinct career accomplishments, which have influenced the transportation field and contributed tremendously to its growth by developing pavement material standards, analytics, and technologies that continue to shape the evolution and advancement of resilient and sustainable transportation systems.

3 Special advisor to the interim chancellor of The Pennsylvania State (Penn State) University

Harrisburg, **John M. Mason, Jr.**, is the 2023 recipient of the W. N. Carey, Jr., Distinguished Service Award. Named for TRB's former executive director, who served from 1967 to 1980, the award recognizes individuals who have given leadership and distinguished service to TRB. As former chancellor and dean of Penn State Harrisburg, Mason served as the chief executive and academic leader of the Capital College, where he was responsible for advancing its principal mission of excellence in teaching, research, and service; strategic planning; budgeting; philanthropy; faculty and staff development; outreach; alumni and community relations; and NCAA Division III athletics. Mason is honored for his more than 40 years of service to TRB and for his unwavering desire to create knowledge through research.

4 CEO of the Jacksonville Transportation Authority in Jacksonville, Florida, and the 2022 TRB Executive Committee chair, **Nathaniel P. Ford, Sr.**, is the recipient of the 2023 Sharon D. Banks Award for Humanitarian Leadership in Transportation. The biennial award was established in memory of the former general manager of AC Transit in Oakland, California, who chaired the TRB Executive Committee in 1998. She passed away in 1999. The award recognizes innovative and successful leadership in people-oriented initiatives in transportation—sustained over an extended period—that exemplifies Banks' ideals of humanity and service. Ford is acknowledged for his visionary and innovative leadership, driven by an innate desire to make public transportation work efficiently for people who ride, regardless of the mode. He is a leading advocate for how autonomous vehicles and other advances can be used to improve the quality of life for travelers throughout the nation.

4

5

5 **Thomas B. Deen**, who served from 1980 to 1994 as TRB's eighth executive director, stands with **Susan Handy**, recipient of the award named for him. The lectureship recognizes the career contributions and achievements of an individual in one of the areas covered by TRB's Technical Activities Division.

VOLUNTEER VOICES

"I really appreciated the sessions I participated in at the 2024 TRB Annual Meeting. They were on environmental and health issues within transportation and research into innovative solutions. Those pertaining to noise, air quality, and emerging contaminants interested me the most, as did those with the opportunity to collaborate. Being able to take part in dialogues and learn from the practical experts are experiences that will influence my research in the future.

—PELUMI ABIODUN
Graduate Researcher, Sustainable and Resilient Infrastructure
Department of Civil and Environmental Engineering
Morgan State University
Baltimore, Maryland

The Gavel Passes to New Executive Committee Leaders

Carol Abel Lewis (*left*), Professor of Transportation Studies and Emeritus Director of the Center for Transportation, Training, and Research at Texas Southern University (TSU) in Houston, as well as the 2023 vice chair of TRB's Executive Committee, was elected as the committee's 2024 chair during the Annual Meeting. Prior to her tenure at TSU, she spent 15 years as the manager and director of planning for Houston's Metropolitan Transit Authority.

Lewis is responsible for educating students in the fundamentals of transportation and urban transportation issues, as well as conducting operational and policy-related transportation research. Her research focuses on automated vehicles for transit and incorporating vulnerable populations into planning activities. From 2018 to 2023, Lewis served as chair of TRB's Special Committee on Diversity, Equity, and Inclusion and is a former member of TRB's Transit Research Analysis Committee. She is also a member of the Houston–Galveston Area Council's Transportation Policy Council and Transportation Advisory Committee and chairs the Gulf Coast Rail District.

In 2016, Lewis received TRB's Sharon D. Banks Humanitarian Award and is the recipient of the Women's Transportation Seminar Rosa Parks Diversity Leadership Award (Houston Chapter). She earned her PhD from the University of Houston and holds bachelor's and master's degrees from the University of Iowa.

Serving with Lewis as TRB Executive Committee vice chair is **Leslie S. Richards**, CEO and General Manager of the Southeastern Pennsylvania Transportation Authority (SEPTA). Prior to joining SEPTA, Richards was the first woman secretary of the Pennsylvania Department of Transportation. She left a lasting mark on the department by creating strategic solutions for the long-term success of Pennsylvania's transportation needs through innovative, collaborative programs such as PennDOT Connects.

A staunch advocate for women and diversity in transportation and government, Richards has been recognized for her leadership in the industry and commitment to public service. She has also worked in the private sector as a senior project manager for environmental and civil engineering firms.

Richards is a graduate of Brown University, where she concentrated in economics and urban studies. She earned a master's degree in regional planning from the University of Pennsylvania.

Serving as new members of the TRB Executive Committee starting in June are **Garrett Eucalitto**, **Scott Marler**, and **Ricardo Martinez**. Reappointed members are **Craig E. Philip** and **Randell Iwasaki**. New ex officio members include **Sue Lawless**, **Sophie Shulman**, and **Veronica Vanterpool**.

Each year, the TRB Executive Committee selects a topic worthy of deeper analysis to address in a policy session. The 2024 policy session topic explored workforce challenges in the maritime industry, as well as such challenges and potential solutions across the various modes; efforts to prime the future transportation pipeline; and examples of workforce development efforts taking place within the industry. The panel of experts are (*left to right*) **Jorge Quezada**, Granite Construction; **Candace E. Blair Cronin**, Federal Management Partners; **Stephanie S. Ivey**, The University of Memphis; and **Rear Admiral Ann Phillips** (USN-Ret.), U.S. Maritime Administration.

Executive Committee

1 U.S. Department of Transportation Secretary **Pete Buttigieg** converses with TRB Executive Director **Victoria Sheehan** in the Meet and Greet Room.

2 By accepting the gavel from outgoing TRB Executive Committee Chair **Diane Gutierrez-Scaccetti** (*right*), **Carol Abel Lewis** officially takes over the role.

Also participating in the Executive Committee's agenda and deliberations are

3 **Robert C. Hampshire**, (*left*) U.S. Department of Transportation, and **Hani Mahmassani**, Northwestern University;

4 **Nancy Daubenberger**, Minnesota Department of Transportation;

5 **Ricardo Martinez**, Emory University School of Medicine; and

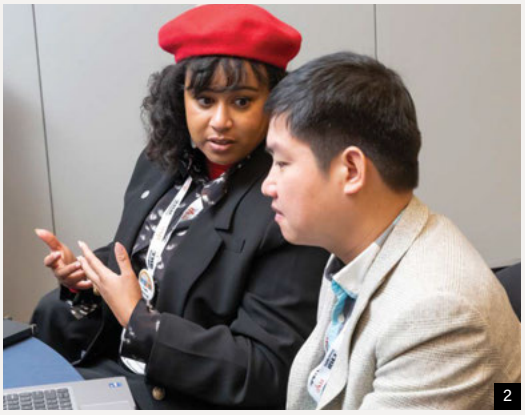
6 **Robin Hutcheson**, Federal Motor Carrier Safety Administration.

In the Moment

1 In the Exhibit Hall, attendees try virtual navigation around a city.

2 **Leuwam Tesfai** (*left*) shares thoughts with a participant in a breakout session on decarbonizing urban freight.

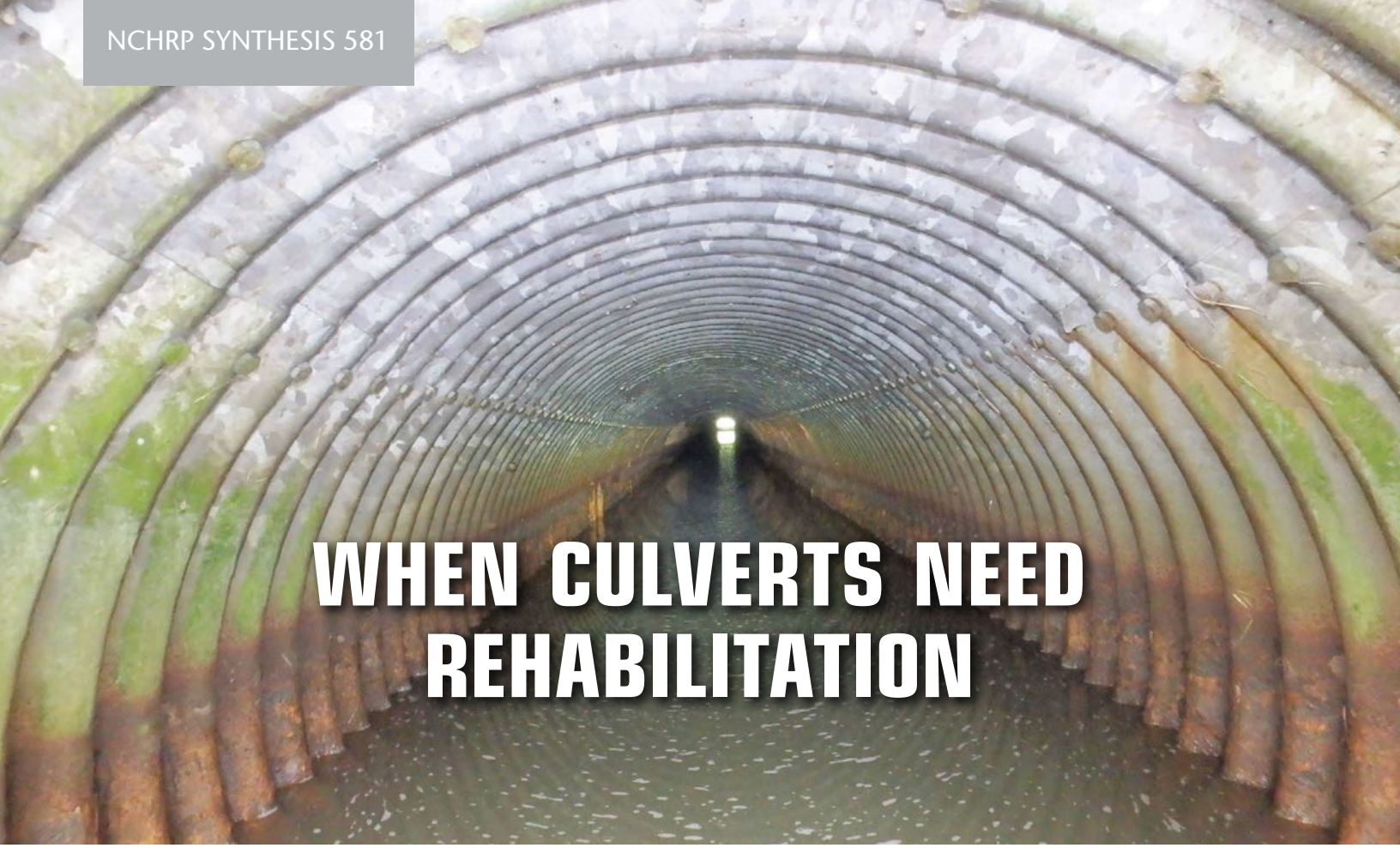
3 Casual exchanges hum through the ballroom as attendees await the opening of the Chair's Plenary Session.



4 TAC member **Tom Hickey** chats with new attendee **Benjamin Diehl** from City College of New York in Brooklyn.

5 Past and present converge in a 1931 Graham–Paige survey truck outfitted with cutting-edge survey equipment, on exhibit by FHWA.

WHEN CULVERTS NEED REHABILITATION



Courtesy of Oregon DOT

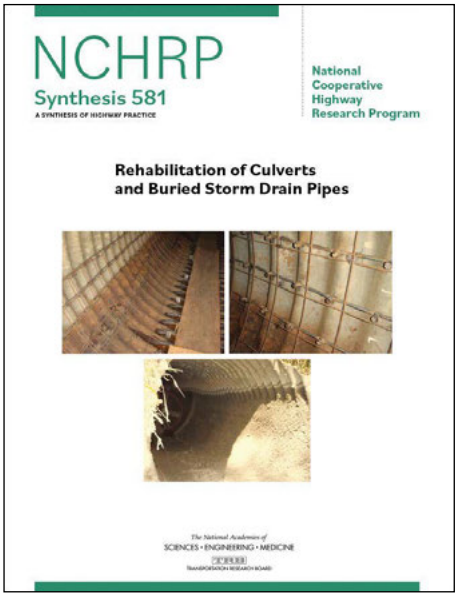
HALIL SEZEN

The author is a professor of structural engineering at The Ohio State University in Columbus.

Water laps the sides of a corroded conduit under I-5 connecting Van Dike Creek with the South Umpqua River near Myrtle Creek, Oregon. Rehabilitation and repair methods can greatly extend the service life of degraded culverts such as this one, but implementation varies widely among state agencies.

Transportation agencies develop management plans to extend the service life of their aging infrastructure. Those assets include thousands of culverts that channel water away from or under U.S. roadways, reducing flooding, erosion, and other hazards. State departments of transportation (DOTs) consider safety, functional performance, and cost when making critical decisions about maintenance, repair, rehabilitation, or replacement of deteriorating structures. AASHTO's 2020 *Culvert and Storm Drain System Inspection Guide* (*1*) helps with this process by providing a condition rating system and assessment criteria, though many state DOTs develop their own. Once degraded culverts are identified, agencies then have to determine the most economical and effective rehabilitation method to restore function or extend the service life if applied in a timely manner.

This article presents current and emerging culvert repair and rehabilitation methodologies, as well as factors affecting their selection and implementation. Drawn from *NCHRP Synthesis 581: Rehabilitation of Culverts and Buried Storm Drain Pipes* (*2*), it also highlights the need



Read *NCHRP Synthesis 581* at https://doi.org/10.17226/26585.

for further research to address information gaps and encourage wider use of promising treatments. For example, data collected for the synthesis show that approximately half of state DOTs do not consider the structural capacity of the existing culvert in their rehabilitation design.

NCHRP Synthesis 581 identifies the most commonly used rehabilitation methods. They include spray-applied structural lining, cured-in-place pipe, sliplining (i.e., grouting), invert concrete paving (to repair culvert floors), stabilization of surrounding backfill soil, end treatment, and trenchless replacement. Unfortunately, there is limited guidance on how to design and implement projects for the repair and rehabilitation of culvert structures. Although some best practices and design guidance documents are available, the development of design criteria could help accelerate the adoption and successful implementation of current and emerging rehabilitation methods. Some state DOTs, for instance, establish their own guidance documents, best practices, requirements, or design criteria if they frequently use certain rehabilitation techniques. Therefore, they would benefit from new research, policies, and standards for different rehabilitation applications that provide minimum requirements and additional guidance.

State DOTs could ideally rehabilitate their culverts more frequently—reducing the need for expensive major repairs in the future—if greater guidance and design criteria were available and they could answer basic questions. For example, can invert concrete paving or lining be unreinforced, or reinforced with welded steel mesh, shear studs, or steel rebar? What are the initial material, thickness, and other design and installation requirements—and limitations—of invert paving, spray-applied structural lining, sliplining, and other rehabilitation methods? State DOTs are interested in learning about best practices, the latest research data, and examples of successful field applications. However, they tend to avoid or discourage the application of new or established methods if their state has limited or no experience with them or if poor performance was observed on a previous project.

New research data and guidance also could help expand the use of emerging or less commonly employed methods. Examples include the rehabilitation of noncircular culverts using sliplining, fiber-reinforced polymer materials, methods to increase hydraulic capacity, and rehabilitation designs to address fish passage requirements. Similarly, new research is needed to quantify the remaining capacity of a deteriorated soil-structure system when backfill soil is lost through joints or perforations in the culvert walls. Such information would enable state DOTs to determine the additional structural capacity required for the rehabilitation design.

Project Approach

The NCHRP synthesis collected and analyzed information from a variety of sources. These included a literature review of relevant standards, best practices, and guidance documents; a web-based questionnaire that was completed by 42 state DOTs; and follow-up interviews with several state DOTs to develop case examples demonstrating different best practices and field applications.

The synthesis investigated factors affecting the selection and implementation of current and emerging culvert rehabilitation methodologies. Challenges abound in determining whether to monitor (do nothing), repair, rehabilitate, or replace a degraded culvert structure. Decisions often depend on the type and level of deficiency observed, such as corrosion, cracking or spalling (i.e., chipping and delamination) of concrete, and permanent deflections. Another difficulty is gauging the likelihood and potential consequences of observed deficiencies or damage progressing if not addressed immediately or within a certain time period. Financial constraints and the effectiveness of available rehabilitation methods also factor in implementation decisions.

Four major culvert types were examined: corrugated metal, precast concrete three-sided or box structures, precast concrete pipe or arch, and thermoplastic pipe. Based on the literature review, the survey questionnaire and case examples focused on the following key topics:

- Culvert types and frequency of their rehabilitation,
- Critical factors affecting the rehabilitation method,
- Local and spot repairs,
- Repair of joints between pipe pieces or metal plates,
- Invert paving and invert lining rehabilitation methods,
- System-level rehabilitation methods for the entire culvert lining,
- Existing structural capacity,
- In-house rehabilitation, and
- Quality assurance.

Key Findings

The survey of state DOTs revealed that corrugated metal pipe (CMP) culverts are rehabilitated more often than concrete culverts. Half of the 42 respondents indicated that they frequently rehabilitate corrugated metal culverts. By contrast, just seven state DOTs reported frequent rehabilitation of precast concrete three-sided or box culverts, while 30 said they rehabilitated such structures infrequently. Responses were similar for precast concrete pipe culverts, with two thirds of respondents—28 state DOTs—reporting infrequent rehabilitation compared with eight that frequently rehabilitate them. A majority—71 percent—of state transportation agencies said they do not use or rehabilitate thermoplastic pipes. These are the least rehabilitated culverts, mainly because thermoplastic pipes came into use relatively recently and thus constitute fewer older installations.

Many state DOTs have statewide programs, published documents or specifications for materials, and installation requirements or practices to provide guidance for repairs after defects are identified in culverts. Just over 45 percent (19 of 42 respondents) have routine preventive maintenance or repair requirements or guidance, while 20 state DOTs have established guidance for culvert replacement.

Jesse Nelson, National Park Service

A new box culvert near the south entrance of Zion National Park in Springdale, Utah, is one of many recent drainage infrastructure improvements along the scenic Zion–Mount Carmel Highway. In 2021, the roadway was badly damaged by a flash flood.

The average age for culverts at the time of rehabilitation ranges from 10 to 100 years and highly depends on the type of culvert and other conditions. Eight of the 42 survey respondents reported an average age of 40 years or fewer for rehabilitation. In general, the service life was shorter for CMP culverts than for those made of reinforced concrete.

Respondents also ranked the effect of several factors on their selection of rehabilitation methods. Most state DOTs considered environmental factors to be either insignificant or important but not critical. By contrast, those with a rehabilitation program (87 percent of respondents) overwhelmingly cited hydraulics as a critical factor. Site conditions were considered critical by 16 state DOTs (42 percent of respondents) while 18 state DOTs (47 percent) deemed them important but not critical. The majority of state DOTs regarded site access as a critical parameter in making decisions about culvert rehabilitation, and three quarters prioritized the impact on the traveling public. Overall, along with hydraulics, the impact on roadway users emerged as one of the most important factors influencing the selection of a culvert rehabilitation method.

A majority of state DOTs (58 percent) said the ability to perform work in-house was an insignificant factor in the selection of a rehabilitation method. This indicates that most state DOTs work with contractors for culvert rehabilitation. Some 68 percent of state DOTs considered expected service life and life-cycle costs to be important, but not critical, in selecting a rehabilitation method, while 26 percent saw them as critical factors. DOTs in Utah and Vermont mentioned aquatic organism passage and regulatory requirements for fish passage as a potential factor in the selection of a rehabilitation method. Two-thirds of state DOTs have quality assurance and quality control requirements for culvert rehabilitation and installation. In addition to standard specifications, Florida DOT has video inspection requirements.

Spot and Joint Repair Methods

The survey asked state DOTs about their use of specific methods to restore the structural capacity of a culvert or storm drain pipe. It sought information on seven local repair, spot patch, and joint repair and sealing methods, such as the local injection of epoxy adhesive or flexible crack fillers in concrete walls. The questionnaire also asked about four concrete invert paving methods and eight general rehabilitation methods.

Some 42 percent of state DOTs with a rehabilitation program said they rarely or sometimes use concrete crack fillers or local injection methods. Metal culverts were rarely or never coated or painted. Nonstructural chemical grouting, including gels and polyurethane foams, were rarely used by 47 percent of state DOTs and never used by 26 percent. Other internal joint-sealing systems—such as rubber membrane, seals, or backing plate—were used more often. All state DOTs reported using cementitious grouting, and they employed it more frequently than other local repair or joint sealing methods included in the survey. Several DOTs frequently combined structural repair methods using cementitious mortar or epoxy materials and nonstructural repair materials, including chemical grouting or foam.

System-Level Methods

Eight general rehabilitation methods were included on the questionnaire. One of the most common—used by more than 90 percent of the responding state DOTs—involves installing concrete invert paving or invert lining in CMP culverts. Fiber-reinforced polymer materials have been gaining popularity in recent years, especially to seal CMP or precast concrete culvert walls to improve durability and prevent corrosion-related deterioration. Only 3 percent of state DOTs reported never using fiber-reinforced polymer lining.

Sandblasting and recoating or painting proved to be an uncommon way to remove corrosion or damage and improve the wall coating. Some 71 percent of state DOTs had never used this method. Cured-in-place pipe is a relatively common method that involves feeding a thermosetting resin-soaked sleeve through the host pipe and then expanding and heating it to cure the resin. While 21 percent of respondents reported frequently using this technique, 24 percent never had. Centrifugally cast and spray-on liners and treatments, which involve pressurized spraying of materials onto the culvert wall surface, are also commonly used methods. However, more than half of state DOTs (59 percent) reported rarely using shotcreting—sprayed concrete or mortar—as a structural rehabilitation method.

The survey revealed several areas of convergence. All 38 state DOTs implementing culvert rehabilitation programs, for instance, use sliplining and other trenchless techniques to install a new internal pipe in existing culverts. Most state DOTs also use a variety of methods to stabilize and fill voids in the backfill soil, mostly through a pressure grouting operation or controlled injection. Almost all state DOTs apply some kind of treatment to the culvert's ends by rehabilitating or adding end walls or by installing slope protection elements. Since many state DOTs use end treatment methods occasionally or rarely, a best practices or guidance document would help promote effective applications.

Bruce Hull, Ohio DOT

In southern Ohio, state DOT maintenance crewmembers smooth concrete along the corroded floor of a corrugated metal pipe. Such linings can help preserve vital infrastructure and reduce the odds of costly, disruptive catastrophes.

Existing Capacity

Half of the state DOTs responding to the survey indicated that they would ignore the structural capacity of the host structure when rehabilitating the culvert. Several provided brief explanations. For example, Oregon DOT stated that for invert paving and repairs, existing capacity of the host structure is included, whereas full deterioration of the host structure is assumed for cured-in-place and spray-applied pipe lining rehabilitation projects. Survey responses suggest that consideration of the host structure's capacity in rehabilitation applications highly depends on the level of actual deterioration observed. Given the safety and economic implications, state DOTs would benefit from additional guidance, including structural design requirements.

Half of the responding state DOTs said that their in-house rehabilitation depends on the availability of internal expertise and experience. Similarly, many listed the availability of equipment and in-house versus contractor costs as critical factors. Conversely, few listed laws and regulations as critical factors. Some state DOTs stated that their maintenance crews can do some of the routine maintenance and basic culvert repairs.

Case Examples

The Delaware DOT commonly uses spray-applied or cementitious linings because of their limited impact on the traveling public and the environment. The agency specifies requirements for installation of spray-applied structural liners using factory-blended portland cement or geopolymer cementitious materials. The rehabilitated culvert system must be able to support all applicable design loads—the existing pipe's capacity is ignored—and provide a minimum service life of 75 years. The load rating of the spray liners is based on the load rating procedure required for the same deteriorated culvert.

One of the research gaps identified by the synthesis report relates to the structural capacity of deteriorated CMP culverts. CMPs develop their strength through the interaction between the metal culvert and soil backfill. However, there is no clear guidance or way to analyze or determine the remaining strength of the degraded culvert system, especially after some of the soil backfill is lost through the joint opening or perforations in its sides or bottom.

Maine DOT has special provisions for structural concrete culvert invert

Courtesy of Maine DOT

Fiber-reinforced polymer liners are set aside for installation inside a corroded dual-pipe culvert that channels West Branch Brook under SR-9 just east of Amherst, Maine. The pilot project, which examined the feasibility and cost benefits of using composite materials to repair an existing corrugated steel structure, included structures to aid migrating fish.

lining using cast-in-place shotcrete and fiber-reinforced polymer composite methods, as well as for sliplining of culverts. In addition to hydraulic capacity and fish passage requirements, the culvert's depth is a driving factor in deciding whether to rehabilitate or replace it. For culverts deeper than 10 feet, rehabilitation—typically sliplining—is preferred, given the higher cost associated with removal of the existing culvert. For culverts with a diameter of three feet or larger and limited deterioration or deficiencies, local repair, small patches, grouting, or filling the holes is not unusual. Maine DOT also has conducted research, developed guidance, and applied a method involving fiber-reinforced polymer composite lining to affordably increase the hydraulic capacity of corroded culverts by up to 40 percent.

Oregon DOT frequently rehabilitates CMP and concrete culverts using concrete invert pavement, cured-in-place pipes, and spray-on liners. The agency has an established design procedure for invert pavement of CMP culverts using rebar-reinforced concrete. This type of rehabilitation project includes three notable aspects. First, because of extensive corrosion and deterioration, the concrete paving or lining is extended well above the water line or mid-height of culvert. In addition to steel wire mesh, the pipe's internal sidewalls are strengthened with longitudinal deformed-steel bars welded to shear studs on each corrugated ridge. Finally, concrete is placed using equipment for spray-applied structural liners.

Wisconsin DOT provides guidance and examples of culvert rehabilitation and trenchless construction in its facilities manual. One novel aspect of its best practices involves the effective sliplining of elliptical or arch-shaped culverts. A majority of significant culvert rehabilitation projects in the state involves slipliners. The biggest issue observed with these installations is during grouting, when excessive pressure has caused floating, joint separation, and—in some cases—deformation. That prompted Wisconsin DOT to revise the standardized special provision that guides these rehabilitations and specify a leaner, more fluid grout mix. The agency currently requires contractors to provide a grouting and bracing plan.

Wisconsin DOT discourages and restricts spray lining to pipe diameters of 48 inches or smaller. The main concern is that manufacturers have been apprehensive about sharing proprietary design methodologies for these liners, resulting in a lack of general standards. As design methodologies become more standardized, the agency is considering easing its restrictions. However, the preference would still be

Courtesy of Oregon DOT

A lattice of steel wires and deformed bars welded to shear studs frame the interior sidewalls of a deteriorated culvert prior to rehabilitation with spray-on concrete. Because of significant corrosion, the fortified new lining must extend beyond mid-height of the corrugated metal pipe.

for larger pipes on which a finite element analysis can be performed.

Conclusions

Survey results show that hydraulics and disruption to users of the roadway are the most critical factors affecting the selection of culvert rehabilitation methods. To reduce the impact on the traveling public, state DOTs avoid open-cut replacement methods in favor of trenchless methods, such as invert concrete pavement, sliplining, and cured-in-place pipe. Concrete invert pavement and sliplining are the most common rehabilitation methods for CMP culverts, whose expected service life is approximately 20 to 50 years, compared with 50 years or more for concrete culverts. Half of the state DOTs indicated that they ignore the existing structural capacity of the host structure in their rehabilitation design.

Research data, best practices, and guidance documents for commonly used rehabilitation applications are limited. State DOTs indicated that they would consider using certain rehabilitation methods if more research data and design guidelines were available. Although not included in the questionnaire, aquatic organism passage and regulatory requirements for fish passage emerged as important factors affecting the rehabilitation design. Most state DOTs team up with contractors to restore or rebuild culverts and so do not consider the ability to perform the work in-house to be a significant factor in selecting the rehabilitation method.

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CULVERTS

Factoid

The New Hampshire Department of Transportation (DOT) inventoried and developed an asset management manual for nearly 100 stone highway culverts built from 1750 to 1930. A granite-splitting method introduced around 1830 helps practitioners date—and preserve—these structures, many of them potentially eligible for listing in the National Register of Historic Places.

—New Hampshire DOT

Is Federal Transportation Performance Management on Target?

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DAVID VAUTIN

The author is assistant director of major plans at the Metropolitan Transportation Commission in the San Francisco Bay Area in California.

A bird's-eye view of Seattle, Washington, includes a vast array of transportation assets: highways, bridges, pavements, roadside features, signage, lighting, and more. Since 2018, transportation agencies have been federally required to set targets, monitor performance, and align transportation investments for their infrastructure.

The Moving Ahead for Progress in the 21st Century Act, also known as MAP-21, was signed into law in 2012. Among other provisions, MAP-21 included new federal transportation performance management requirements for state departments of transportation (DOTs), metropolitan planning organizations (MPOs), and transit operators. For the first time, public agencies—whether large or small—across the country were required to set targets, monitor performance, and align investments to support progress toward a consistent set of federally identified measures related to three primary issues: safety, asset management, and system performance.

After years of rulemaking processes informed by thousands of comments from public agencies, advocacy organizations, and the public, by 2018 FHWA and FTA had finalized all rules authorized under MAP-21. This meant that target-setting activities at the state, regional, and local scales were required to commence. In the years since, state DOTs, MPOs, and transit agencies have convened working groups, established targets for approval by leadership and boards, tracked their progress, and shifted investment priorities as appropriate. At the end of the first four-year performance period, stakeholders at all levels of government have had an opportunity to reflect on progress to date.

On March 30, 2023, TRB held a webinar—Successes and Challenges: The First 4 Years of Federal Performance Management—to explore this topic.[1] The three performance management practitioners featured—Minnesota DOT's Deanna Belden, the North Jersey Transportation Planning Authority's Keith Miller, and the Washington Metropolitan Area Transit Authority's Jordan Holt—offered their perspectives. Mshadoni Smith-Jackson, FHWA's team leader of

[1] View the webinar's slide deck at https://onlinepubs.trb.org/onlinepubs/webinars/230330.pdf.

Elvert Barnes, Flickr, CC BY-NC 2.0 DEED

Commuting by bike to work may be safer in Washington, DC, thanks to protected two-way bike lanes such as this one along 15th Street, between G Street and Pennsylvania Avenue, NW. Transportation safety performance measures are focused on reducing or eliminating driver, pedestrian, and cyclist deaths and injuries.

performance and asset management, facilitated the discussion, in which the panelists highlighted an important fact: Many public agencies were already engaging in transportation performance measurement, management, or monitoring for years prior to the change in federal law. While these efforts varied in their scope and complexity (depending on the organization in question), they reflected a more bottom-up approach to establishing goals and evaluating performance. According to panelist Jordan Holt, director of performance improvement at the Washington Metropolitan Area Transit Authority, by the time federal performance rules were finalized, "we had a good infrastructure to build on."

For many organizations, newly established federal performance measures supplemented—rather than supplanted—existing measures that reflected critical local, regional, or statewide priorities. Although strictly limited to safety, asset management, and system performance issues identified in MAP-21, the new measures did provide a degree of nationwide consistency on commonly shared transportation goals, allowing organizations to benchmark their progress against peer agencies. This provided value not just to federal policy makers but also for performance management staff at organizations throughout the country.

What's Working Well?

An outside observer might hypothesize that the greatest success of federal transportation management processes would be having reams of robust metrics and targets instantly available with the press of a button, adding quantitative consistency to an otherwise complex transportation landscape. But all three panelists agreed that it is the performance target-setting process itself—and the meaningful convenings and conversations that it sparked—that is the most positive and impactful change. Target-setting dialogues brought together disparate teams across organizations to explore highly technical and often unglamorous topics like data set quality issues or trendline estimate techniques, but these ultimately led to high-level conversations about how to affect organizational change or communicate the performance story to the public. According to panelist Keith Miller, Manager of data analysis and forecasting at the North Jersey Transportation Planning Authority, "discussions in the guise of target setting are the greatest opportunities coming out of this process."

Emerging federal requirements also sparked the availability of new data sets and tools to support target-setting activities. Federal efforts to procure consistent data—such as the National Performance Management Research Data Set—and to support the development of easy-to-use tools helped organizations with a wide range of institutional capacities engage in meaningful internal and external dialogues. While data availability and quality were by no means perfect, actions on the federal level helped state, regional, and local agencies focus their energies

Headway, Unsplash

An unexpected takeaway: One of the best results from federal requirements has not been the collecting of massive amounts of data but getting transportation managers together to compare notes.

Elvert Barnes, Flickr, CC BY-SA 2.0 DEED

Passengers wait on a platform at Metro Center, the main hub in Washington, DC's, Metrorail system. Federal target-setting requirements have helped agencies like the Washington Metropolitan Area Transit Authority bolster the quality of its asset management inventory. The federal requirements also prompted national discussion and standardization.

on target-setting dialogues rather than having to procure data and build tools from scratch. For data sets inherently specific to each organization, federal requirements spurred greater efforts to improve data quality. For example, the Washington Metropolitan Area Transit Authority increasingly emphasized strengthening the quality of its asset management inventory over the past decade. Federal target-setting deadlines acted as a catalyst for these improvements.

What Gaps Exist?

One of the greatest challenges for public agencies is communicating differences between their federally required targets—established for the next one to four years per federal regulations—and the long-range targets unique to their state, region, or local transit agency. Although differences in data and methodologies are part of the story, a deeper philosophical difference is central to the narrative. Federally required targets are set for a near-term, one-to-four-year time horizon and—for some organizations—federal rules establish penalties for failing to meet an established performance target. This can be at odds with an individual organization's performance management frameworks, which use targets to establish long-range desired outcomes and better reflect state, regional, and local policy-maker aspirations. Panelist Deanna Belden, director of performance, risk, and investment analysis at Minnesota DOT, noted that federal targets "might be better described as expected outcomes—what we actually think might happen." For issues like safety on our roadways or transit systems, Holt underscored that "there is a big discomfort . . . at the board level, as well as with executives for setting non-zero safety targets." Penalties associated with federal performance rules also may encourage organizations to set more conservative near-term federal targets to be deemed successful under the federal performance management framework, even if this is inconsistent with their longer-term organizational aims (*1*).

Although the number of federally identified performance measures is already quite significant, Belden emphasized that "national measures do not tell the complete story." This sentiment was echoed by Miller and Holt. While federal efforts elevated performance trends related to safety, asset management, and system performance, state DOTs, MPOs, and transit agencies are seeking to advance many other policy goals using performance-based approaches. Given this context, states, regions, and transit agencies have crafted meaningful performance measures that tackle a wide range of topics, such as climate resilience, economic development, and social equity. Some states have even established mandatory performance targets aligning with such measures. California's climate performance targets applied at the MPO and state DOT levels are a notable example. Although the flexibility of today's federal performance framework enabled this experimentation and customization to meet local needs,

James St. John, Flickr, CC BY 2.0 DEED

Beyond the reddish hue of rock and scattered stands of scrub, a brown haze of air pollution envelopes Denver, Colorado. Some states have used performance targets to tackle issues like climate resilience, which is not part of the existing federal performance management framework.

it also contributed to less consistency nationwide (*2*).

What's Next?

Federal transportation performance management is entering its second decade, with all organizations involved better equipped to strengthen their performance management practices in the years ahead. Yet, the following key questions remain unresolved:

- Will federal requirements evolve to encourage more aspirational goals, rather than penalizing organizations for perceived underperformance?
- Will new performance measures be established at the federal scale that better reflect some of the most critical planning issues of the 21st century, notably those related to climate and social equity?
- Will recent significant infusions of new federal monies into transportation translate into meaningful performance gains on broadly shared national goals?

Hopefully, by the end of this decade, transportation practitioners will be able to determine if they are truly on target—or if the United States mostly missed the mark in its implementation of performance management.

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"Discussions in the guise of target setting are the greatest opportunities coming out of this process."

—KEITH MILLER

Manager of Data Analysis and Forecasting
North Jersey Transportation and Planning Authority

NCHRP RESEARCH REPORTS 1035 AND 993

Michael Grant

SETTING PERFORMANCE TARGETS THAT MATTER

MICHAEL GRANT, KERRI SNYDER, AND ANNA BATISTA

Grant is vice president of transportation at ICF in Arlington, Virginia. Snyder is a transportation and environmental planner at ICF in Houston, Texas. Batista is a director at High Street Consulting Group in Pittsburgh, Pennsylvania.

Drivers on a well-traveled road in Pittsburgh, Pennsylvania, get a close-up view of transportation performance topics like pavement condition, congestion, reliability, and safety. But when needs compete, how do transportation practitioners responsible for federally mandated performance management promote good resource allocation decisions? Two NCHRP reports offer guidance.

Transportation performance management is a strategic approach that uses system information to support investment and policy decisions to achieve national performance goals. Federal rules require transportation agencies—such as state departments of transportation (DOTs) and metropolitan planning organizations (MPOs)—to establish near-term performance targets in relation to national performance measures addressing safety, infrastructure condition, travel time reliability, and freight reliability. Some also must set targets for reducing congestion and emissions.[1] Although agencies have gone through the first performance period cycle for target setting, they continue to face challenges. The first set of challenges agencies face is deciding how to set their targets, the level at which to set them, and how to navigate the messages their targets send to sponsors and the public. The second set of challenges is for agencies to determine what they can do to influence performance outcomes, how investments should be adjusted, and how to integrate the targets into initiatives taking place at their agencies. In other words, how do they make their targets meaningful?

The objective of National Cooperative Highway Research Program (NCHRP) Project 23-07, "Effective Methods for Setting Transportation Performance Targets," was to create a resource to help state DOTs and MPOs address the first set of challenges.[2] The guide that resulted from this research, *NCHRP Research Report 1035: Guide to Effective Methods for Setting Transportation Performance Targets*, helps practitioners evaluate, select, and then

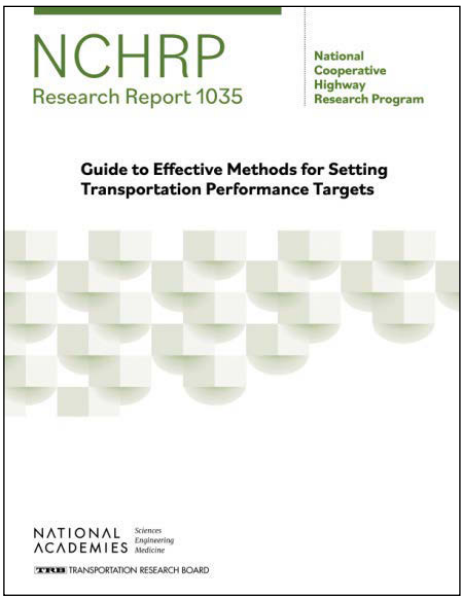
[1] Review the transportation performance management statutes and regulations at https://www.fhwa.dot.gov/tpm/about/how.cfm.

[2] Learn about NCHRP Project 23-07, "Effective Methods for Setting Transportation Performance Targets," at https://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=4788.

implement different methods for setting targets for national performance measures (*1*).

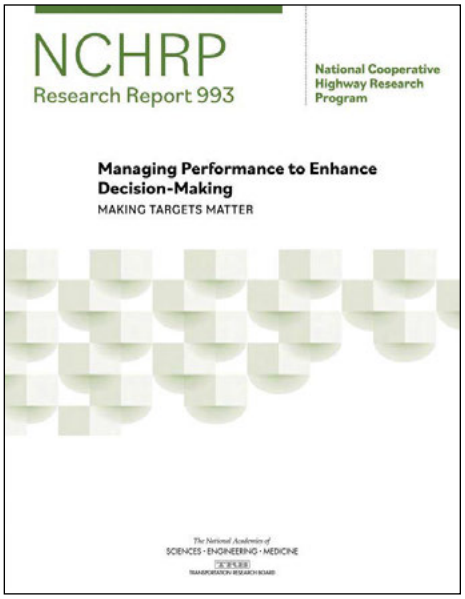
Similarly, NCHRP Project 02-27, "Making Targets Matter: Managing Performance to Enhance Decision-Making," addresses the second set of challenges, providing a feedback framework along with a set of concrete strategies for how to use performance targets to influence decision making.[3] This project culminated in suggestions presented in *NCHRP Research Report 993: Managing Performance to Enhance Decision-Making: Making Targets Matter* (*2*).

Together, these resources can help agencies set targets for the national performance measures and use them and other performance measures to influence decision making to improve system performance.



This practitioner-ready guide focuses on selecting effective methods for the target-setting component of transportation performance management and addresses how to reevaluate targets, particularly when unforeseen changes impact the transportation system, performance data, and performance reporting requirements.

[3] Read about NCHRP Project 02-27, "Making Targets Matter: Managing Performance to Enhance Decision-Making," at https://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=4546.



Practitioners responsible for target setting and performance reporting can use this research report to learn about elements of the feedback process, examine the role of feedback within their agencies, and review strategies to improve the feedback process.

Guide to Setting Targets

NCHRP Research Report 993 provides practitioners with useful instructions on target-setting methods, including how to assess target-setting method options, execute methods, and use the target-setting process meaningfully to improve performance. Under this research, the approach to the guide was to understand the methods that state DOTs and MPOs already have used to set targets for the national performance measures, assess which ones could be used most effectively to set targets, and help practitioners select and implement the recommended methods.

The project team initially found that across the methods agencies implemented in the first federal performance period, target-setting approaches fell into a few common categories, as follows:

- Policy-based methods that align the target with the agency's vision or long-term goals, such as a 3 percent reduction in fatalities per year;
- Historically driven target setting based on forecasted trends, such as a trend over the past five years;
- Probabilistic and risk-based methods that use statistical analysis to explore likely variations in performance levels or consider the risk that a roadway segment will become either less or more reliable;
- Multivariable statistical models—such as regression models—that account for explanatory factors that influence performance; or
- Other tools and models, such as pavement management systems, bridge management systems, or travel forecasting models.

Some agencies use multiple approaches to forecast anticipated performance and combine results to select a target.

While data availability, data quality, and access to resources and tools are often key factors in selecting a target-setting method, what appears to most influence an agency's approach is the target-setting philosophy of the staff and leaders. The report identified the following ways in which agencies often set targets:

- Establish realistic targets that reflect the performance level that is predicted to occur;
- Reflect the agency's aspirations for performance (such as zero road fatalities), even if they are somewhat unlikely to be achieved; and
- Aim for targets that are very likely to be achieved or set at the minimum threshold to ensure that the agency meets the target.

Contents of the Guide

The guide is divided into three parts. Part I includes an overview of target-setting methods and tips for selecting methods, including a discussion of target-setting philosophies. Part II provides a menu of target-setting methods organized by national performance measure: safety, infrastructure condition, reliability (travel time and freight), and congestion. For each method, a fact sheet includes an explanation of the method; data and tools needed to execute the method; steps to follow; and information on applicability, advantages, and limitations. To

help the user compare methods, each fact sheet contains information on the ease of application, technical robustness, ease of communication, and policy considerations. Part III includes a discussion of nonrequired performance measures and explores the reasons for using and setting targets for them. This section provides examples of measures and targets related to accessibility, greenhouse gas emissions, active transportation, transit ridership, and customer satisfaction.

Making Targets Matter

Since NCHRP Project 02-27 was not restricted to the national performance measures, research was conducted on how to make sure that targets established by agencies are used to influence decisions on plans, investments, and operations that will impact performance outcomes. *NCHRP Research Report 993* provides suggestions for how agencies can make target-setting and performance management more than just a box-checking exercise.

According to in-depth discussions with practitioners across the country, the key to making targets truly matter is getting more—and better—feedback integrated into agency processes. Successful agencies use feedback about the transportation network and the outcomes of interventions to make decisions on impactful efforts and investments that achieve performance targets.

The first step to help practitioners make this a reality involves conceptualizing the feedback framework. In this framework, feedback is broken down into several core elements (Figure 1). This framework is used to outline a series of strategies for better feedback that can focus practitioners' efforts to improve the flow of information at their agencies. The report's six strategies aim to improve different elements of feedback. (See Page 26, Six Strategies to Attain Better Feedback.)

To showcase how agencies already implementing these strategies are being successful across long-term planning, medium-term programming, and day-to-day operations, the report includes case examples highlighting feedback in action.

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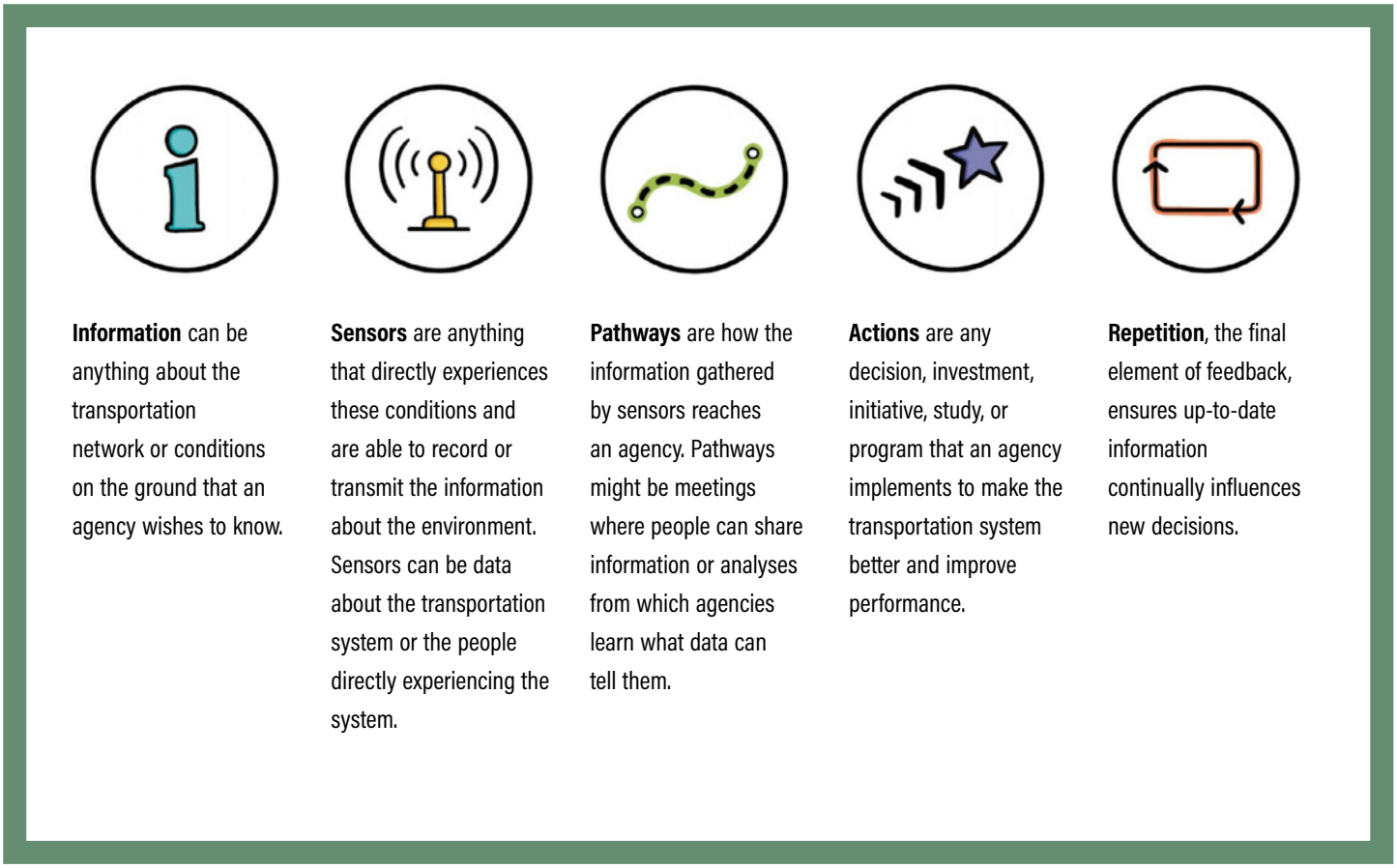

FIGURE 1 Elements of the feedback framework.

Six Strategies to Attain Better Feedback

Prepare Sensors

Strategies to better prepare sensors are about getting people and data optimally situated and ready to give useful and targeted information to agencies.

1. **Build buy-in for the long term.**
   Building buy-in is shorthand for the process of identifying key partners and fostering long-term relationships with them that spur a sequential process of awareness, acceptance, and support for performance initiatives.

2. **Navigate your data ecosystem.**
   Performance professionals can focus on strengthening access to the agency's data sensors by getting to know the data landscape, starting a dialogue with data owners, and linking data to questions on how to improve performance.

Establish Pathways

Pathways are the conduits along which information flows.

3. **Convene across boundaries.**
   Convening provides clear opportunities to tap people sensors for their priorities and insights and to reference data sensors to inform discussions on trends, conditions, and solutions.

4. **Formalize assessment of what works.**
   Assessment, also called analysis, is associated with using data to understand impacts. Formalizing this process is crucial to ongoing feedback.

Integrate Feedback

After improving people and data sensors, establishing clear pathways, and taking in new feedback, the next challenge is integrating the feedback into agency actions and communication.

5. **Take action.**
   Understanding the menu of adjustment options at agencies' disposal to impact performance outcomes will help practitioners decide which action to take. A series of principles guides how to implement them smoothly.

6. **Tell your performance story.**
   An agency's performance story is the arrangement of all it does to improve performance into a narrative using story elements. The guide explores how to communicate an agency's performance vision so leaders, peers, and the public take notice.

"While data availability, data quality, and access to resources and tools are often key factors in selecting a target-setting method, what appears to most influence an agency's approach is the target-setting philosophy of the staff and leaders."

Different Skills for Design–Build Delivery

Courtesy of Florida Department of Transportation

LAURENCE FARRELL AND ROBERT HYNES

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Construction cranes position the westbound arch of a new bridge span on US-98 connecting Pensacola and Gulf Breeze, Florida. Managing massive design–build transportation projects—such as this $440 million Pensacola Bay Bridge replacement—involves different skills than traditional design–bid–build contracts.

Parts of this article were excerpted or derived from Design–Bid–Build vs. Design–Build *by Laurence Farrell and David Covington, published in* Equipment World *on October 18, 2013, and reprinted with permission.*

The area construction engineer was more than a little nervous when he walked into the district construction engineer's office. The district had just received award notification of a major capital project, fully funded under the state's transportation budget, and he would play a key role supervising an on-site team of three to five resident engineers. Notice to proceed would come down any day. The project entailed the construction of a four-lane, limited-access, six-mile highway on new alignment through undisturbed right-of-way in a rapidly growing area. In addition, the road required the design and construction of nine bridges, some of them 1,000 feet long and roughly 11 stories tall.

Questions raced through the area construction engineer's mind. Where was the sealed design? Where was the approved materials list? How many additional inspectors would he need for a project of this scale? He was surprised when informed that there were no approved designs. Nor would he be billing or managing the project off an approved materials list. Moreover, not only would there be no significant influx of additional inspectors; none were even needed since he would be responsible only for independent assurance and independent verification rather than quality assurance.

"What type of project is this?" asked the area construction engineer. (It was like nothing he'd ever encountered.) "Design–build," the district construction engineer replied. "I need you to review your transportation design skills, especially the AASHTO Green Book,[1] and seriously look into obtaining Project

[1] Commonly called the Green Book, AASHTO's *A Policy on Geometric Design of Highways and Streets*, 7th Edition, can be found at https://store.transportation.org/item/collectiondetail/180.

Management Professional or construction management certification."

The area construction engineer walked back to his construction trailer in a state of fluster. He was now directly responsible for a large project of statewide significance using a vastly different development process than the design–bid–build system to which he was accustomed. His boss's guidance suggested he would need to brush up on his engineering design skills and probably dive deeply into the utilities relocation process—all while maintaining day-to-day staff supervision and oversight of his current projects.

This article reviews the design–bid–build and design–build processes, highlighting the differences in delivery methods. It also outlines the additional skill sets needed to serve effectively as an area or resident construction engineer on a design–build project and how those different skills are applied on the job.

Traditional Design–Bid–Build

Many federal, state, and local government agencies—such as departments of transportation, departments of natural resources, and public utilities across the United States—consistently use the design–acquisition–construction method commonly known as design–bid–build. The process is sequential and normally begins with multiple design reviews followed by right-of-way acquisition purchases and utility relocations. The design phase typically ends with attaining permits from the required local, state, and federal natural resources and environmental agencies. A professional engineer and land surveyor sign and seal the final plans, certifying them as ready for bid. From this point forward, design changes incur significant time and cost impacts and thus rarely occur.

The agency overseeing the project then solicits bids according to published criteria, using a variety of acquisition methods to award the project. In most cases, that entails selecting the least expensive proposal that meets technical acceptability, known as "lowest price technically acceptable." With an approved design and contract, physical construction begins. The agency manages construction by performing quality assurance functions defined in the contract and pays the contractor according to the quantity of materials installed at the agreed-on unit price.

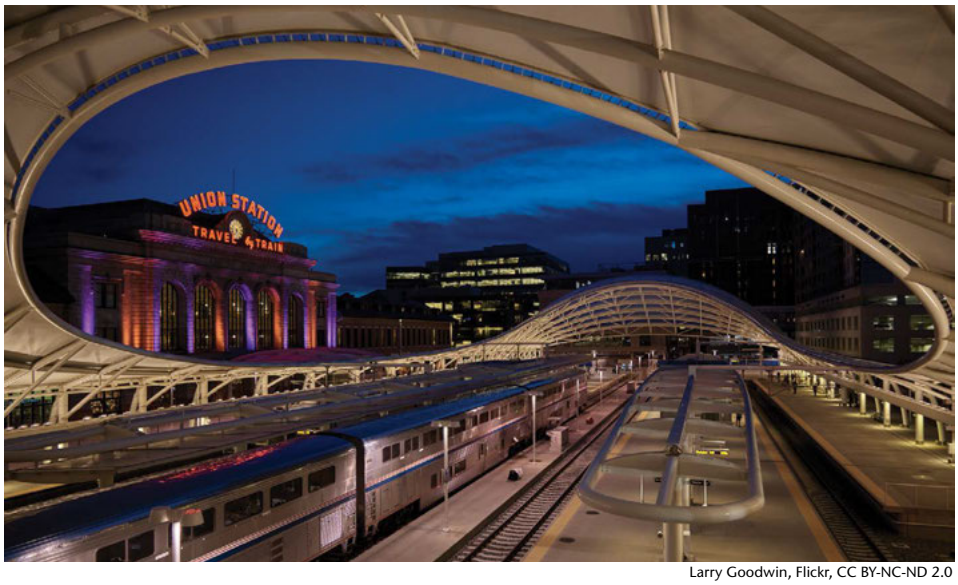
Contrasting Approaches

The design–build delivery method differs significantly from the traditional design–bid–build process. Initially, the agency produces a conceptual design. Most local, state, and federal agencies use a 30 percent design that provides the basic design elements of the infrastructure improvement—such as a road, bridge, or water conveyance—and right-of-way limits.

Unlike virtually all design–bid–build projects, a design–build project does not require the purchase of real estate prior to release of the bid. If the agency has not yet bought the property, the design-builder may do so after the notice to proceed is issued—using local, state, or federal funds. Next, the agency issues a request for qualifications and, subsequently, a request for proposals from the shortlisted pool of highly qualified offerors. Since the design is only conceptual at this point, the request for proposals usually consists purely of design and construction requirements. For a road and bridge project, for example, the requirements might comprise free-flowing ramps, defined level of service, grade, and other relevant criteria or metrics. At this stage, it is critical that the agency clearly defines the project's scope because ambiguity can lead to a wide range of submittals—documentation that ensures construction plans and materials match the contract's details—and further increases risks and costs after the project is awarded.

After offerors submit technical and price proposals, the state transportation department or designated agency chooses a design-builder based on a predefined selection process. The design-builder then completes the design and obtains the remaining right-of-way property, as well as required construction permits. With the project officially in the construction phase, the area engineer may now serve simultaneously as the project manager.

As the agency's legal and primary representative, the area engineer—who sometimes serves as a resident engineer



Larry Goodwin, Flickr, CC BY-NC-ND 2.0

A curved canopy shelters the peripheral platforms of Colorado's revitalized Denver Union Station. The massive design–build restoration project, which transformed 20 acres of blighted former rail yard into a bustling multimodal transit hub and popular downtown destination, garnered a national award when completed—two months ahead of schedule—in 2014.

because of staffing issues—reviews and approves all design submittals, utilities, permits, and other requirements. In parallel with this review, the design-builder obtains the necessary permits and arranges utility relocation. As with the traditional design–bid–build process, design–build permits must be secured before seal and approval of the final design.

One of the primary advantages of the design–build method is the option of concurrent design and construction. This is especially efficient on large bridge and road projects. The design-builder can perform mass grading while simultaneously devising the more intricate road and bridge components. The concurrence of design and construction potentially saves time and may greatly accelerate the project's completion.

It is important to note that even though construction is underway, the project is also in the design phase, and the area construction engineer or resident engineer in charge of day-to-day operations is directly responsible for both aspects. Area construction engineers supervising a design–build project similar to the six-mile highway project described earlier typically would spend about half of their time on project management, one quarter on design review, and one quarter supervising actual construction tasks. On a design–bid–build project, by contrast, construction-related activities consume almost all of the area construction engineer's time and also affect the department's resident engineer, who effectively splits time equally between design and construction.

For design–build projects, the design-builder is responsible for quality assurance and quality control. This significantly reduces the agency's requirement for construction inspectors, who now perform only independent assurance and independent verification. In essence, the agency provides quality control of the design–builder's quality assurance processes. Moreover, rather than experts in specific disciplines such as asphalt, concrete, and grading (as is common on other large projects), each inspector assigned to a design–build project is typically a senior-level professional with vast knowledge in many areas of construction.

Courtesy of Washington State Department of Transportation

Supported by 24 concrete girders, a flyover ramp takes shape across I-5 between Seattle and Tacoma, Washington. This design–build project, part of the $2.69 billion Puget Sound Gateway Program to improve the state's highway and freight network, proved less disruptive than constructing a tunnel linking the interstate to a new airport expressway.

As construction progresses, the design-builder bills by work packages, not by unit price material placement, as is common in design–bid–build projects. At notice to proceed, the design-builder submits for approval a schedule of values: project deliverables organized by definable work packages and estimated costs. For example, a work package may be to place 20 linear feet of 18-inch culvert or lay 100 linear feet of asphalt for a 12-foot-wide road. The project consists of a series of large work packages containing many smaller tasks that the design-builder then completes.

Upon initiation of each task or work package, the agency usually pays the design-builder 20 percent or another agreed-on percentage to serve as a down payment. The remaining balance is paid upon each package's completion and acceptance by the department. Unit price does not factor in payment to the design-builder.

Throughout this process, the area construction engineer monitors routine quality standards that the design-builder must maintain. Once construction is complete, the agency takes the project into inventory through regular acceptance methods used for design–bid–build.

Distinct Skill Set

The two construction delivery methods require different knowledge and expertise. Given the nature of most design–bid–build construction projects—namely that the engineering is complete and comprehensive, with well-defined processes—many aspects of the area or resident engineer's day-to-day tasks are routine and derived from published bid quantities and established pricing. Even for large design–bid–build projects with complex design changes, change orders follow a very prescriptive process. The agency's representative determines bid quantities and unit pricing from an available database, conducts a schedule analysis for any impacts, and then issues a change or payment voucher to the contractor.

By their nature, most design–build procurement contracts work best for large, complex, and one-of-a-kind projects that cannot effectively utilize the unit pricing method. Even small but distinctive projects, such as the many rail replacement and electrical projects

that have only schematic drawings, are essentially design–build projects and require the same skill set as a larger undertaking. Given the singular qualities of design–build projects, to be effective and successful the area or resident engineer should possess the skills and abilities outlined in Figure 1.

Design Expertise

Having an area or resident engineer with a professional engineer license is essential to a project's success. Legally, design is part of the design–build construction contract and often is the main driver in delay claims. The area or resident engineer oversees and has direct responsibility for design and construction and, therefore, needs expertise in both processes. On a $250 million design–build project, for example, the design alone may cost well over $30 million, and all project metrics—schedule, scope, budget, and quality—apply to this phase, as well.

It would be impossible for the area or resident engineer to be successful in a design–build project without fully knowing the design process. Incomplete mastery of the 30, 60, 90, and 100 percent design process—in which detailed drawings and other construction documents are developed according to milestones mapped to the level or percentage of work completed before the project's start—limits the resident engineer in proactive problem solving in design-related issues and increases the design risk. The area or resident engineer representing the owner works alongside the contractor's engineer of record during the design review and submittal process to resolve problems, just as the owner's construction team would do in any other phase of the project. Design waivers or exceptions proposed by the design-builder bear close monitoring and facilitation by the area or resident engineer. Such waivers and exceptions are time consuming and often subject to delay by the local, state, or federal approving agency. A degree of expertise in design can help the area or resident engineer prevent exceptional submittals from resulting in costly delay claims against the agency.

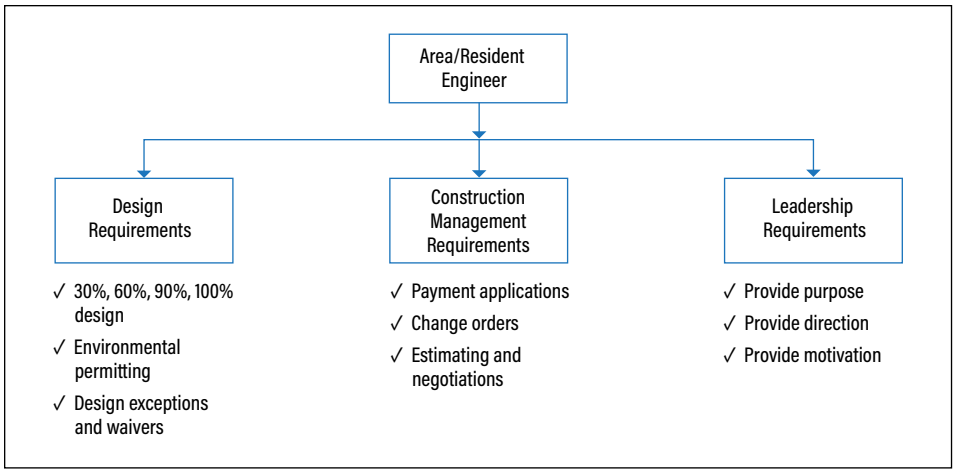


FIGURE 1 Skill sets for effective design–build project management.

Payment and Work Sequences

From a construction management perspective, there are several significant differences between design–bid–build and design–build projects. All stem from how the contract's payment method is structured.

Unlike a design–bid–build contract in which payment is based on material quantities with established unit pricing, payment in a design–build contract derives from a mutually agreeable schedule of values negotiated between the owner and contractor after the notice to proceed. The bid sheet in the contract bid packet describes only the general, broad categories of the payment structure and does not serve as a payment authorization document. Table 1 shows a representative bid sheet for a typical rail transit system switch replacement contract. Although the bid sheet delineates the major payment

TABLE 1 Base Bid Schedule

ITEM	SPEC. SEC.	DESCRIPTION	UNIT	EST QTY	UNIT PRICE	ITEM TOTAL
1	01 20 10	Differing Site Conditions	Allowance	XXXX	$1,000,000	$1,000,000
2	01 20 10	District Caused Delays	Allowance	XXXX	$750,000	$750,000
3	01 20 10	Incentive/Weekend Shutdowns	Allowance	XXXX	$249,000	$249,000
4	01 20 10	Permits	Allowance	XXXX	$249,000	$249,000
5	01 20 10	Signs	Allowance	XXXX	$12,000	$12,000
6	01 35 24	RWP Training	Hours	500	$110	$55,000
7	01 35 24	Watchperson	Hours	6,000	$200	$1,200,000
8	01 57 10	Temporary Traffic Maintenance and Controls During Construction	LS	N/A	$41,500	$41,500
9	01 71 23	Mobilization (Includes Equipment)	LS	N/A	$1,159,189	$1,159,189
10	01 43 53	Field Demonstration	LS	N/A	$1,100	$1,100
11	02 41 10	Demolition	LS	N/A	$1,650,000	$1,650,000
12	34 05 27 34 22 44 34 11 35 34 11 37 34 11 41 34 11 03	Track Work	LS	N/A	$6,270,000	$6,270,000

NOTE: SPEC. SEC. = Specification Section; EST QTY = Estimated Quantity; XXXX = value not determined by number of units; RWP = Roadway Worker Protection; LS = Lump Sum, N/A = nonapplicable.

buckets, disbursements to the contractor require a more detailed breakdown and fidelity to the specific job.

The schedule of values provides that fidelity by dividing each definable feature of work into numerous smaller work packages. A representative example from the rail switch replacement project is shown in Table 2. Completion of these work packages is the basis for a lump-sum payment to the contractor. For this mode of payment to be effective, however, the area or resident engineer should understand the contractor's construction methods and sequence for building the project. Those without full knowledge of the construction sequence risk approving an unbalanced schedule of values, with misalignment between work accomplished and payments to the contractor.

Navigating Revisions

Change orders in a design–bid–build contract consist of the material quantities and costs involved in the change plus any overhead. Change orders in a design–build contract are significantly more complex. In such cases, the area or resident engineer must first determine if a change condition exists at all. Since the contractor controls the design in design–build contracts, requests for a change order may be unwarranted. This tension between contractor and area or resident engineer on change orders is a constant in design–build projects and the primary reason why an unambiguous contract is vital.

Once the area or resident engineer determines that a change condition exists, the construction management team must map out the entire construction sequence and gauge the change's effect on the project. This tremendously complex and time-consuming process can take months. For example, a change condition involving a 500-ton crane that is available only three times a year may require an entire resequencing of the project. Only after the construction management team examines the work sequence and determines the change condition's impact can the area or resident engineer estimate the cost of the change.

TABLE 2 Schedule of Values for Rail Transit Interlocking Renewal

Item	Description	Unit	Est Qty	Unit Price	Item Total
6	Temporary Traffic Maintenance and Controls During Construction	LS	1	$ 41,037.20	
6.10	Temporary Controls–Prepare Traffic Control Plans for D Street	EA	1	$ 4,200.00	$ 4,200.00
6.11	Temporary TCP Closure D Street	EA	1	$ 13,112.00	$ 13,112.00
6.12	Prepare SWPPP Plan	LS	1	$ 5,745.00	$ 5,745.00
6.13	SWPPP Implementation and Maintenance	MO	18	$ 998.90	$ 17,980.20

Note: EST QTY = Estimated Quantity; LS = Lump Sum; EA = Each; TCP = Traffic Control Plan; SWPPP = Stormwater Pollution Prevention Plan; MO = Months.

Cost Estimation and Negotiation

As head of the construction management team, the area or resident engineer assigned to a design–build project should be fully competent in bottom-up estimating and negotiating with contractors. Because change orders are not unit priced, the team must determine the cost of the change order from a comprehensive estimating process and then negotiate with the contractor for final pricing. This is an arduous process. First, the area or resident engineer must create a new materials list. That person then must fully review the construction sequence and determine and confirm pricing from an independent source. Only after completion of this process can negotiations with the contractor commence. These negotiations must be structured, fact-based, and focused on the money drivers of the change order. In a design–build project, the construction management team can expect multiple rounds of negotiations with the contractor before reaching a final pricing agreement on large change orders.

Directing Teams

Leadership is a critical component of effective construction management on a design–build project. These projects are often quite large, with multiple teams working on disparate parts of the contract. A design–build project of $250 million or more, for example, will require extensive full-time construction personnel, including assistant resident engineers, office engineers, staff engineers, schedulers, quality control managers, and inspectors. On large design–build projects, it is not uncommon to have 15 construction personnel assigned to manage the project.

Complexity also is greater on a design–build than a design–bid–build project because the area or resident engineer initially serves as the owner's design manager. Only after construction commences does the role shift to construction tasks. This difference requires great flexibility on the part of the area or resident engineer, who also has more of a project management role than on design–bid–build projects. Often, the construction management team simultaneously serves as the project management team, a role that involves a distinct skill set.

Conclusion

Serving as an area or resident engineer on a design–build project demands a more diverse skill set, compared with the same role on a design–bid–build project. Design–build projects require the construction management team to have extensive knowledge in engineering design, construction means and methods, estimating, and negotiation. These skill sets are generally not required in design–bid–build contracts, which are material-based and unit-priced. Understanding why these additional skill sets are important and how they are applied on a design–build project can help ensure the effectiveness and success of the area or resident engineer and the construction management team.

CONSENSUS STUDY REPORT

Investing in Equitable and Resilient Infrastructure

Andrew Heneen, Wikimedia Commons, CC BY 4.0 DEED

STEVE MODDEMEYER

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Waves surge over Tampa's Bayshore Boulevard as Hurricane Idalia slams the Florida coast in 2023. Equitable infrastructure planning and investment could help boost community resilience, along with the sustainability of assets such as this popular route for drivers, pedestrians, and cyclists.

The content of this article is partially derived and excerpted from the National Academies of Sciences, Engineering, and Medicine consensus study report, Equitable and Resilient Infrastructure Investments.

Amplified in intensity and frequency by climate change, extreme weather events such as floods, deep freezes, and heat domes are taking an ever-increasing human and economic toll on communities across the United States. While media coverage sometimes portrays these natural disasters as indiscriminately affecting rich and poor alike, in reality the damage and lasting impact often fall unequally—with residents of low-income neighborhoods typically bearing the brunt. A National Academies of Sciences, Engineering, and Medicine consensus study report, *Equitable and Resilient Infrastructure Investments*, identifies research strategies to ensure that infrastructure investments equitably increase resilience and improve collaborative decision making with systematically divested communities (*1*).

The report takes its title from the theme of a public workshop organized

Read the full report at https://doi.org/10.17226/26633.

by the Committee on Applied Research Topics for Hazard Mitigation and Resilience. The committee was convened by the Resilient America Program (now the Science and Technology for Resilience Program) within the National Academies' Policy and Global Affairs Division to identify applied research topics, information, and expertise that might inform actions and opportunities for collaboration in the fields of hazard mitigation and resilience. The workshop examined three topics: partnerships for equitable infrastructure development, systemic change toward resilient and equitable infrastructure investment, and innovations in finance and financial analysis. These topics were selected based on information gained from daylong public workshops and committee members' experience with hazard mitigation and resilience.

Workshop presentations and discussions focused on how to direct infrastructure investments to support resilience and equity and to reflect specific community requirements. The panelists probed three areas of infrastructure investments and their potential to protect people and property during natural disasters and other disruptive events, as well as to increase community resilience.

The first deep dive explored the collaborative development, design, and operation of community resilience hubs. These hubs provide information, tools, and other assistance—such as food distribution or emergency shelter—during an extreme event. Panelists discussed how the concept could be expanded to strengthen adaptive capacity and deliver services that enhance community resilience year-round, despite changes in climate and technologies. The second deep dive focused on housing infrastructure and how investments influence both household and community resilience, while the third examined transportation infrastructure.

The committee's work included identifying activities in each of the applied research topics and specific questions to consider when undertaking related research. Tying all three deep dives together is a common thread: Equitable, inclusive, and trusted processes and leaders are essential for accepted and sustainable decisions. Such decisions are particularly important to address climate impacts that lack short-term solutions.

Win Henderson, FEMA

Residents of Jefferson Parish, Louisiana, take refuge on a sandbag-laden bridge to await evacuation with others stranded by Hurricane Katrina. Like that devastating 2005 storm, extreme weather events often expose gaps in community resilience and other inequities.

Interdependent Environments

The built and natural environments are connected to the health of communities. Focusing on protection and restoration of natural environments in areas where disastrous events devastate some communities disproportionately could lead to better long-term outcomes for residents. Likewise, smart resilience strategies in built environments can include health-related benefits from increased opportunities for physical activities, greater social engagement, improvements in mental health, perceptions of crime, and fewer traffic accidents. Research has associated these benefits with built-environment planning activities, such as improved walkability, compact neighborhood design, enhanced connectivity, and safe and efficient infrastructure (*2*). Based on the presentations, examples, and research opportunities discussed in the workshop, the committee identified the following applied research questions pertaining to the interdependence of the built and natural environments as they relate to equitable and resilient infrastructure investments:

- How can we investigate, understand, and apply functional and design relationships between neighborhood housing and access to natural areas and open space?
- How can we measure the interrelationships between the built and natural environments to foster investment that brings about optimal and equitable conditions for historically marginalized communities?
- How can we integrate the concept of pre–disaster mitigation versus post–disaster resilience with local community voices to support equitable investment decisions in built environments?
- Where have urban areas successfully enhanced and restored natural environments that serve as a source for food, fibers, and water, and as a buffer to mitigate natural hazard risk?

Courtesy of the New York City Department of Environmental Protection

Native plants and river stones top a sustainable stormwater management system along Beach 67th Street in the flood-prone New York City neighborhood of Arverne. Completed last summer, the green infrastructure median features underground storage tanks covered with engineered soil and resurfaced roads.

Innovations in Economic and Financial Analyses

Infrastructure projects are investments in the future of a community. Traditionally, public funds finance these projects. In many communities, however, deficits, the inability of the public sector to deliver efficient investment spending, and a lack of political will have led governments to reduce allocations for infrastructure. Research could help develop new analytical tools to demonstrate the benefits of public investment in resilient and equitable infrastructure and lead to new mechanisms for financing such projects.

As a key driver of sustainable growth, infrastructure constitutes a vital pillar of fiscal stimulus for economic recovery, particularly in the postpandemic period. It also serves as a crucial component in the transition to a low-carbon economy. Complementing opportunities to increase the magnitude of funding for infrastructure are considerations about improving the quality of these investments, including by ensuring that infrastructure does not inadvertently exacerbate inequities.

Promoting infrastructure that is well planned, efficiently implemented, resilient, equitable, and sustainable is an essential enabler for achieving sustainable growth. The focus on quality took on greater significance during the COVID-19 crisis, which highlighted the need to "build back better" by maximizing the ability of infrastructure assets at the earliest stages of the project's programming and design to improve resilience to—and reduce the costs of—future shocks, including climate change (*3*). Economic stimulus at the federal, state, and local levels can serve as a critical lever to ensure that infrastructure investments are high quality, sustainable, and equitable. Increased climate-resilient infrastructure development also can reduce the risk of physical stranded assets, such as a wastewater pumping station rendered inadequate upon completion by climate change–amplified flows. In addition, it can diminish service disruptions caused by flooded roads or power outages and create opportunities to meet the infrastructure service needs—including access to potable water, electricity, and health care—for all communities in a more efficient way.

Public funding can play an important—and sometimes driving—role in ensuring that infrastructure is climate resilient and equitable. Thus, it is a particularly attractive source of capital whose value exceeds the dollars denoted on the public balance sheet. Innovation not only in how these funds are invested but also in how they spur equitable and climate-resilient outcomes will be critical.

Research opportunities involving innovative financing for equitable infrastructure development include the following questions:

What is the range of public financing for climate-resilient infrastructure that includes mechanisms, incentives, or other measures—such as equity requirements—to ensure that the projects it supports are equitable?

- Where these measures exist, how do they ensure that projects are equitably co-developed with residents of the affected communities?
- Which community groups and other interested parties were engaged, and what was the process that defined equity to ensure that the end users experienced it?

How are these public financing programs supporting climate objectives in addition to equity and community resilience, if defined more broadly than climate resilience?

- Where they exist, how are measures that ensure climate resilience developed?
- What assessments were done to understand climate vulnerability, and were these assessments considerate of equity aspects?

What are the specific financial mechanisms for equitable infrastructure development, such as grants, concessional or commercial loans, and guarantees?

- What are the terms and conditions of such financing, and are they equitable in a way that does not disproportionately disadvantage historically underinvested communities?
- Do the terms and conditions allow for greater or less access to financing?
- How effective are these mechanisms in the context of equitable outcomes?

Courtesy of State Farm, Flickr, CC BY 2.0

Charred remains are all that are left of a home destroyed by the deadly wildfire that decimated the Lahaina community on Maui's lush coast in 2023. Climate change is amplifying the frequency and intensity of hazards such as this one, which forced tens of thousands of people to evacuate and killed more than 100.

How innovative are these financial mechanisms, as measured by the originality of their terms and conditions, their connections to nonfinancial impacts and co-benefits (e.g., measures of improved equity or resilience), and their complexity?

What is the role of wraparound funding—a collaborative, team-based approach to service and support planning—and financing in mitigation, recovery, and other aspects of risk reduction?

In addition, the committee noted the following steps that could help enable innovative financing for equitable infrastructure development:

1. Map federal, state, and local public funding sources for both climate-resilient infrastructure and equity goals, including the processes undertaken to ensure that equity issues are well developed and adequately reflected in the program.
2. Provide localized data and information about vulnerability beyond climate vulnerability.
3. Ensure broad representation in research and in interpreting and assessing its outcomes before developing recommendations about whether and how innovative financing sources can better enable climate-resilient, equitable outcomes.

Quantifying Impact

Benefit–cost analysis is a decision-making tool that policy makers can use for evaluating public-sector investments, such as infrastructure construction when ordinary markets do not exist or cannot achieve efficient outcomes, or where desired outcomes extend beyond economic efficiency. Policy makers also use benefit–cost analysis to evaluate a project's protection against disasters (mitigation), the ramifications of infrastructure damage and loss (resilience), and decisions regarding reconstruction alternatives, including "building back better." Increasingly, decision makers see infrastructure investment as a major strategy to cope with climate change impacts, for example, constructing barriers or elevating structures to protect against sea-level rise. In fact, studies have found that mitigation against disasters yields a benefit–cost ratio of at least 4 to 1 for historical cases (*4–6*).

Applied to infrastructure funding, however, benefit–cost analysis can lead to inequitable outcomes, such as discounting the investment's value to future generations and inappropriately valuing or omitting public health, community involvement and buy-in, resilience, and other factors that are hard to monetize. Benefit–cost analysis also excludes equity considerations, such as failing to account for historic disinvestment in low-income communities, Indigenous communities, and communities of color. The tendency to assess the cumulative benefits and costs of projects, rather than the distribution of these benefits and costs, frequently limits these analyses.

The committee identified the following applied research questions pertaining to benefit–cost analysis for resilient and equitable infrastructure development:

- How can we include distributional considerations in benefit–cost analysis to analyze equity, social justice, and other broad societal goals?
- How can we adapt benefit–cost analysis to account for difficult-to-monetize outcomes, such as resilience, public health, and equity?
- Are there alternative decision analysis approaches to benefit–cost analysis to evaluate resilient infrastructure investments?
- What adjustment to benefit–cost analysis would better incorporate benefits to future generations?

In addition, the committee noted factors that could improve benefit–cost analysis as applied to resilient and equitable infrastructure development, including exploring equity considerations during recovery from disasters and enhancing public participation in risk-reduction decisions.

Conclusions

Hazard events caused by extreme weather and other large-scale emergencies continue to devastate communities in the United States. While nature does not discriminate, decades of inadequate adoption and enforcement of codes and standards and discriminatory policy and practices have resulted in low-income communities, Indigenous communities, and communities of color bearing a disproportionate share of the social,

economic, health, and environmental burdens caused by extreme weather and other natural disasters (*7–9*).

In addition, current thinking about community resilience often fails to consider that many residents may lack the resources to engage in risk reduction, mitigation, and planning. Although there are never enough funds to do the level of desired resilience planning, communities can address their needs incrementally. To reduce the equity gap in community resilience, efforts to enhance adaptability should include funds and resources for planning and construction along with rebalancing public infrastructure investments and addressing social inequalities.

Recognizing the importance of directing infrastructure investments to opportunities that will increase community resilience and reduce the equity gap, the committee focused on identifying applied research needs and opportunities to better create and capitalize on such openings. Research findings from these topics could help equitably shape the flow of infrastructure resources to broadly strengthen the capacity of communities to be more resilient in the face of extraordinary change.

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"While media coverage sometimes portrays natural disasters as indiscriminately affecting rich and poor alike, in reality the damage and lasting impact often fall unequally—with residents of low-income neighborhoods typically bearing the brunt."

Electric Vehicles

Powering Up in Rural America

Vivika Stamolis, Crystal Mountain Resort

COLE GRISHAM AND BEN RASMUSSEN

Grisham is a senior transportation systems planner at the FHWA Western Federal Lands Highway Division in Vancouver, Washington. Rasmussen is a public lands team leader at the U.S. Department of Transportation Volpe Center in Cambridge, Massachusetts.

An electric vehicle charges up before traveling through Enumclaw, Washington, the gateway to Mount Rainier National Park. Public charging stations remain rare in rural communities—a disparity that federal and state transportation infrastructure programs aim to address.

The terrain may vary from mountains to forests to farmland, but rural communities share a notable feature: Everyday destinations, such as work or the grocery store, often lie far from home. Rural residents not only drive more than their urban counterparts but also spend more on fuel and vehicle maintenance and have fewer alternatives to driving to meet their transportation needs (*1*). Tribal communities, the majority of which are in extremely remote regions, face even greater gaps, with 66 percent of the transportation network composed of unimproved earth and gravel roads (*2*). Electric vehicles and the expansion of public charging infrastructure now underway across the country could improve rural mobility and help ease the growing disparity with urban areas, which typically receive more than 60 percent of federal transportation funding allocated to states (*3*).

This focus on urban areas for transportation funding mirrors where federal and state agencies strategically invest in supporting infrastructure, such as electric vehicle charging stations. As states implement their electric vehicle deployment plans, there is an emphasis on connecting urban areas along major highway corridors such as in the Pacific Northwest, as shown in Figure 1 (Page 38). While intracity connectivity is essential to building a comprehensive national electric vehicle charging network, current deployment plans miss many rural communities that also need access to the transportation network. Other initiatives could perpetuate such imbalances. For example, the federal government aims to have electric vehicles make up half of all vehicle sales in the United States by 2030 (*4*). Efforts to achieve that milestone risk deepening the divide between city dwellers with access to multimodal transportation options and rural residents who remain predominantly reliant on gasoline-fueled vehicles and uncertain access to electric-vehicle infrastructure.

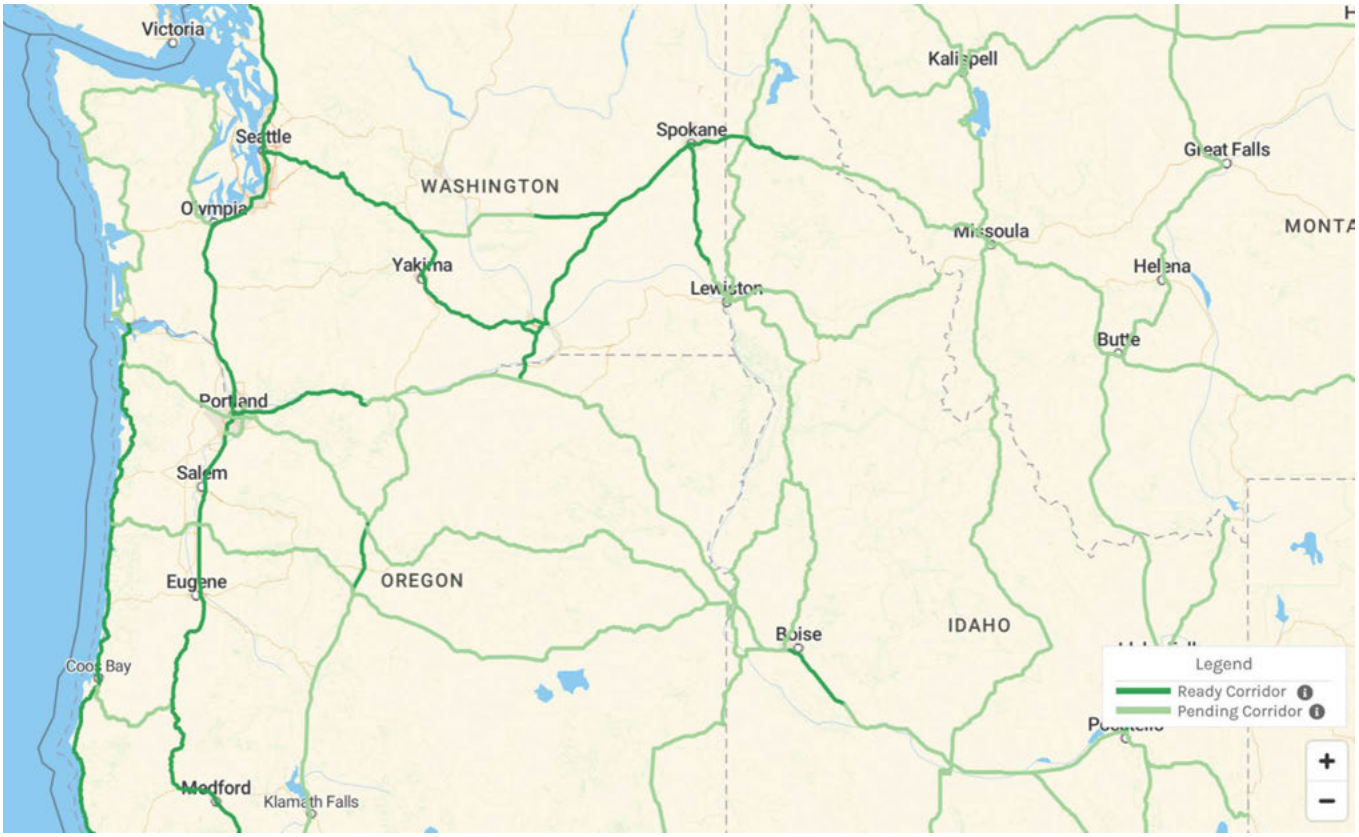

FIGURE 1 Electric vehicle corridors in the Pacific Northwest. (Source: FHWA, 2023.)

State of Practice and Funding Opportunities

Two major federal programs are driving investment in electric vehicles nationwide. The 2021 Infrastructure Investment and Jobs Act, commonly known as the Bipartisan Infrastructure Law, established the National Electric Vehicle Infrastructure (NEVI) Formula Program to provide nearly $5 billion to states. Designed to strategically deploy electric vehicle charging infrastructure and to establish an interconnected network to facilitate data collection, access, and reliability, the FHWA-administered program will fund up to 80 percent of eligible project costs for the following:

- Acquisition, installation, and network connection of electric vehicle charging stations;
- Operation and maintenance of electric vehicle charging stations; and
- Long-term electric vehicle charging station data sharing.

In addition, NEVI requires that these initial electric vehicle charging stations are to be located along sections of interstate or other major U.S. highways designated as FHWA Alternative Fuel Corridors (AFCs). A state can propose alternative public locations and roads for installing charging stations if it and the U.S. Department of Transportation (U.S. DOT) determine that all statewide AFCs have been fully developed.

FHWA began funding NEVI in 2022 and will continue to distribute funds to each state each year through FY 2026.[1] To receive funding, states must annually submit plans to the U.S. DOT and U.S. Department of Energy Joint Office that describe how the state intends to use its NEVI funds. These plans also may identify new AFCs and seek Joint Office approval to install charging stations at the proposed locations.

The second major source of federal funding is FHWA's Charging and Fueling Infrastructure (CFI) discretionary grant program, which provides nearly $2.5 billion for states, local governments, federally recognized tribes and affiliated groups, U.S. territories, and transportation providers and operators to deploy publicly accessible electric vehicle charging and alternative fueling infrastructure in urban and rural communities and along AFCs. The CFI program offers two categories of grants, which are funded equally: the Community Charging and Fueling grants (community program) and the Alternative Fuel Corridor grants (corridor program).

[1] Calculate the amount each state will receive according to the FHWA funding formula summarized at https://www.fhwa.dot.gov/bipartisan-infrastructure-law/evs_5year_nevi_funding_by_state.cfm.

FIGURE 2 Alternative fuel corridors in the United States. (Source: The White House, 2021.)

Infrastructure deployments funded by the community program must be located on public roads or in publicly accessible locations, including public parking facilities, buildings, schools, and parks. Low-income, underserved, rural, and high-density communities are prioritized for funding. Corridor program grants focus on infrastructure deployments along designated AFCs. Eligible applicants for both programs include metropolitan planning organizations; U.S. territories; special purpose districts and public authorities; as well as state, local, and tribal governments.

In 2022, U.S. DOT published *Charging Forward: A Toolkit for Planning and Funding Rural Electric Mobility Infrastructure.*[2] This one-stop resource was created to help rural communities plan and fund electric vehicle charging infrastructure. It focuses on infrastructure for light-duty electric passenger vehicles but also addresses funding opportunities and planning considerations for other types of electric vehicles, including transit and school buses, medium- and heavy-duty vehicles, and agricultural equipment. The toolkit is intended for a variety of rural stakeholders to identify key partners for a project, take advantage of relevant planning tools, and identify available funding or financing to help make that project a reality. The toolkit recently was updated to incorporate feedback gathered through virtual workshops with rural communities across the nation and to expand content on transit and micromobility. The updated version also includes more information on planning and funding for Native American communities.

Policy Issues for Rural Charging Infrastructure

For transportation researchers and practitioners, the following primary policy issues merit attention:

- Covering gaps in the NEVI Alternative Fuel Corridors through rural areas,
- Providing reliable access to rural public lands, and
- Ensuring equitable access to electric vehicle charging infrastructure.

Figure 2 shows the federally designated AFCs. These routes and their supporting charging infrastructure are located on National Highway System corridors that connect major population centers within and between states. The green routes indicate electric vehicle existing routes while the dashed routes are pending. At a national level, the map shows a reasonably well-connected network. However,

[2] Explore the rural electric vehicle toolkit at https://www.transportation.gov/rural/ev/toolkit.

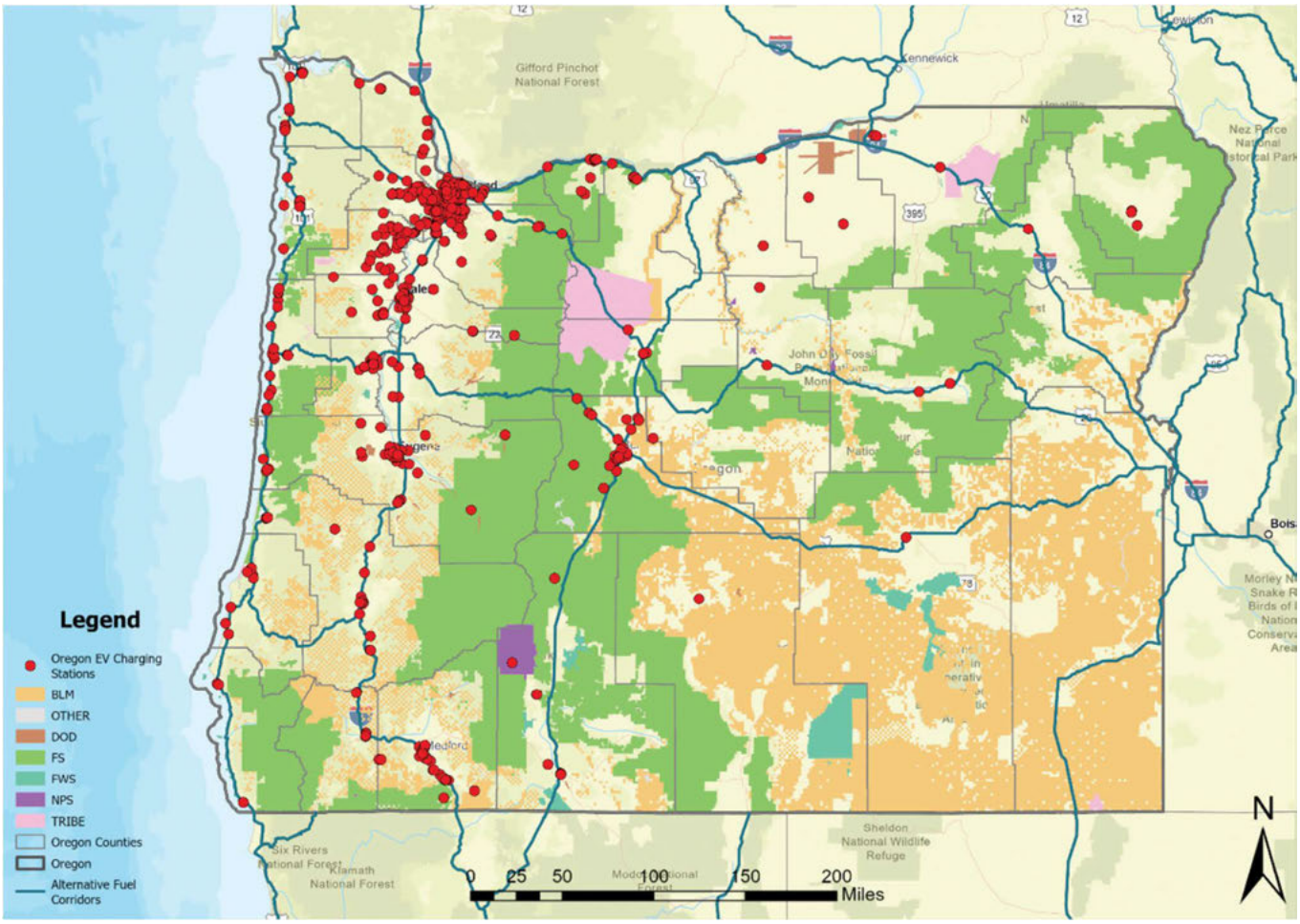

FIGURE 3 Electric vehicle charging infrastructure and alternative fuel corridors in Oregon. (Source: U.S. Department of Energy.)

by looking at the state level and layering other data, gaps become apparent.

Figure 3 provides an example. The map of Oregon's existing public electric vehicle charging stations and designated AFCs shows little to no charging capacity on much of the state's federal lands or in the gateway communities that abut them. Electric vehicle drivers may be able to charge their vehicle on major highways, but they are mostly out of luck when visiting national parks or other public lands that occupy vast swaths of rural America.

Similarly, Oregon's two largest tribal communities by land area—the Confederated Tribes of Warm Springs and the Confederated Tribes of the Umatilla Reservation—have only one public electric vehicle charging station in or adjacent to their lands. It is possible that the designation of highways through these lands as AFCs may improve access to electric vehicle charging infrastructure, but it is not clear what investments will be made on tribally owned facilities.

Looking Ahead

Electric vehicle investments along AFCs benefit both urban and rural communities. As states complete their buildouts along the Interstate highway network, additional AFCs on other major U.S. highways will connect more rural areas throughout the country. In addition, FHWA's CFI community program, which had its most recent call for proposals in spring 2023, promises to promote investments in rural areas for years to come.

While some states have invested heavily in electric vehicle charging infrastructure through federal and state investments, others have not. It is possible that these states will feel pressure as their neighbors expand their electric vehicle charging networks. However, a fully built-out nationwide charging network depends upon the availability of federal

funding sources beyond the current Bipartisan Infrastructure Law.

Recently, federal land management agencies, including the National Park Service, USDA Forest Service, U.S. Fish and Wildlife Service, and Bureau of Land Management, mapped charging infrastructure to determine if electric vehicle drivers could reach public lands. This exercise revealed that while many public lands are connected by either existing or proposed electric vehicle infrastructure, gaps remain—especially in more remote areas of the country. A similar exercise could be undertaken for rural and underserved areas. Federal land management agencies are now working with state departments of transportation to boost investment in charging infrastructure and designate more AFCs on roadways connecting to their lands. These agencies also are engaged in internal five-year planning initiatives to prioritize electric vehicle charging infrastructure investments on the lands they manage.

Strategically investing in publicly available electric vehicle charging infrastructure for years to come will help ensure that all areas of the country become connected as electric vehicles proliferate on the nation's roadways.

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"As states implement their electric vehicle deployment plans, there is an emphasis on connecting urban areas along major highway corridors, such as the Pacific Northwest. While intracity connectivity is essential to building a comprehensive national electric vehicle charging network, current deployment plans miss many rural communities that also need access to the transportation network."

Jacquelyne D. Grimshaw

Vice President for Government Affairs, Center for Neighborhood Technology

Jacky Grimshaw is an agent of change. Her skills include the ability to use original research and facts born from a methodical and scientific approach to change public policies, foster new attitudes, and improve day-to-day reality for underserved communities. Grimshaw also possesses the determination to empower others to do the right thing to transform the world into a more equitable place.

Graduating in 1965 with a bachelor of science in biology from Marquette University in Milwaukee, Wisconsin, she began her career in the health care sector, performing quantitative research in hematology and gastroenterology. As she gained experience, Grimshaw notes that she "took the opportunity to use the scientific method to question issues of health effects in the urban environment, especially in disinvested communities." Graduate classes in public policy at Governors State University in University Park, Illinois, taught her how to use qualitative methods. She worked for Chicago Public Schools, as well as for state and federal government organizations, and in the 1980s joined the Chicago Mayor's Office of Intergovernmental Affairs as deputy director, then director. In 1986, she was the mayor's top legislative aide and later served as the city's deputy treasurer for economic development. In the 1990s, Grimshaw's foresight brought the concept of carsharing to Chicago, and I-GO CarSharing, one of the first nonprofit carsharing companies in the United States, resulted. By the time she led the advocacy effort that combined the metropolitan planning organization and land-use planning agencies into the current planning agency, the Chicago Metropolitan Agency for Planning, her career had transitioned from biology to transportation.

Since 1992, when she joined the Center for Neighborhood Technology, a Chicago-based nonprofit organization focused on sustainable development, Grimshaw has helped transform policies, communities, and perspectives on topics ranging from mass transit to environmental justice. Notable initiatives include creating and leading programs to foster public participation in transportation planning and improve air and water quality. "I've been fortunate to have a team of researchers to answer questions that require quantitative solutions," she admits.

"Involving residents in decision making about solutions to problems they face in their communities is the right thing to do."

Grimshaw's own research has focused more on the qualitative, which she illustrates with an example from early 2000, when the Chicago Housing Authority was demolishing public housing high rises along the State Street corridor while nearby buildings were still occupied. Realizing that asthma and other respiratory diseases were highly prevalent in this community and anticipating severe adverse impacts, Grimshaw and her research team developed a questionnaire for residents who would be affected by the teardowns. "Then, we used the survey results to develop a campaign for respiratory health care for children," she recalls. Grimshaw also was involved in creating the Chicagoland Transportation and Air Quality Commission, which helped the community get involved in transportation decisions and better understand how vehicle emissions—as well as the dust from the razing of nearby public housing—could affect their health. "Our efforts prompted the housing authority to conform to the Clean Air Act," she notes, pointing out that "the research performed was triggered because of our work in the community. We couldn't turn a blind eye."

Grimshaw believes that research—especially qualitative research—is essential to develop solutions for marginalized and disinvested people. "The people in many communities we worked in experienced things being done *to* them, not *for* them," she stresses. "Involving residents in decision making about solutions to problems in their communities is the right thing to do and results in better outcomes."

A longtime TRB volunteer, Grimshaw was the 2004–2005 chair of TRB's Task Force on Environmental Justice in Transportation and of the standing committee of the same name (now known as the Standing Committee on Equity in Transportation) from 2005 to 2011. She was a member of the Transit Cooperative Research Program (TCRP) Project Panel on Combating Global Warming Through Sustainable Surface Transportation Policy and the Project Panel on Transportation Services for People with Disabilities and Older Adults During a Pandemic and Other Emergencies.

In 2022, Grimshaw received TRB's Sharon D. Banks Award for Humanitarian Leadership in Transportation. She was honored as an advocate "for those who are often not included in decision-making 'rooms'…and staunchly trying to ensure that benefits and opportunities afforded by transportation policies and investments improve outcomes for all."

In 2023, the Center for Neighborhood Technology launched the Jacky Grimshaw Fellows Fund to provide "exceptional women of color with the essential skills they need to lead transportation policy into an equitable future." A champion and mentor to many, Grimshaw continues to inspire change.

Jeffrey D. Borowiec

Aviation Program Director, Woolpert, Inc.

Jeff Borowiec is a fierce advocate for research and innovation. He explains, "Research is at the center of everything we do as a society to improve our health and quality of life—and it is no different in transportation." From the hectic simplicity of his first aviation job managing the Long Beach, California, office of Island Express Helicopters to his current position as an aviation program director at Woolpert, Borowiec leverages more than three decades of experience in aviation research and transportation policy. At Woolpert, he helps lead statewide efforts involving airport system planning, economic impact analysis, and advanced air mobility planning. Previously, Borowiec spent 28 years with the Texas A&M Transportation Institute (TTI), in Bryan. During his tenure, he rose from assistant research scientist to aviation practice leader and on to senior research scientist. He received TTI's Researcher of the Year Award in 2012.

"Much of the work I did at TTI supported the system planning and stakeholder outreach efforts of the Texas Department of Transportation Aviation Division," Borowiec recalls. He conducted technical studies covering topics ranging from agricultural aviation to advanced air mobility, visited nearly all of the system's 300 airports, and helped conduct more than 100 public meetings.

His love of air flight reaches beyond the research lab and classroom. He is an instrument-rated private pilot who also holds a remote pilot certificate that entrusts him to safely operate a drone within the U.S. National Airspace System. His formal education includes a bachelor of science degree in aeronautical management technology from Arizona State University in Tempe, a master of public administration with an option in public works management from California State University at Long Beach, and a PhD in urban and regional science with a specialization in transportation and aviation from Texas A&M University in College Station.

"Aviation is on the precipice of significant change."

Borowiec began attending the TRB Annual Meeting in the 1990s when his graduate school advisor accepted a position as a TRB senior program officer. He chaired the TRB Standing Committee on Aviation System Planning from 2016 to 2022 and has served on the editorial board of TRB's journal, the *Transportation Research Record,* since 2020. He is TRB's current Aviation Group chair and a member of the Technical Activities Council.

"Aviation education is a passion of mine," admits Borowiec, who has been a frequent guest lecturer in graduate planning and transportation courses at Texas A&M. "I always encourage students to ask questions, explore different areas, and seek out diverse perspectives—not only to learn something new but also to find out what they like." He also is a voracious reader who encourages others to read. "This not only broadens our horizons but makes us better researchers, writers, and communicators," he explains, noting that he urges students to go beyond their comfort zones not only in what they read but in what they pursue in their careers. "How else," he asks, "will they realize their full potential?"

Looking to the future, Borowiec points out that "aviation is on the precipice of significant change. New and emerging technologies will influence the way we move people and goods, and how we shop. Electric aviation, uncrewed aircraft operations, the return of supersonic passenger flight, drone delivery in our neighborhoods, and new and sustainable aviation fuels are only the beginning." Although aviation's future is bright, he cautions, "it is going to take a lot of talented people to develop, operate, and maintain this new and exciting aviation system. We need to engage students at all levels and make them aware of the careers that are available to them in aviation. We have made great strides in aviation workforce development in recent years, but we still have work to do."

Borowiec considers himself fortunate. "I work with some great colleagues—many of whom are a lot younger than I am—and I learn from them every day. They have a lot to offer, and we need to listen to what they are telling us." He describes a recent visit to the autonomy research lab of a large aviation manufacturer. "It was staffed by a half-dozen twentysomethings who were incredibly sharp, focused, and well spoken." After the meeting, he remembers commenting to a colleague on how comforting it was to see these young professionals leading the way in this next generation of automation research. "They were really in their element!"

TRANSPORTATION INFLUENCER

Emily Lindsey

Emily Lindsey is the Active and Emerging Mobility program manager for the Denver Regional Council of Governments in Colorado. She is also chair of the Data, Planning, and Analysis Group Young Members Subcommittee and a member of the TRB Standing Committee on Transportation Planning Policy and Processes.

What is your role as Data, Planning, and Analysis Group Young Members Subcommittee chair?
I'm excited to chair the Data, Planning, and Analysis Group's first Young Members Subcommittee. After being appointed chair in the summer of 2023, I began working with some wonderful volunteers so we could hit the ground running. The subcommittee is made up of a wide variety of researchers, practitioners, students, and other experts in the transportation sector. It is an exciting opportunity to work with young professionals from across the industry. Our subcommittee is planning to work with members on a few new initiatives. We are hoping to better connect the research community with transportation practitioners and help young professionals get more involved in the Data, Planning, and Analysis Group's work across a variety of standing committees.

What is enabling you to be successful in this role?
As a program manager at the Denver Regional Council of Governments, I work with local, regional, state, and federal partners to advance transportation and mobility goals throughout the region. My experience managing regional transportation plans, leading multiagency partnerships, and collaborating with partner agencies has set me up for success in this role. I hope to bring people together and work toward our common goals while celebrating our members' unique experiences in the transportation industry.

What do you find most helpful about TRB?
TRB is the best place to connect with people in the transportation industry. It offers a unique opportunity to collaborate with people from across the world in pursuit of improving transportation and mobility by sharing research and knowledge with professionals throughout the sector.

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

MEMBERS *ON THE MOVE*

Steve Andrle, a senior program officer who served as Transit Cooperative Research Program manager and deputy director of the Second Strategic Highway Research Program (SHRP 2), retired after 30 years at TRB.

Nelson Gibson, Senior Program Officer in the Technical Activities Division and former *TR News* Editorial Board member, left TRB on February 7, 2024, to take a position at FHWA.

Oulimata Khoule, formerly with the Washington Metropolitan Area Transit Authority, joined TRB as a senior program assistant.

Stephen Maher, Deputy Director for program content in the Technical Activities Division, entered phased retirement after 30 years of service.

Krishna Murthy joined the Airport Cooperative Research Program as a senior program officer. He previously worked at Hartsfield–Jackson Atlanta International Airport and for several consulting firms.

Gwen Pelletier, a member of the Standing Committee on Environmental Issues in Aviation who had previously worked with Ramboll, returned to CDM Smith as a principal environmental scientist.

Shushanna Thompson, previously with Safe Kids Worldwide, joined TRB as a senior program officer for the Technical Activities Division.

Shawn Wilson, former TRB Executive Committee Chair, has accepted the position of the national agency coordination leader for transportation and infrastructure at WSP. Wilson served as secretary of the Louisiana Department of Transportation and Development from 2016 to 2023.

Andrea Zachary is now indexing manager for TRB's Transportation Research Information Services (TRIS) database. With more than 20 years of information management experience, she had previously worked at the Boeing Library and for FAA.

Latinos In Transit Discuss Transportation Equity

On September 23, 2023, Latinos In Transit (LIT) held its Second Annual Leadership Summit in Washington, DC. At the event, TRB hosted a panel discussion on Equity in Transportation, in which panelists discussed the historical context of transit planning decisions related to community engagement, fare equity, access, transit-oriented development, and gentrification. The panelists were

- Noah Berger, Merrimack Valley Transit;
- Reinaldo Germano, Foursquare Integrated Transportation Planning;
- Circe Torruellas, Gannett Fleming; and
- Veronica Vanterpool, FTA.

Gwen Chisholm-Smith, manager of TRB's Transit Cooperative Research Program (TCRP), moderated the discussion.

Making an Impact

In his opening remarks, Berger urged attendees to be mindful of the history of this country, explaining that many civil rights protests have taken place on transit vehicles. This includes integration, as well as rights and equal access for persons with disabilities. "Transit," he noted, "is key to accessing opportunities and freedom, and its power comes from how it is used."

One overarching theme that emerged was that equity is the basis of good transportation planning and that looking through the lens of equity can inform policy decisions and infrastructure choices. Vanterpool discussed how equity is the foundation of FTA's work, which she described as connecting people to opportunities (such as jobs, medical appointments, school, and social engagements). She further highlighted the Biden Administration's Justice40 Initiative, which aims to ensure that 40 percent of the overall benefits of certain federal investments flow to disadvantaged communities.[1]

Karen Febey, TRB

Equity in Transportation panel discussion participants are (*left to right*) Mariela Garcia-Colberg, TRB Senior Program Officer; Veronica Vanterpool, FTA Deputy Administrator; Noah Berger, Merrimack Valley Transit Administrator and Chief Executive Officer; Circe Torruellas, Gannett Fleming Senior Program Manager; Reinaldo Germano, Foursquare Integrated Transportation Planning Project Manager and Senior Transportation Planner; and Gwen Chisholm-Smith, TCRP Manager.

"For example," she explained, "one such investment could be in a rural Alaskan community that needs a bus maintenance facility for its two buses that serve the community's 160 residents." Similarly, Torruellas noted, "Overall, during the Biden Administration, equity is playing a large role and affecting the conversation of how equity looks in the delivery process for transportation projects."

Concentrating on the local level, Berger described how Merrimack Valley buses—which serve the northeast corner of Massachusetts—became fare-free in March 2022. This initiative was a success. Bus ridership is 20 percent above pre-pandemic levels, complaints are down by a third, and the transit authority's driver workforce has increased by a third. With fare-free buses, the riders from this region no longer have to make the difficult choices of affording transit or paying for essentials.

Achieving Goals

Panelists also discussed how much of what is done to achieve transportation equity is accomplished through active community engagement with groups of people who have not traditionally been involved in the transportation decision-making processes. When planning transportation policies and infrastructure, emphasized Torruellas, "Do not cut your public engagement budget. This is a critical piece of the work you are doing, and without it, you are cutting critical information." Germano added, "Transportation professionals must think about how best to engage people who have historically not been involved in the planning of transportation policies and projects."

Another theme the panelists discussed was the use of data in transportation decision making. "Prudent use of data involves examining how people move in their communities—beyond going to work," Germano warned, "so that transportation professionals can leverage data to prioritize investments and the trip as a whole." Berger stressed that reports or anecdotal information from people—not just from data—should help inform what is funded.

The panel session left attendees energized and better informed about ways to work toward a more just transportation system in the United States.

—Karen Febey,
TRB Senior Report Review Officer

The mission of Latinos In Transit (LIT) is to promote the advancement and development of Latinos and other minorities in transportation. More information about LIT can be found at latinosintransit.org.

[1] Learn more about Justice40 at https://www.whitehouse.gov/environmentaljustice/justice40/.

CONSENSUS STUDY REPORT

Recycled Plastics in Pavement and Other Infrastructure

DAVID DZOMBAK AND MONICA STARNES

David Dzombak, Hamerschlag University Professor Emeritus of civil and environmental engineering at Carnegie Mellon University in Pittsburgh, Pennsylvania, chaired the study committee. Monica Starnes is a TRB senior program officer and served as the project's study director.

California Department of Transportation

A work crew tamps new pavement made from recycled asphalt and a mix including recycled material from single-use plastic bottles on a segment of Highway 162 in Oroville, California. The pilot project incorporated the equivalent of 150,000 plastic bottles per mile.

Plastics are ubiquitous in modern society. As synthetic materials designed for specific end applications, they offer novel and customizable qualities that make them materials of choice for use in many products. These advantages, however, have contributed to the growing use of plastics for short-life, single-use applications that has led to a marked increase in plastics waste. Recycling plastics for use in asphalt and other infrastructure is a potential means of diverting this waste from landfills and litter, where much of it currently ends up.

To understand the prospects for using recycled plastics waste in infrastructure, the U.S. Congress called for a National Academies of Sciences, Engineering, and Medicine study to review the current use of recycled plastics in infrastructure and to evaluate the opportunities and barriers for their increased use. The U.S. Department of Transportation (U.S. DOT) and EPA commissioned the study, which was conducted by a committee of experts.

The EPA reports that plastics accounted for more than 36 million metric tons of waste in the United States in 2018—approximately 12 percent of the total solid waste generated in the country (*1*). Only three million metric tons (9 percent) were recycled. There are many types of plastics used in products, and they have a range of chemical compositions and physical properties that complicate their recycling. The process involves sorting the waste material based on properties such as composition, melting point, density, and color. The sorted waste then needs to be decontaminated and processed into pellets or flakes. Some common manufactured products that use recycled plastics include carpet, outdoor furniture, clothing, and toys.

Recycled plastics are being used at scale in a handful of infrastructure applications, most significantly in stormwater drainage pipes. Opportunities for wider use have been limited, however, partly because of demanding requirements for high-quality materials when constructing expensive and long-lived infrastructure. The array of inhibiting factors differs by application but includes the following:

- High costs for obtaining material supplies,
- Uncertainties about long-term service performance,
- General lack of familiarity with products made from recycled plastics, and
- Uncertainty about durability and environmental impacts.

To attract commercial interest for reuse in infrastructure and other applications, a recycled plastic consistently must be able to meet the desired properties for the application. It also must be available in sufficient supplies on a reliable basis; cost-competitive with conventional materials; socially acceptable; legally permitted; and free of undue environmental, health, and safety risks.

Furthermore, when used in long-lived infrastructure, the recycled plastic must contribute to sustained acceptable levels of service and environmental performance over the life cycle of the asset. True recyclability also includes the potential to reuse a product that contains recycled material when it reaches the end of its useful life. Asphalt pavement, for example, is one of the most recycled products in the United States, with roughly 90 million metric tons recycled in 2019 (*2*). Simply adding recycled plastic to asphalt could make future recycling more difficult. This possibility deserves further research and testing.

NEXT STEPS AND ADVICE

Until more plastics waste is captured, sorted, and cleaned for secondary applications, incorporating the limited

supplies of high-quality recycled plastics in infrastructure could divert this material from use in other, higher-value applications. In response, the committee outlined a series of actions intended to prompt more concerted efforts to reduce plastics waste overall, increase the quantity and quality of recycled material, and develop and exploit applications for its use—including in infrastructure when cost beneficial.

The EPA, which has primary responsibility for developing and planning the implementation of the 2021 National Recycling Strategy,[1] is well positioned to provide the overall strategic leadership, coordination, and support for carrying out the recommended actions in the report. With its research and funding capacity, U.S. DOT can play a supportive role by working with state transportation agencies to advance research, field testing, and standards development for the use of recycled plastics in the transportation sector.

To read Recycled Plastics in Infrastructure: Current Practices, Understanding, and Opportunities, *visit https://doi.org/10.17226/27172.*

[1] Learn more about the National Recycling Strategy at https://www.epa.gov/circulareconomy.

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Critical Issues in Transportation

In January 2024, the TRB Executive Committee released Critical Issues in Transportation for 2024 and Beyond*, its latest edition on the topic. Published every few years, the report outlines major transportation policy and research issues that are national or global in scope and importance. While past* Critical Issues *reports have provided lists of specific research questions, this edition takes a broader view of how transportation affects society at large. The following is excerpted or derived from the report.*

A massive shift away from fossil fuels to clean energy has begun that will require a complete turnover of hundreds of millions of motor vehicles by 2050 to help meet national decarbonization goals. Commuting to work has changed dramatically because of the COVID-19 pandemic in ways that pose significant threats to public transportation. Ten thousand more people died from road crashes in 2022 than 10 years ago. Society at large is grappling with the nation's history of racial discrimination and increasing disparities in wealth and incomes. The dynamic changes being driven by these and other environmental, public health, and socioeconomic forces require reassessing the role of transportation in addressing societal challenges and the research that informs the choices that society will need to make in 2024 and the coming years.

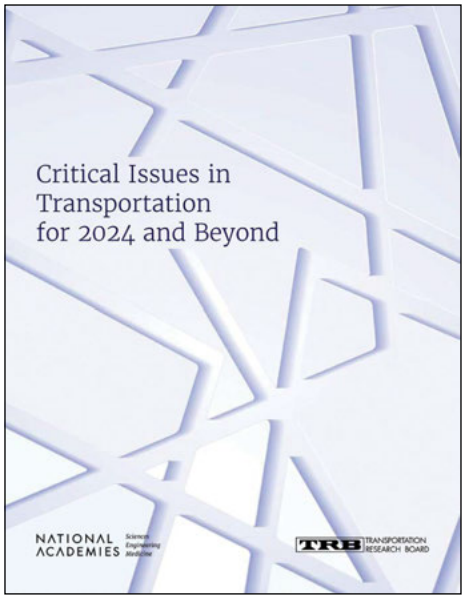
For this edition of *Critical Issues in Transportation*, the Transportation Research Board's Executive Committee chose to focus on five vitally important societal goals to meet these major challenges facing society:

1. Mitigating and responding to climate change;
2. Promoting equity and inclusion;
3. Increasing road safety;
4. Advancing public health; and
5. Building and sustaining a strong, competitive economy.

All five goals contribute to the ultimate goal of a thriving society.

Transportation is essential for achieving all of these societal goals. It has two key components: the movement of people and goods from origin to destination and infrastructure systems—the physical and digital structures that enable travel by foot, vehicles, vessels, and aircraft. Transportation, in turn, is heavily dependent on the following foundational factors and policy levers:

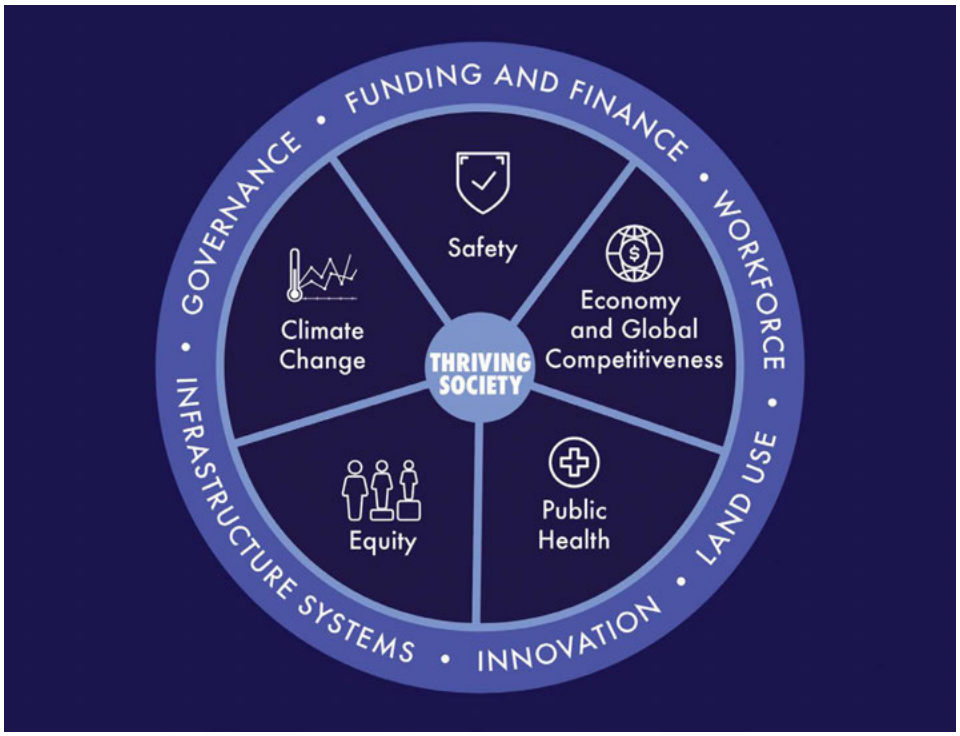
- Public policy and oversight (**governance**);
- Demand for travel generated and modal options dictated by the built environment (**land use**);



Read the full report at https://doi.org/10.17226/27432.

- Adequacy of revenues (**funding and finance**) to provide and maintain infrastructure;
- Extent, quality, and engagement of its **workforce**; and
- Fostering and implementation of **innovation**.

Understanding the complex interactions among the articulated societal goals, transportation itself, and the foundational factors and policy levers is essential for transportation



This graphic represents the Executive Committee's vision for this publication and its aspirations for the Transportation Research Board. The five vitally important societal goals shown between the spokes of this wheel all contribute to the ultimate goal of a thriving society. Transportation is essential for achieving these societal goals, but its success in doing so is dependent on all of the major determinants and influences on transportation shown around the rim of the wheel.

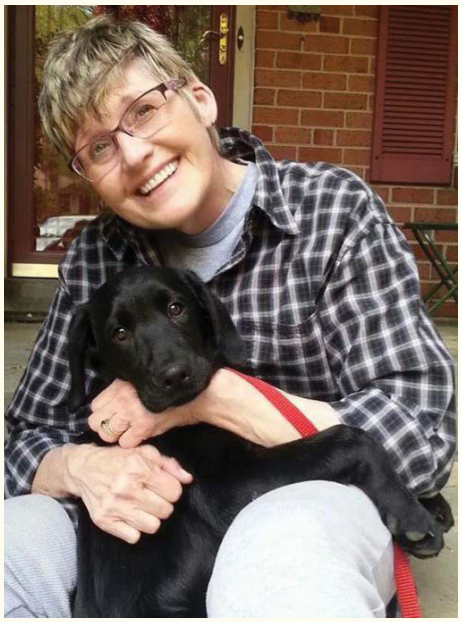
to be successful in contributing positively toward a thriving society. These interactions are discussed in more detail in the report's individual sections. Research and development (R&D) that accounts for the multifaceted issues and interactions among the foundational factors and policy drivers, their transportation influences, and the achievement of societal goals will inform better policy choices to increase transportation's contributions to a thriving society.

Technological innovations have created the opportunity to significantly reduce transportation's reliance on fossil fuels by allowing for the transition—for most vehicle types—to clean electric power without increasing the cost of the electricity for charging batteries or of vehicle ownership and operation. If successful, this energy transition and the resulting reduced vehicle emissions will have substantial public health and environmental justice benefits. Even so, a tremendous effort will be required to deploy charging infrastructure; further improve battery performance and cost; transform vehicle manufacturing; develop net-zero carbon fuels for aircraft, vessels, and other heavy vehicles that depend on high-energy–density fuels; ensure an equitable distribution of the benefit of this transition; and minimize the adverse environmental impacts of mining and processing the minerals required for the vast number of batteries that will be needed. Technology may also improve transportation productivity and highway safety. However, R&D will be necessary to identify and promote scientifically based policies that are acceptable in a pluralistic society.

Addressing transportation's role in the nation's history of racial discrimination and improving the transportation options of low-income households generally will require equitable and effective transportation policies and funding, as well as the development of a greater consensus around evidence-based options for establishing such policies and allocating resources accordingly.

Centuries of investment and development have resulted in a vast transportation infrastructure that supports personal and freight travel, as well as the substantial cost of maintaining and operating it. Continuing reinvestment in privately funded infrastructure appears to be on a reliable footing. However, public infrastructure faces greater uncertainty due to historically high levels of federal public debt and continued resistance among elected officials to enact necessary taxes and user fees to maintain and expand existing roads, transit, airports, and ports. The transportation research community can help address this problem by documenting and spreading information about acceptable innovations and practices that work.

Fragmented governance and land use policies may well be integral to the United States due to its history, culture, and forms of government. Even so, innovations in transportation governance and land use policies that address climate change and equity can be documented and shared. Implementing these innovations and other policies described in this publication depends on attracting and retaining a diverse workforce that is skilled across multiple disciplines. The challenges and opportunities for rewarding careers in transportation are as great as the need to attract talented people to the field.



Courtesy of Mike Lidsky

Former Senior Program Officer Donna Vlasak-Lidsky radiates her signature "100-watt smile" while enjoying time with her dog, Vinnie.

Farewell to a Friend

DONNA VLASAK-LIDSKY
1949–2023

Donna Vlasak-Lidsky, a TRB Transit Cooperative Research Program (TCRP) senior program officer who retired in December 2015, is fondly remembered by her colleagues.

Born in Binghamton, New York, Donna majored in design and environmental analysis at Cornell University in Ithaca, New York, and earned a master's degree in urban planning from the University of Michigan. She worked as a transportation planner for several municipal planning agencies—including the Washington Metropolitan Area Transit Authority—before joining TRB in August 1993 as a senior program officer with what was then known as the Synthesis Program. Her work at TRB spanned topics ranging from public transit to airport practices and involved managing projects, as well as shepherding the TRB synthesis reports describing the research, particularly for TCRP and the Airport Cooperative Research Program (ACRP).

"Donna brought light and laughter to our work environment for many years," notes Gwen Chisholm-Smith, TCRP Manager, summarizing the thoughts of many of her coworkers. Donna's ability to keep panel members on task remains well regarded. A close colleague, Senior Program Officer Jo Allen Gause remembers Donna as "a nimble problem solver and a natural-born mentor with a 100-watt smile." According to Gause, Donna would find multiple options for getting principal investigators to complete their work on time, and she did so while making meetings fun for everyone. "Our job was to manage the work process," Gause explains. "A lot of that is facilitating meetings."

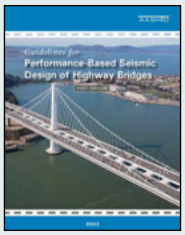
Senior Program Officer Jennifer Libby Weeks, concurs: "Donna had so much energy, and she was very good at not letting her panel members try to weasel out of any work." Although she held many to scheduled commitments, "panel members spoke very highly of her," adds Senior Program Officer Mariela Garcia-Colberg.

Dianne Schwager, also a senior program officer, was Donna's long-standing TRB neighbor in an adjacent office. "Our children were similar ages, and this gave us a lot to talk about. Donna was a very warm and thoughtful person."

Dan Boyle, of Dan Boyle and Associates in San Diego, California, recalls first meeting Donna in the mid-1990s when he chaired the TRB Committee on Public Transportation Marketing and Fare Policy. "Donna was invariably cheerful, even when things got a little tense—as they do when experts disagree," he recalls. "She had an uncanny ability to keep experts focused on editing a document that would be very useful to transit agencies." Boyle credits Donna with bolstering his confidence, including inviting him to participate in the creation of a TRB special report that helped him launch his transit consultancy. "I enjoyed every opportunity I had to work on a synthesis project with her," he notes. Nelson Gibson, former Senior Program Officer and team lead, remembers that "before working for TRB, I had the pleasure of serving on two of Donna's synthesis panels."

Donna is also remembered for her great sense of humor. "She made you feel like you were part of a team," notes Gause. "Donna used to say, 'Well, I'm old school. Let's find a way to get it done, even if we need to use chalk.' She made sure volunteers had a great experience and was a wonderful mentor."

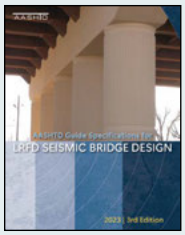
Of Donna's time at TRB, her husband Mike notes, "Donna loved working at TRB—the people, the stimulating plethora of topics she dealt with, and the consultants and committee members she met along the way. Nothing but fond memories."



Guidelines for Performance-Based Seismic Design of Highway Bridges, 1st Edition

AASHTO, ISBN 978-1-56051-788-7, https://store.transportation.org/item/collectiondetail/250.

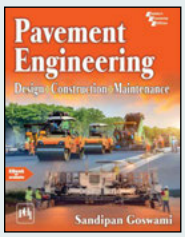
These guidelines represent the first implementation of performance-based seismic design for U.S. bridges. Their goal is to provide bridge designers and owners with a methodology for selecting the appropriate level of performance for a given bridge and implementing a design process that will result in achieving that level of performance. The guidelines provide design methodology for performance-based seismic design of bridges, establish three bridge operational categories (i.e., critical, recovery, and ordinary) based on their importance in the transportation system, define the performance goals for each of these operational categories, and present the fundamentals of direct displacement-based design for bridges.



AASHTO Guide Specifications for LRFD Seismic Bridge Design, 3rd Edition

AASHTO, ISBN 978-1-56051-811-2, https://store.transportation.org/Item/CollectionDetail/251.

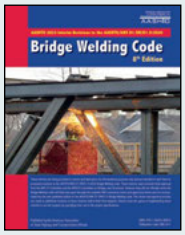
These specifications were developed for use in the design and construction of conventional bridges. Intended to enable these bridges to resist the effects of earthquake motions, the specifications were approved as an alternative to the seismic provisions in *AASHTO LRFD Bridge Design Specifications, 9th Edition*. Detailed guidance and commentary are included on earthquake-resisting elements and systems, global design strategies, demand modeling, capacity calculation, and liquefaction effects. Capacity design procedures underpin the guide's methodology and include prescriptive detailing for plastic-hinging regions and design requirements for capacity protection of elements that should not experience damage.



Pavement Engineering

Sandipan Goswami, PHI Learning, ISBN 978-9-39181-810-4, https://www.phindia.com/Books/BookDetail/9789391818104/pavement-engineering-goswami.

This comprehensive text is up to date with industry standards and best practices, and it offers exhaustive coverage of the design, construction, and maintenance of pavements. This book follows the *AASHTO Guide for Design of Pavement Structures*; meets the latest code provisions and pavement design methods recommended by the Indian Roads Congress and the Bureau of Indian Standards; and is designed as a textbook for civil engineering, highway engineering, and traffic and transportation engineering students.



2023 Interim Revisions to the AASHTO/AWS D1.5M/D1.5:2020 Bridge Welding Code, 8th Edition

AASHTO, ISBN 978-1-56051-809-9, https://store.transportation.org/Item/CollectionDetail?ID=242.

Published in 2020, *AASHTO/AWS D1.5M/D1.5:2020 Bridge Welding Code, 8th Edition*, includes welding requirements for bridges made from carbon and low-alloy constructional steels and designed for use with AASHTO or American Railway Engineering and Maintenance-of-Way Association requirements. These 2023 interim revisions are intended to inform users of proposed revisions regarding flare groove welds, shielding gas flow rate, hydrogen diffusion post-heat temperature limits, use of materials not specifically listed in the Bridge Welding Code, and other updates.

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

TRB PUBLICATIONS

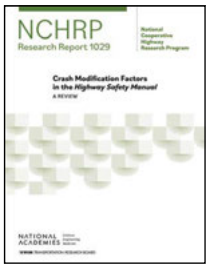
Transportation Research Record 2678, Issue 1

This issue examines rail decarbonization alternatives, low-traffic neighborhoods and scale effects in Paris, competition in ride-hailing service operations, and indirect tensile cracking test data for quality control and acceptance.

Transportation Research Record 2678, Issue 2

Topics in this issue include information loss in the transportation asset management process, assessing safety at bus stops, lane management strategies in a connected environment, viability of asphalt mixtures with iron ore tailings, and other research.

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.



Crash Modification Factors in the *Highway Safety Manual*: A Review
NCHRP Research Report 1029

This report assesses the current criteria and existing process for evaluating and identifying the quality of crash modification factors for appropriate use with the AASHTO *Highway Safety Manual* and presents proposed revisions to the criteria and process, including how existing and new crash modification factors may be incorporated into the *Highway Safety Manual*. The evaluation criteria are applied to identify and assess crash modification factors.

2023; 52 pp.; TRB affiliates, $48; TRB nonaffiliates, $64. Subscriber categories: Highways • Safety and Human Factors.

How to Measure and Communicate the Value of Access Management
NCHRP Research Report 1032

This guide on the use of an online access management communication toolkit is designed to help public agency staff and their consultants more easily understand, measure, and communicate the value of access management techniques when developing or implementing access management plans, programs, or projects.

2023; 112 pp.; TRB affiliates, $62.25; TRB nonaffiliates, $83. Subscriber categories: Administration and Management • Design • Planning and Forecasting.

Long-Term Roadside Crash Data Collection Program
NCHRP Research Report 1033

This report presents an expanded long-term crash data collection program for single-vehicle, run-off-road crashes and conditions associated with them. The program builds on previous research and will be of interest to those seeking to address current safety needs and changes in vehicle fleet composition, road design, roadside hardware features, and traffic conditions.

2023; 108 pp.; TRB affiliates, $62.25; TRB nonaffiliates, $83. Subscriber categories: Design • Operations and Traffic Management • Safety and Human Factors.

Guide to Effective Methods for Setting Transportation Performance Targets
NCHRP Research Report 1035

This report is designed to help state departments of transportation (DOTs) and metropolitan planning organizations identify effective methods for setting transportation performance targets based on established national measures.

2023; 148 pp.; TRB affiliates, $70.50; TRB nonaffiliates, $94. Subscriber categories: Highways • Administration and Management.

Reducing Risks to Worker Safety in Work Zones Due to Distracted Drivers
NCHRP Research Report 1037

This report, which identifies and evaluates temporary traffic control strategies aimed at reducing worker safety risks due to distracted driving in work zones, concludes that temporary portable rumble strips tend to have a more consistent positive effect in reducing distracted driving than do other methods.

2023; 44 pp.; TRB affiliates, $45; TRB nonaffiliates, $60. Subscriber categories: Construction • Operations and Traffic Management • Safety and Human Factors.

Applications of RFID and Wireless Technologies
NCHRP Research Report 1063

This report addresses the significant gaps between the capability of existing wireless transmission technologies and their implementation, including a readiness assessment of radio frequency identification technology.

2023; 150 pp.; TRB affiliates, $70.50; TRB nonaffiliates, $94. Subscriber categories: Highways • Construction • Materials.

Pedestrian and Bicycle Safety Performance Functions
NCHRP Research Report 1064

This report presents state DOTs and other transportation professionals with an update of pedestrian and bicycle safety performance functions.

2023; 306 pp.; TRB affiliates, $90.75; TRB nonaffiliates, $121. Subscriber categories: Pedestrians and Bicyclists • Design • Safety and Human Factors.

Risk Assessment Techniques for Transportation Asset Management
NCHRP Research Report 1066

This report discusses how to assess risks and summarizes 12 studies that demonstrate how to enhance the measurement of risks, quantify risks, and better link risk management processes with the appropriate tools. The report provides tools and techniques for identifying and evaluating asset management risks at the enterprise, network, and program levels.

2023; 156 pp.; TRB affiliates, $70.50; TRB nonaffiliates, $94. Subscriber categories: Highways • Administration and Management • Planning and Forecasting.

MASH Railing Load Requirements for Bridge Deck Overhang
NCHRP Research Report 1078

This report presents an evaluation of the structural demand and load distribution in concrete bridge deck overhangs supporting barriers subjected to vehicle impact loads. Simulated impact loads were specified to represent crash tests consistent with AASHTO's *Manual for Assessing Safety Hardware* (MASH).

2023; 266 pp.; TRB affiliates: $81.75; TRB nonaffiliates: $109. Subscriber categories: Highways • Bridges and Other Structures • Safety and Human Factors.

Shared-Risk Insurance Pools for Transit Agencies
NCHRP Research Report 1079

This report explains how insurance pools function, how to evaluate the feasibility of a shared-risk insurance pool, and how to establish and manage this type of pool.

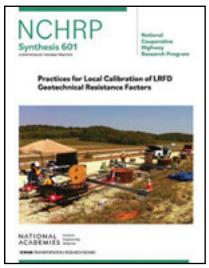
2023; 70 pp.; TRB affiliates: $54; TRB nonaffiliates: $72. Subscriber categories: Public Transportation • Administration and Management.

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

State DOT Models for Organizing and Operating Emergency Response
NCHRP Research Report 1088

This report shows how state DOTs have organized to manage and respond to emergencies of all types and sizes, including how to surge up for large, long-lasting incidents.

2023; 52 pp.; TRB affiliates: $48; TRB nonaffiliates: $64. Subscriber categories: Highways • Administration and Management • Security and Emergencies.



Practices for Local Calibration of LRFD Geotechnical Resistance Factors
NCHRP Synthesis 601

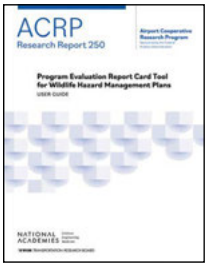
This synthesis documents the extent to which state DOTs have developed agency-specific geotechnical design methods and resistance factors. It also details challenges of the development and benefits resulting from implementation of the methods.

2023; 108 pp.; TRB affiliates, $62.25; TRB nonaffiliates, $83. Subscriber categories: Bridges and Other Structures • Geotechnology • Highways.

Resilient Design with Distributed Rainfall-Runoff Modeling
NCHRP Synthesis 602

This synthesis documents the practices of state DOTs on the use of distributed rainfall-runoff models, given the increased frequency of extreme rainfall events, inland and coastal flooding, and other water-related stressors that pose challenges to roadway infrastructure. The report also identifies state DOTs that have adopted distributed rainfall-runoff models and the context in which these models are applied.

2023; 120 pp.; TRB affiliates, $62.25; TRB nonaffiliates, $83. Subscriber categories: Highways • Environment • Hydraulics and Hydrology.



Program Evaluation Report Card Tool for Wildlife Hazard Management Plans: User Guide
ACRP Research Report 250

This report was designed to assess the effectiveness of wildlife hazard management plans in reducing the risk of wildlife strikes with aircraft over time.

2023; 86 pp.; TRB affiliates, $59.25; TRB nonaffiliates, $79. Subscriber categories: Aviation.

Digital Marketing to Enhance Customer Experience and Increase Airport Revenue
ACRP Research Report 251

This report helps airports explore the use of digitalization to make a passenger's journey from curb to gate a more seamless experience and to leverage an inherent business advantage—passenger time spent at the airport—into potential revenue-generating opportunities.

2023; 138 pp.; TRB affiliates, $66; TRB nonaffiliates, $88. Subscriber categories: Aviation.

Identifying and Prioritizing Behavioral Interventions to Improve Child Passenger Safety in For-Hire Vehicles
BTSCRP Research Report 6

This report provides guidelines for improving child passenger safety in rideshare and taxi vehicles by covering steps to ensure child restraint systems requirements are complete and consistent, providing strategies for communicating with for-hire companies, and including suggestions for legislative provisions.

2023; 60 pp.; TRB affiliates, $51; TRB nonaffiliates, $68. Subscriber categories: Passenger Transportation • Safety and Human Factors • Vehicles and Equipment.

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).

SUBMISSION REQUIREMENTS:

- **Articles** submitted for possible publication in *TR News* and any correspondence on editorial matters should be sent to the *TR News* Senior 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.

Note: Authors are responsible for the authenticity and accuracy of their articles and for obtaining written permissions from publishers or persons who own the copyright to any previously published or copyrighted material used in the articles, **as well as any copyrighted images** submitted as graphics. Authors are required to disclose any use of large language models (e.g., ChatGPT) or generative artificial intelligence tools to produce text, graphic, or photographic content.

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