National Cooperative Highway Research Program

Fiscal Year 2025 May 2024

Announcement of Research Projects

The **National Cooperative Highway Research Program** (NCHRP) is supported on a continuing basis by funds from participating member states of the American Association of State Highway and Transportation Officials (AASHTO), with the full cooperation and support of the Federal Highway Administration, U.S. Department of Transportation. The NCHRP is administered by the Transportation Research Board (TRB) of the National Academies of Sciences, Engineering, and Medicine. The NCHRP is an applied contract research program that provides practical and timely solutions to problems facing highway and transportation practitioners and administrators.

Each year, AASHTO refers a research program to the TRB consisting of high-priority problems for which solutions are required by the states. The NCHRP program for FY 2025 is expected to include 8 continuations and 63 new projects. An additional project from the NCHRP 20-44 Implementation Program is included in this announcement.

This announcement contains preliminary descriptions of only those new projects expected to be advertised for competitive proposals, and for which nominations for qualified professionals to serve on research oversight panels are sought. Nominations will be accepted on the TRB website through MyTRB at https://volunteer.mytrb.org/Panel/AvailableProjects

Before nominating yourself to serve as a panel member, please review our Conflict of Interest policy: https://www.trb.org/NCHRP/COI-CRP.aspx. Please be advised that if you are selected to serve on a panel and we receive a proposal for that project that presents a conflict of interest for you, we will reject the proposal. This also applies to liaisons.

Detailed Requests for Proposals (RFPs) for these new projects will be developed beginning in August 2024. Please note that NCHRP requests for proposals (RFPs) are available only on the TRBwebsite. Those who have an interest in receiving RFPs can register on the website http://trb.org/nchrp. Upon registration, you will receive an e-mail notification of every RFP posting and an e-mail notification of new anticipated projects in future years.

Because NCHRP projects seek practical remedies for operational problems, proposals should demonstrate strong capability gained through extensive successful experiences in the relevant problem area. Consequently, any agency interested in submitting a proposal should first make a thorough self-appraisal to determine whether it possesses the capability and experience necessary to ensure successful completion of the project. The specifications for preparing proposals are set forth in the brochure titled *Information and Instructions for Preparing Proposals*. **Proposals will be rejected if they are not prepared in strict conformance with the section titled "Instructions for Preparing and Submitting Proposals."** The brochure is available on the Internet at the website referenced above.

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IMPORTANT NOTICE

Potential proposers should understand clearly that the research program described herein is tentative. The final program will depend on the level of funding available from the Federal-aid apportionments for FY 2025. Meanwhile, to ensure that research contracts can be executed as soon as possible after the beginning of the fiscal year, the NCHRP is proceeding with the customary sequence of events through the point of research agency selection for all projects. The first round of detailed Requests for Proposals will be available starting in September 2024; proposals will be due beginning in October 2024, and research agency selections will be made beginning in December 2024. This places the risk of incurring proposal costs at the election of the research agencies. Beyond the point of selecting agencies, all activity relative to the FY 2025 program will cease until the funding authorization is known. These circumstances of uncertainty are beyond NCHRP control and are covered here so that potential proposers will be aware of the risk inherent in electing to propose on tentative projects.

National Cooperative Highway Research Program

NCHRP FY 2025

Project Number	Problem Number	Title	Funds	SPO	Synopsis Page
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03-152	G/03-01	Integrating the Use of New Software Subsystems and Software Within Evolving Traffic Management Systems	$350,000	Zuxuan Deng	7
03-153	G/03-02	Audible Indications for Accessible Pedestrian Signals	$450,000	Yi Zhao	8
07-37	G/07-01	Update of the AASHTO Guide for the Planning, Design and Operation of Pedestrian Facilities	$1,000,000	Yi Zhao	9
08-185	B/08-15	Generative Artificial Intelligence (AI) Enabled Pilot for NOCoE Knowledge Center	$450,000	Zuxuan Deng	10
08-186	B/08-16	Best Practices for Distributed Rainfall-Runoff Models to Transform Hydrologic and Hydraulic Modeling for Resilient Transportation Planning and Design	$700,000	Mike Brooks	10
08-187	B/08-10	Use and Application of Generative AI Models (e.g., ChatGPT, Bard) in the Context of Transportation Planning	$500,000	Roberto Barcena	11
08-188	B/08-01	Third Party Origin-Destination Data Validation for Travel Demand Models	$500,000	Arefeh Nasri	12
08-189	B/08-14	Transportation Systems Management and Operations (TSMO) Strategy Effectiveness Clearinghouse	$350,000	Zuxuan Deng	13
08-190	B/08-08	National Evaluation of Truck Parking Demand and Rest Area Locations	$600,000	Patrick Zelinski	14
08-191	B/08-20	Advancing Safe Connections for the Tribal and Rural	$500,000	Camille Crichton-Sumners	14

		Communities to the Intercity Bus Network			
08-192	B/08-21	Urban Freight Transportation Impacts of E-commerce	$400,000	Trey Wadsworth	15
08-193	B/08-18	Factors Affecting Implementation of Equitable Alternate Pedestrian Access Routes in the Public Right-of-Way	$750,000	Arefeh Nasri	16
08-194	B/08-05	Active Transportation Messaging and Communications in Support of Active Transportation Investment, Including Investment in Safety Countermeasures	$400,000	Mike Brooks	17
08-195	B/08-12	Developing a Guidebook on Use and Application of Demographic Data for Building Community Profiles	$425,000	Trey Wadsworth	18
09-73	D/09-01	Sample Storage Time Impact on Performance Properties for Balanced Mix Design (BMD)	$650,000	Amir Hanna	19
10-141	D/10-08	Guidebook for Using Digital Project Delivery Practices to Integrate Design and Construction, Improve Productivity, and Manage Risk	$375,000	Ahmad Abu-Hawash	20
10-142	D/10-03	Guide for Successful Implementation and Integration of Digital Construction Inspection Technologies into DOT Workflows	$600,000	Ahmad Abu-Hawash	21
10-143	D/10-02	Utility Inspection Processes for Transportation Accommodation and Relocation	$500,000	Chris McKenney	22
10-144	D/10-04	Rightsizing Pay Factors to Incentivize Quality Highway Construction	$500,000	Jennifer L. Weeks	23
10-145	D/10-06	Developing Asphalt Emulsion Based High Friction Surface Treatments (HFST)	$450,000	Amir Hanna	23

10-146	D/10-01	Development of a quality control and quality assurance system for Traffic Speed Deflection Devices	$500,000	Amir Hanna	24
12-128	C/12-01	Flexural Resistance of I-Sections for Skewed and/or Curved Steel I-Girder Bridges	$500,000	Ahmad Abu-Hawash	25
12-129	C/12-02	Evaluating Concrete Girders with Non-compliant Shear Details	$950,000	Ahmad Abu-Hawash	27
13-10	F/13-01	Use of UAS to Enhance the Design, Maintenance, Inspection, and Construction of Transportation Infrastructure.	$500,000	Ahmad Abu-Hawash	27
15-83	C/15-02	Develop a Next-Decade Strategic Research Agenda for Geometric Design of Highways and Streets	$350,000	Zuxuan Deng	28
15-84	C/15-04	Balanced Roadside Design Guidance for All Road Users	$500,000	Zuxuan Deng	29
15-85	C/15-03	Improved Superelevation Design Based on Advancing Technologies	$500,000	Amir Hanna	30
15-86	C/15-01	Pedestrian sight distance for crossing decisions	$350,000	Yi Zhao	32
17-130	G/17-17	Development of Comprehensive Training for the Second Edition of the Highway Safety Manual	$400,000	Yi Zhao	32
17-131	G/17-02	Updated Guidance on Reduced Left-Turn Conflict Intersections	$600,000	Yi Zhao	33
17-132	G/17-07	Tools to Support State DOT Implementation of the Safe System Approach	$1,000,000	Richard Retting	34
17-133	G/17-06	Validity of the 85th-Percentile Speed for Freeways, Expressways, and Rural Highways.	$500,000	Richard Retting	34
17-134	G/17-03	Centerline Buffer Area Safety Benefit Trade Offs	$250,000	Anne-Marie Turner	35
17-135	G/17-13	Graphic Resource for Practitioners to Illustrate HSM Prediction Method Data Elements and Definitions	$400,000	Yi Zhao	36

17-136	G/17-05	The Effects of Trees on Road User Safety in Urban and Suburban Contexts	$750,000	Anne-Marie Turner	37
17-137	G/17-11	Crash Prediction Methods for Long-Term Work Zones	$700,000	Zuxuan Deng	37
17-138	G/17-01	Pavement Marking Selection for Bridge and Pavement Preservation Treatments	$400,000	Amir Hanna	38
18-22	D/18-01	Concrete Shrinkage Measurement and Management Practices	$600,000	Amir Hanna	39
20-44(58)	Implement-ation Program	Implementing the Research Results of NCHRP Research Report 1002, Metropolitan Planning Organizations: Strategies for Future Success	$360,000	Sid Mohan	40
20-131	SP/20-11	Identifying Methods to Qualitatively Value Research for Transportation Agencies	$325,000	David Jared	41
20-132	SP/20-16	Emergency Management in an Electric Future: Guidelines to Increase Safety	$300,000	Patrick Zelinski	42
20-133	SP/20-14	Guidelines for AI-based Decision Supporting System (DSS) solutions for State Departments of Transportation (DOT)	$400,000	Roberto Barcena	43
20-134	SP/20-03	Best Practices for Confirming Land Ownership of the Right of Way and Impacts to Adjacent Properties	$600,000	Chris McKenney	43
20-135	SP/20-08	Incorporating Public Health Outcomes into the Transportation Planning and Decision-Making Process	$450,000	Camille Crichton-Sumners	44
20-136	SP/20-17	Use of data from sensors integrated within connected vehicles in maintenance management and pavement management.	$750,000	Amir Hanna	45
20-137	SP/20-07	Compensating community members for participation in transportation decision-making: emerging best practices.	$400,000	Jennifer L. Weeks	46

20-138	SP/20-06	Defining and assessing transportation system health to achieve a resilient and sustainable transportation system.	$350,000	Trey Wadsworth	47
22-64	C/22-01	Develop a Methodology for Using ISPEs to Update MASH	$500,000	Zuxuan Deng	48
22-65	C/22-02	Updating Full-Scale Testing Evaluation Requirements for Sign Supports, Poles, and Work-Zone Devices relative to MASH and EN12767	$350,000	Anne-Marie Turner	49
22-66	C/22-03	Development of Critical Impact Point and Impact Angle Guidance for the Manual for Assessing Safety Hardware (MASH)	$750,000	Anne-Marie Turner	50
22-67	C/22-04	Investigation of 4:1 V-Ditch Traversability and MASH Cable Barrier Test Matrices	$750,000	Anne-Marie Turner	51
23-42	A/23-10	Scoping Study to Identify Curriculum Development Needs for Workforce Development in Transportation Asset Management	$250,000	Mike Brooks	52
23-43	A/23-03	Successful DOT Utility Relocation Build America Buy America Practices	$250,000	David Jared	53
23-44	A/23-02	Improving Relationships between DOTs and Utility Companies	$500,000	David Jared	54
23-45	A/23-06	A Knowledge Management Manual for Transportation Agencies	$500,000	David Jared	54
23-46	A/23-05	Impact and Opportunity of Artificial Intelligence (AI) and Automation on the Transportation Workforce: Exploring Skill Gaps, Competency Requirements, Mindset Shifts, and Transportation Agency Strategies	$500,000	Roberto Barcena	56
23-47	A/23-01	Guide for Successful Strategies and Programs for Pavement	$350,000	Amir Hanna	56

		Preventive Maintenance Inspector Training			
23-48	A/23-09	Understanding, Creating and Measuring Public Value; lessons learned from public agencies	$300,000	Trey Wadsworth	57
23-49	A/23-07	Anticipatory Knowledge Delivery for State DOTs	$350,000	David Jared	58
25-72	B/25-12	Field Methods and Interlaboratory Tests to Establish the Accuracy and Precision of Measured Concentrations Of Emerging Contaminants In Stormwater Runoff And Stormwater-Treatment System Effluent	$650,000	Mike Brooks	59
25-73	B/25-01	Successful Community Impact Strategies During the Construction of Projects	$350,000	Jennifer L. Weeks	60
25-74	B/25-13	Advancing Methods to Evaluate Greenhouse Gas Emissions During Transportation Decision Making and Performance Management	$300,000	Mike Brooks	61
25-75	B/25-07	Simplified Methodology for Risk-Based Air Quality Assessments of NEPA Alternatives	$450,000	Mike Brooks	61

NEW PROJECTS

Project 01-64
Development of Longitudinal Cracking Models for Portland Cement Concrete Pavements

Research Field: Design
Source: AASHTO Committee on Materials and Pavements
Allocation: $600,000
NCHRP Staff: Amir N. Hanna

The formation of longitudinal cracks compromises structural adequacy and reduces the service life of jointed plain concrete pavements (JPCP) and continuously reinforced concrete pavements (CRCP). While longitudinal cracking of rigid pavements has been widely observed by state transportation agencies, the current version of the AASHTOWare Pavement ME Design software does not consider this critical distress. Studies have shown that the formation of longitudinal cracks can be initiated by several factors ranging from construction issues to various design features. Thus, there is a need for research to determine the design features that affect the formation of longitudinal cracking and to develop longitudinal cracking models that can be incorporated into Pavement ME.
The Long-Term Pavement Performance (LTPP) experiments include hundreds of jointed concrete pavements with various design features. Specific Pavement Studies-2 (SPS-2) examines the effect of structural factors and provides a unique opportunity to investigate observations of longitudinal cracking with specific design features. Rigid pavement sections from the General Pavement Studies (GPS) will supplement the SPS-2 data and provide insight into design features not included in the SPS-2 study.
The objective of this research is to identify or develop models to predict JPCP longitudinal cracking. Research tasks will likely include the following. (1) Conduct a literature review to identify previous relevant work relating to longitudinal cracking with design features. The literature review should review past work performed to assess the cause and extent of longitudinal cracking. (2) Review and select appropriate LTPP data based on data reliability, and identify gaps and other sources of data, if needed. (3) Survey state departments of transportation that have experience related to structural longitudinal cracks and collect data for possible inclusion in the analysis. (4) Identify design features associated with longitudinal cracking. (5) Identify or develop models that predict longitudinal cracking based on relevant design features. (6) Verify the accuracy of the model and make necessary adjustments based on traffic, region, and climate. (7) Develop an implementation plan that includes a presentation to the AASHTO Pavement ME Task Force to be included in the current pavement design procedure and software and guidance on the implementation and validity of the models and transfer function.

Project NCHRP 03-152

Integrating the Use of New Software Subsystems and Software Within Evolving Traffic Management Systems

Research Field: Traffic
Source: Missouri Department of Transportation
Allocation: $350,000
NCHRP Staff: Zuxuan Deng

As agencies progress toward the next generation of their Traffic Management Systems (TMSs), the addition of new operation strategies or functionality is often integrally tied to operating system replacement or new software installation. A new or revised TMS may be designed and have the capability to facilitate the integration of an operating system that accommodates the addition of multiple software programs. The addition of software programs may include commercial off-the-shelf (COTS), open-source, or customized software developed by agency staff, external developers, or a combination. Agencies face uncertainty in finding the best way to design, procure, manage, and integrate software subsystems, programs, or applications to meet the current or evolving TMS needs.

There are many potential options and variations of requirements and designs that could be applied to software subsystems and meet the needs for an agency's TMS. Currently there are limited resources to support identifying requirements, evaluating design options, and assessing different technologies (e.g., cloud, server, hybrid cloud and server) or solutions (e.g., distributed, centrally managed) for integrating and managing new or evolving TMS software subsystem, programs or applications. This project seeks to provide insights and understanding of options and practices with developing and managing requirements, designing, procuring, evaluating technologies, and maintaining TMS software subsystems, programs, and application programming interfaces (APIs).

The objective of this project is to synthesize practices and develop a technical report identifying the key issues to consider and challenges with designing, procuring, managing, and integrating new software subsystems, software, and APIs within a TMS.

Project 03-153
Audible Indications for Accessible Pedestrian Signals

Research Field: Traffic
Source: Georgia Department of Transportation
Allocation: $450,000
NCHRP Staff: Yi Zhao

Groups representing people who are blind or have low vision advocate for speech indications

instead of percussive tones to increase their safety in crossing roadways. However, the *Manual on Uniform Traffic Control Devices* (MUTCD) mandates that Accessible Pedestrian Signal (APS) revert to the 1-second locator tone during the change interval.

The previous research identified that more continuous audible countdowns may auditorily mask the sounds of vehicles about to cross the pedestrian path. Additionally, it was found that continuous acoustic information provided by audible countdowns may be more likely to draw cognitive attention away from attending to vehicle sounds, and processing of audible countdowns may be more cognitively demanding, thus decreasing the safety of pedestrians who are blind. This necessitates comprehensive research to address the following two questions from the groups representing people who are blind or have low vision:

- Should the default walk indication be a speech message rather than a percussive tone?
- Should audible countdown information be permitted or required during the pedestrian change interval?

The objective of this research is to use human factors research to investigate the safety and effectiveness of different audible indications and to identify potential revised language for consideration by the National Committee on Unified Traffic Control Devices (NCUTCD).

Project 07-37
Update of the AASHTO Guide for the Planning, Design, and Operation of Pedestrian Facilities

Research Field: Traffic
Source: AASHTO Technical Committee on Nonmotorized Transportation
Allocation: $1,000,000
NCHRP Staff: Yi Zhao

The *AASHTO Guide for the Planning, Design, and Operation of Pedestrian Facilities*, second edition (hereafter referred to as the "Guide") was released in 2021. It covers pedestrian planning and design. As the pedestrian transportation field is evolving rapidly, it is critical that guidance is current. For instance, the FHWA's National Roadway Safety Strategy recognizes that pedestrian fatalities and serious injuries have been increasing over the past several years and has adopted a Safe Systems Approach. This, in turn, promotes the Complete Streets standards and policies through the Bipartisan Infrastructure Law. In 2014, the U.S. Access Board issued a Supplemental Notice of Proposed Rulemaking for shared use paths, which will require changes to the Guide. The final rule for the U.S. Access Board's Public Rights of Way Accessibility Guidelines was completed in August 2023 and several updates to the Guide are required to meet the final rule. State DOTs need additional research on innovative pedestrian safety treatments so they can make

informed decisions at the project level, including decisions about accommodations for different ages and abilities of customers using the transportation system.

The objective of this research is to develop draft materials for AASHTO consideration to update the *Guide for the Planning Design and Operation of Pedestrian Facilities*. The draft materials will provide decision-makers with current tools to improve pedestrian safety and mobility in various contexts to help them address a broad range of issues and needs associated with pedestrian facility planning, design, and operation.

Project NCHRP 08-185
Generative Artificial Intelligence (AI) Enabled Pilot for NOCoE Knowledge Center

Research Field:	Transportation Research
Source:	Texas Department of Transportation
Allocation:	$450,000
NCHRP Staff:	Zuxuan Deng

The National Operations Center of Excellence (NOCoE) Knowledge Center is the centerpiece of NOCoE's website. It houses over 2,300 resources on diverse topics of interest for the Transportation Systems Management and Operations (TSMO) practitioners, including case studies; research studies; and Federal Highway Administration (FHWA), state, and local agency resources. It also features search capabilities, including advanced search capabilities to facilitate users to quickly search and shortlist resources of interest. The Knowledge Center is the most accessed site for NOCoE.

The innovation of Generative AI tools offers an opportunity in curating, synthesizing, and managing knowledge. It has a potential to leverage the NOCoE knowledge center resources to curate new knowledge, such as producing an initial draft of literature review, producing executive summaries, and responding to user prompts and questions to provide detailed insightful feedback from the library of existing resources. The Generative AI tools are poised to revolutionize knowledge management. For the NOCoE Knowledge Center users, such tools can reduce the time and effort required to search, process, and curate knowledge. For NOCoE staff it will reduce manual effort needed in scanning TSMO resources available through state and local agency websites.

The objective of this research is to develop a concept and design of a generative AI enable knowledge management pilot for NOCoE's Knowledge Center.

Project 08-186

Best Practices for Distributed Rainfall-Runoff Models to Transform Hydrologic and Hydraulic Modeling for Resilient Transportation Planning and Design

Research Field: Transportation Planning
Source: AASHTO Committee on Transportation System Security and Resilience
Allocation: $700,000
NCHRP Staff: Mike Brooks

Distributed Rainfall-Runoff Models (DRRMs) are the primary tool that will be needed to assess future precipitation impacts to the transportation system. *NCHRP Synthesis 602: Resilient Design with Distributed Rainfall-Runoff Modeling* identified that the use of DRRMs is still limited. The synthesis also suggested for future research the development of a document focused on developing case studies that will demonstrate how to best create and apply DRRMs in the context of transportation infrastructure. The proposed research will focus on the capabilities of these models to effectively model future rainfall conditions for resilient, adaptive planning and design. Without DRRM guidelines, professionals will be limited in their use of current precipitation frequency estimations from NOAA's ATLAS 15 model.

The objective of this research is to begin transforming the state of practice in transportation hydraulic and hydrologic modeling and provide essential guidelines needed to fully leverage ATLAS 15, which will provide future rainfall data for the United States by 2026. DRRMs allow engineers and planners to assess rainfall and associated flooding vulnerabilities on transportation infrastructure. Currently there are no guidelines for DRRMs in a transportation context, and state DOTs' ability to successfully leverage ATLAS 15 will be supported by this research. A practice manual for the application of DRRMs for resilient transportation planning and design will be developed to achieve the project objective.

Project NCHRP 08-187
Use and Application of Generative AI Models (e.g., ChatGPT, Bard) in the Context of Transportation Planning

Research Field: Transportation Planning
Source: AASHTO Committee on Planning
Allocation: $500,000
NCHRP Staff: Roberto Barcena

Transportation planning plays a vital role in developing efficient and sustainable transportation systems that meet the evolving needs of communities. As technology advances, the field of transportation planning can benefit from the use of generative artificial intelligence (AI) models to enhance decision-making processes. Generative AI models have the potential to significantly

affect transportation planning by generating synthetic data, forecasting future scenarios, and optimizing decision-making, to name a few effects.

The objective of this research is to develop an initial framework for the use and application of generative AI models that will develop the following:

- Educational resources and guidelines to enhance the understanding and adoption of generative AI models among transportation planning professionals, policymakers, and researchers.
- Processes to identify possible data limitations and data quality to support the effective use of generative AI models in transportation planning.
- Methods to enhance the transparency and interpretability of generative AI models, facilitating model validation, and accountability in the decision-making process.
- Practices to identify and mitigate biases in generative AI models to ensure the equitable and just application of these models in transportation planning.
- Strategies to overcome scalability and implementation challenges associated with the integration of generative AI models into existing transportation planning processes.

Project 08-188
Third Party Origin-Destination Data Validation for Travel Demand Models

Research Field:	Transportation Planning
Source:	Virginia Department of Transportation
Allocation:	$500,000
NCHRP Staff:	Arefeh Nasri

The private sector Origin-Destination (O/D) data have rapidly become a primary source in the development of travel demand models, while at the same time changes in the privacy landscape and computational algorithms are rapidly changing the nature of these data with unknown consequences to data quality and stability. This issue is further compounded by the emergence of new sources to represent trip flows, bringing into question the representativeness of such samples. While these data are available from several vendors, the myriad approaches and technologies used to estimate O/D flows are proprietary and therefore generally impossible to assess directly. The alternative is to assess these data against other independent data sources for internal consistency via data validation. However, no standard guidance exists on how to conduct this validation, leaving the process to be reinvented or skipped altogether. The task is made more difficult by differences in spatial and temporal granularity and extents as well as imputed trip characteristics provided by each vendor, meaning the guidance and reference data need to be flexible enough to evaluate a wide range of data.

The objective of this research is to identify best practices for validating proprietary third-party O/D data used to estimate travel patterns. This would involve development of guidelines on validating third-party O/D data and identification of independent non-proprietary datasets for use in validation efforts.

Project NCHRP 08-189
Transportation Systems Management and Operations (TSMO) Strategy Effectiveness Clearinghouse

Research Field:	Transportation Planning
Source:	Texas Department of Transportation
Allocation:	$350,000
NCHRP Staff:	Zuxuan Deng

As agencies seek to improve transportation safety and mobility, effectively operating transportation facilities and networks is critically important. A well-operated system can improve safety and resiliency, as well as the ability to move people and goods. There are hundreds of Transportation Systems Management and Operations (TSMO) strategies that could be deployed on a facility or network. Knowing which TSMO strategies are more likely to be effective at addressing safety and operations issues enables agencies and practitioners to make data-driven decisions to effectively use limited funding. Better evaluation methods will support agencies in assessing their own use of TSMO strategies, and developing a clearinghouse enables sharing strategy effectiveness information to improve efficiency and decision-making. Evaluating TSMO strategies is often complicated by unique characteristics of TSMO strategies, such as deployment in combination with other strategies; intermittent or flexible use based on prevailing conditions rather than continuous use; and widespread effects across a network. Having better evaluation methods and assessing the feasibility of a potential operations equivalent of CMFs would enable more effective and efficient investments in TSMO strategies.

The objective of this project is to create evaluation methods and a clearinghouse of TSMO strategy evaluations so there is one place where practitioners can go to learn about the potential effectiveness of TSMO strategies and enable practitioners to better assess the likely impacts of their own potential deployments.

The clearinghouse will contain an organized, searchable, sortable collection of TSMO strategy evaluations (published and unpublished) that provides a “one-stop-shop” for information about the potential effectiveness of TSMO strategies. The clearinghouse will assist agencies with data-driven decision-making and help them assess the likely impacts of their own potential deployments. Research findings and an introduction to the clearinghouse will be made available via the technical report, technical presentations, and webinars.

Project NCHRP 08-190
National Evaluation of Truck Parking Demand and Rest Area Locations

Research Field: Transportation Planning
Source: AASHTO Special Committee on Freight
Allocation: $600,000
NCHRP Staff: Patrick Zelinski

The national network of rest areas was developed more than 60 years ago with the planning of the Interstate Highway System, and much has changed since then. From the deregulation of trucking to the globalization of supply chains, demands on rest areas have changed with the times. Transportation funding is shrinking, while dynamic supply chains are shifting how and where goods are moving.

Safety along highways related to trucks parking in unauthorized areas is a growing concern for states, as is the cost of operating and maintaining public rest areas. COVID-19 prompted many states to shutter rest areas—some permanently. This had devastating impacts on truck drivers, the economy, and the safety of highway travelers as truck drivers were forced to stop and rest on the shoulders and ramps of highways. NCHRP conducted several truck parking projects over the past decade, including the active project NCHRP 08-141, "A Guidebook for Local Truck Parking Regulations." States have limited funds and would greatly benefit from an evaluation process for prioritizing funding for rest areas based on need.

The objective of this research is to develop a process for evaluating and assessing the needs of public rest areas for supporting supply chains based on current and projected trucking industry use of publicly owned and maintained highway rest areas, as well as unauthorized parking along state and Interstate highways (e.g., on ramps and shoulders). Potential products of the research will include (1) a decision-making tool that can help states prioritize funding for public rest area operation, maintenance, relocation, closing, construction, and expansion; (2) guidance on how to identify locations where new public rest areas or an expansion of existing public rest areas is needed based on existing and planned freight generators, existing and projected truck volumes, origins and destinations, and technologies, such as autonomous and zero-emission trucks; and (3) a nationwide inventory of public highway rest areas that provides details about the year built, available truck parking, restrooms, and other amenities.

Project 08-191
Advancing Safe Connections for Tribal and Rural Communities to the Intercity Bus Network

Research Field: Transportation Planning

Source: AASHTO Council on Public Transportation
Allocation: $500,000
NCHRP Staff: Camille Crichton-Sumners

Intercity bus service is an integral piece of the mobility network across the country that provides access to employment, education, healthcare, community services, and the national intercity transportation network. The industry seeks to increase effectiveness following setbacks encountered during the COVID-19 pandemic. The key to a successful intercity bus network is rural and tribal transit systems partnerships and integration with local transportation resources and other intercity and interstate modes. Lessons gleaned from establishing service to tribal areas can often be transferred to non-tribal rural areas. However, research on tribal connections reveals different governance structures, historical experiences, and cultural norms. Rural and tribal transit systems are often either unaware of the need to connect with the intercity bus network or unable to overcome technological, jurisdictional, political, and/or regulatory hurdles necessary to create a strong, interconnected mobility network. The previous guidelines on how to connect rural and tribal areas to the intercity bus network are obsolete because of recent system changes, which include the realignment of routes and operators, the complete replacement of the interlined fare technologies, and the loss of major intercity bus facilities.

The objective of this research is to develop a guide for expanding access to transportation for tribal and rural communities that includes successful practices for (1) connecting rural and tribal transit systems to the reinvented intercity bus network, including integrating technologies, physically co-locating stops, aligning schedules, meeting regulatory requirements, and establishing interlined tickets; (2) fostering collaboration among local and tribal governments and facilitating coordination between rural and tribal transit agencies and intercity bus providers; and (3) providing protocols for intercity bus providers, local and tribal government, and state DOTs to address business needs and cultural concerns.

Project 08-192
Urban Freight Transportation Impacts of E-commerce

Research Field: Transportation Planning
Source: Texas Department of Transportation
Allocation: $400,000
NCHRP Staff: Trey Joseph Wadsworth

An understanding of e-commerce freight vehicle and operating characteristics, such as vehicle sizes, travel patterns, and staging or parking needs, is needed to inform several critical public sector decisions. These include:

1. Zoning regulations, project permitting, and other land use considerations;
2. Infrastructure capacity planning or safety improvements;
3. Regulation or incorporation of new last-mile modes;
4. Freight activity modeling; and
5. Economic development.

The objective of this research is to provide state, local, and regional transportation professionals with the knowledge they need to make informed decisions regarding urban freight transportation effects of e-commerce within their jurisdictions. Major study tasks would likely include: (1) literature review and background research to determine what is known about e-commerce impacts on urban transportation, (2) structured outreach to identify relevant state, regional, and local transportation agency concerns, (3) analysis of available data and review of available models to quantify e-commerce impacts on urban surface freight transportation where possible and describe them qualitatively where not, and (4) identification of proposed, piloted, or implemented practices, tools, or strategies for mitigating adverse effects and promoting efficiency.

The final product would be a document including: (1) relevant background information on e-commerce, (2) an updated literature review focusing on e-commerce's urban transportation impacts, (3) an understanding of the drivers and determinants of e-commerce in general, (4) outreach results regarding the e-commerce issue and information needs faced by practitioners, (5) quantitative and qualitative analyses of e-commerce impacts on urban freight, (6) guidelines on incorporating e-commerce considerations in plans, policies, and models, and (7) information on current or proposed strategies, tools, and policies to mitigate adverse impacts and promote efficient and equitable urban goods movement.

Project 08-193
Factors Affecting Implementation of Equitable Alternate Pedestrian Access Routes in the Public Right-of-Way

Research Field: Transportation Planning
Source: AASHTO Council on Active Transportation
Allocation: $750,000
NCHRP Staff: Arefeh Nasri

To date, there has been limited research on the needs of people with disabilities related to accessible alternate pedestrian access routes. National accessibility guidance is limited to the Manual on Uniform Traffic Control Devices for Streets and Highways (MUTCD) and Public Rights-of-Way Access Guidelines (PROWAG) and state/local guidance varies considerably. There has been no research on the extent and reasons for noncompliance with accessibility guidelines for pedestrian access routes. Many design solutions have not been formally evaluated

for effectiveness or user acceptance, leading to inconsistencies. Research is needed to understand how inaccessible alternate pedestrian access routes impact people with disabilities and to identify strategies for addressing noncompliance. Furthermore, most design solutions intended for accessibility (such as ramps, railings, surfacing materials, etc.) have not been formally evaluated for effectiveness or user acceptance, resulting in uncertainty and disagreement among practitioners.

The objective of this research is to develop a guide to assist state departments of transportation (DOTs) to better understand challenges and solutions for implementation of accessible temporary routes considering needs across disability types. The guide shall include the following:

- Assessment of pedestrian needs and alternate access routes during transportation projects' construction or maintenance;
- Evaluation of current disability community's engagement practices and future strategies in facility planning, design, or preconstruction of the access routes;
- Identification of reasons for noncompliance with accessibility guidelines at national, state, and local levels;
- Analysis of gaps in national accessibility guidance and practices, with recommendations for addressing them; and
- Identification of contextual factors influencing alternate pedestrian access routes within different scenarios (e.g., emergencies, evacuation, or disaster recovery) with standards for implementation and review.

Project 08-194
Active Transportation Messaging and Communications in Support of Active Transportation Investment, Including Investment in Safety Countermeasures

Research Field:	Transportation Planning
Source:	AASHTO Council on Active Transportation
Allocation:	$400,000
NCHRP Staff:	Mike Brooks

The transportation sector needs clear, accurate, and consistent active transportation messaging and communications. Active transportation encompasses complex and important issues, such as equity, accessibility, data, and safety. Communications and messaging can raise awareness of the benefits of active transportation and help transportation agency cultures accept the policies and practices needed to provide safe and equitable active transportation on highways, such as de-emphasizing (vehicular) mobility and accepting a lower level of service.

Providing consistent messaging and terminology for internal state department of transportation (DOT) communications will assist transportation professionals to better communicate the value of

active transportation, including its role and co-benefits related to equity, safety, and sustainability, as they seek research, funding, and projects. Similarly, consistent communications will facilitate improved stakeholder communications related to benefits and methods of providing safe and effective active transportation.

The purpose of this research is to develop a resource or set of resources for providing consistent messaging on active transportation within state DOT communications, policies, manuals, guidelines and other documents, and external communications with various stakeholder groups, including elected officials, communities, and the general public. The messaging should address the following topics:

- Benefits of active transportation;
- Support/justification for investment in active transportation; and
- Support/justification for investment in the countermeasures needed to provide safe and equitable active transportation, including speed management.

Project 08-195
Developing a Guide on the Use and Application of Demographic Data for Building Community Profiles

Research Field: Transportation Planning
Source: AASHTO Committee on Planning
Allocation: $425,000
NCHRP Staff: Trey Joseph Wadsworth

Accurate and comprehensive demographic data is essential to understand the characteristics, needs, and trends of communities and enable effective decision-making in various fields, including transportation planning, infrastructure development, and public services. Current demographic inputs to planning tools have raised several questions about the accuracy and usefulness of some data and datasets. These include uncertainties around the 2020 Census and use of US Census data in general; COVID-19 related changes to travel patterns; generational differences in travel needs and desires; and migration patterns.

There are challenges and knowledge gaps in utilizing demographic data, not limited to only US Census data, to build community profiles. Further, there is a lack of comprehensive guidance and resources on identifying and accessing relevant demographic data sources well beyond the US Census data. Newer data sources can be challenging to integrate and analyze due to differences in formats, data quality, and privacy concerns. Transportation planners need practical guidelines on using different demographic data sources to inform planning decisions. Agencies have a duty to build community profiles that consider equity and social justice dimensions. Development in

demographic data techniques could support agencies in identifying disparities in access to transportation, services, and opportunities. Greater use of demographic data provides numerous benefits, but also raises privacy concerns and requires adherence to ethical standards. Safeguarding individual privacy and ensuring ethical use of demographic data are paramount as this field develops.

The objective of this research is to develop a guide that offers transportation planners, policymakers, and researchers a guide on the use and application of demographic data for building community profiles to improve practices around travel and demand forecasting. The guide will provide practical methodologies, tools, and case studies, enabling more accurate, insightful, and equitable community profiling for effective decision-making in transportation planning and related fields.

The guide would provide the following information to transportation planners, policymakers, and researchers: (1) data availability and accessibility, (2) travel patterns, (3) data integration and analysis, (4) application of demographic data in transportation planning, (5) community engagement, (6) consideration of equity and social justice; and (7) privacy and data ethics.

Project 09-73
Sample Storage Time Impact on Performance Properties for Balanced Mix Design

Research Field:	Materials and Construction
Source:	AASHTO Committee on Materials and Pavements
Allocation:	$650,000
NCHRP Staff:	Amir N. Hanna

The growing demand for performance testing within the asphalt industry accentuates the need to have consistent handling, sample preparation, and storage of asphalt mixture test specimens. As more agencies are moving to balanced mix design (BMD) and implementing performance tests, there is an urgent need to standardize the fabrication practices of asphalt specimens to avoid disputes between agencies and contractors. One major gap identified in *NCHRP Synthesis 552: Practices for Fabricating Asphalt Specimens for Performance Testing in Laboratories* is the effect of the storage practices of loose mixtures and compacted specimens on the mixture aging, which further affects the mixture performance. Therefore, the inconsistent storage practices will result in disputes between agencies and contractors regarding the BMD properties during the mix design and quality acceptance. To address this issue, this study will focus on defining aging terms related to sample storage and establishing suitable storage practices based on the storage-related effects on mixture properties. The proposed practices will minimize the disputes among agencies and contractors regarding the mixture properties. This study will provide recommendations to supplement current materials standards regarding the mix design and performance testing to promote the implementation of BMD.

The objective of this research is to assess the impact of storage time of loose mixtures and compacted specimens on performance properties of asphalt mixtures. The main outcome from this study will be a recommendation for an AASHTO Standard Practice on storage requirements for asphalt mixture performance tests. This will include storage time and conditions (e.g., sealed vs. unsealed, type of container, location of container, temperature, humidity) for loose mixtures, compacted bulk specimens, and prepared test specimens. This study will focus on plant-produced mixtures targeting the acceptance process and will also verify storage impacts on laboratory- versus plant-produced mixtures from both a cracking and rutting performance standpoint.

Project 10-141
Guide for Using Digital Project Delivery Practices to Integrate Design and Construction, Improve Productivity, and Manage Risk

Research Field: Materials and Construction
Source: Minnesota DOT
Allocation: $375,000
NCHRP Staff: Ahmad Abu-Hawash

Digital practices, such as 3D/4D modeling, e-Construction/eTicketing, and Building Information Modeling (BIM) for Infrastructure, are profoundly affecting how DOTs are delivering highway projects because they leverage data, the Internet, and mobile devices. These practices are enhancing project delivery through more effective collaboration and coordinated data exchange to limit errors at handoffs. DOTs are replacing paper and image-based workflows with more intelligent digital processes to tap the potential of digital information more fully for collaboration, productivity, and risk and quality management. For example, 3D design models provide better communication, virtual clash detection, and constructability evaluation before producing proposal documents or obtaining final construction pricing. eTicketing allows for enhanced materials quality management and faster payment. In addition, with artificial intelligence solutions on the horizon, agencies want to understand what is happening today and how that can help them prepare for the very near digital future. There is a need for national research on the utilization of digital practices, the benefits realized, and how these practices are successfully deployed within the various project delivery methods.

The objective of this research is to evaluate the use and effectiveness of digital practices, nationally and internationally, for various project delivery methods, including alternative contracting methods (ACMs) where National Environmental Protection Act (NEPA)/preliminary design, final design, construction, and sometimes maintenance/operations are integrated (e.g., design-build [DB], construction manager/general contractor [CM/GC], progressive design-build [PDB], public private partnerships [P3s]).

The result of this study is a collection of tools and workflows to incorporate integrated digital practices into transportation projects, which would serve as a guide for DOTs to evaluate their potential use on specific projects. This research will include a series of case studies to identify effective practices, as well as limitations associated with using digital practices.

Project 10-142
Guide for Successful Implementation and Integration of Digital Construction Inspection Technologies into DOT Workflows

Research Field: Materials and Construction
Source: AASHTO Committee on Construction
Allocation: $600,000
NCHRP Staff: Ahmad Abu-Hawash

In recent years, the landscape of transportation infrastructure has been rapidly evolving, presenting DOTs with a plethora of emerging methods and tools designed to enhance the efficiency and efficacy of field inspections. These advancements promise a revolution in the way inspections are conducted, potentially ushering in an era of streamlined, digitalized processes that can significantly augment the current capabilities of DOTs. However, this surge in available technologies has also brought forth a complex maze of choices, leaving DOTs grappling with decisions on which tools to integrate into their existing systems for optimal results. Moreover, the integration of digital tools into inspection activities is not just about the adoption of technology; it encompasses a broader spectrum that includes understanding the nuances of tool interoperability, training requisites, and setting achievable milestones. The transition to a digitalized inspection process is a multifaceted endeavor, requiring a holistic approach that considers various interconnected elements that contribute to a successful implementation.

In addition, technology developers generate solutions faster than the transportation sector can implement them, and sometimes without a clear understanding of the needs and pain points important to DOTs. Because of this, there is a need for better public-private collaboration methods that will ensure a more agile and expeditious creation of tools that meet DOT needs and fit their workflows.

A well-rounded framework will pave the way for a more streamlined and manageable digital inspection process, allowing DOTs to navigate the complex array of choices with clarity and confidence.

The objective of this research is to develop a guide to assist state DOTs with:

- Implementing digital inspection technologies across the project lifecycle aligned with FHWA's Advancing Building Information Modeling (BIM) for Infrastructure — National Strategic Roadmap.
- Collaboration and engagement with technology developers, state highway agencies, vendors; and
- Streamlined digital data transitions throughout the DOT project lifecycle.

Project 10-143
Utility Inspection Processes for Transportation Accommodation and Relocation

Research Field: Materials and Construction
Source: AASHTO Committee on Right of Way, Utilities, and Outdoor Advertising
Allocation: $500,000
NCHRP Staff: Christopher T. McKenney

Every year, state departments of transportation (DOTs) nationwide negotiate many agreements with utility owners during the project development and delivery process. Field verifications that the proposed utility installations or relocations have been properly constructed are integral components of the process. Unfortunately, field verification and monitoring are perhaps the weakest component of the entire utility management process to date. This can be attributed, in part, to utility owners not notifying state DOTs when they start construction or the failure to communicate with the state DOT's inspectors in a timely fashion. There may be other reasons internal to transportation agencies, not all of which are well understood or documented, which negatively impact an agency's ability to conduct utility inspections effectively. A frequently mentioned reason is DOT utility inspectors are overstretched due to limited resources. Other potential reasons include a lack of appropriate tools to conduct effective, meaningful inspections; adequate training for inspectors; inconsistent or absent agency standards; and a deficiency on the part of an agency to prioritize this function. Research is needed to identify and assess the requirements of utility inspection of highway accommodations and relocations.

The objective of this research is to develop a compendium of utility construction inspection practices and test new inspection protocols and procedures to achieve:

- Consistency in construction inspection reporting with best construction management practices.
- Cost savings during construction and through the lifetime of transportation and utility facilities.
- Improvements in the quality of utility inspections leading to higher performance of utility contractors, and clearer contract requirements and specifications.
- Improved utility as-built data collection practices, reducing risk of utility damages and

increased jobsite safety.

- Reduced nonconformance with regulatory requirements, per National Program Review.
- Project improvements to quality, safety, cost, and schedule.

Project 10-144
Rightsizing Pay Factors to Incentivize Quality Highway Construction

Research Field: Materials and Construction
Source: AASHTO Committee on Materials and Pavements
Allocation: $500,000
NCHRP Staff: Jennifer L. Weeks

State departments of transportation (DOTs) are tasked with overseeing the expenditure of public funds to produce a product meeting specifications at the lowest cost by a qualified contractor. They use incentives as a tool to raise the quality level of the work above the minimum. Many state DOTs include pay factors as part of their construction materials quality assurance program. However, there is concern about the adequacy of pay factors as an incentive. There remains concern that pay factors are not incentivizing quality sufficiently to achieve the desired condition and performance of assets that met or exceeded the construction quality specifications. As a result, many state DOTs have adopted disincentives to poor performance with respect to quality assurance.

State DOTs need contractors to be profitable so that they can continue to construct the needed infrastructure. Rightsizing pay factors calls for balancing two opposing positions to provide the best return to the public. While state DOTs seek the best quality project at a given cost or price, contractors are motivated by profit in which a certain quantity and quality of resources are assigned to achieve a certain quality outcome.

The purpose of this research is to develop a guide and tool to assist state DOTs to establish effective pay factors to be applied during construction that will incentivize quality construction and improve the lifecycle performance of the asset.

Project 10-145
Developing Asphalt Emulsion-Based High Friction Surface Treatments

Research Field: Materials and Construction
Source: Illinois Department of Transportation
Allocation: $450,000
NCHRP Staff: Amir N. Hanna

In recent years, FHWA has encouraged state departments of transportation to place high friction surface treatments (HFSTs) on sections of roadways where there could be potential for skidding or running off the road at sharp horizontal curves due to friction loss. HFSTs are very expensive as the binder material used is typically "sprayed on" polymers embedded with hard, wear-resistant aggregate. HFST increases pavement friction at existing or potentially high crash areas. The AASHTO Emulsion Task Force has investigated this HFST area of safety and has suggested that asphalt emulsion spray treatments (e.g., chip seal/fog seal) like the polymer "sprayed on" treatment could be a suitable, inexpensive substitute. The idea is to use an asphalt emulsion that is modified to increase its adhesion and stiffness properties to bond tightly to the applied hard durable aggregate as well as the road surface.

The research objective is to evaluate the feasibility of asphalt emulsion-based HFST and answer key questions, such as does asphalt emulsion have equal or better aggregate retention versus polymer binder? Does asphalt emulsion-based HFST have equal or better skid resistance in the lab versus polymer binder? Does asphalt emulsion-based HFST have equal or better performance in the field? Does asphalt emulsion-based HFST have equal or lower life-cycle cost versus polymer binder?

It is anticipated that the research will at minimum include (1) review of previous work in the area (national and international), current types of HFST, and where available, the history of application and performance; (2) collect a representative selection of samples of current technologies, including various polymer binders, aggregates, and asphalt emulsions; (3) determine the best method to quantify the performance of HFST in the lab considering chip retention and skid resistance; (4) determine the best method to quantify the performance of HFST in the field considering chip retention and skid resistance; (5) provide a life-cycle cost analysis of various HFSTs based on various base materials (asphalt emulsion, polymer binder, aggregates, etc.); and (6) develop asphalt emulsion-based HSFT guidance, based on polymer binder HSFT treatments.

Project 10-146
Development of a Quality Control and Quality Assurance System for Traffic Speed Deflection Devices

Research Field:	Materials and Construction
Source:	Mississippi Department of Transportation
Allocation:	$500,000
NCHRP Staff:	Amir N. Hanna

In recent decades, significant progress has been made in the development of Traffic Speed Deflection Devices (TSDDs), with more than 20 TSDDs currently in use worldwide. However, there are no commonly accepted rules and procedures for calibration and approval of these systems. Established approaches for stationary bearing capacity measuring devices, such as the falling weight deflectometer (FWD), cannot be directly used for TSDD applications, but form a good basis to start from. NCHRP Project 10-105 investigated using FWD data to verify TSDD measurements and

demonstrated that many factors in the field could significantly impact the confidence of the proposed FWD-based verification approach. As more and more state agencies collect TSDD data, they plan on incorporating it into their pavement management process at network and project levels. However, unexplained TSDD measurement variations could misguide the decision-making process, leading to inappropriate maintenance and rehabilitation decisions. Pavement managers need a good verification tool to perform quality assurance of the TSDD systems and develop confidence in the quality of TSDD data for pavement management and design decision-making.

Due to the dynamic measurement nature of the TSDD, checking the calibration and thus the approval of the measuring systems is only possible in moving operation. Setting up stationary calibration facilities, as is the case in FWD calibration centers, is therefore not possible. Innovative approaches must be found that make it possible to produce reproducible and comparable calibration sections. In addition, suitable section lengths must be determined, and the scope and documentation of self-monitoring by the operator must be defined. All approaches are to be derived independently of the device and applicable to all TSDDs.
The objective of the proposed research is to develop a reliable procedure to ensure the quality of pavement structural assessments with TSDD devices. The procedure should be adapted to the special requirements and challenges of TSDD measurement technology and be reproducible at different locations. The desired research is expected to improve asset performance; strengthen resiliency; assist in evaluating emerging trends in technologies, policies, and practices; and innovate and modernize products and services. To achieve this objective, the research will review literature, develop a catalogue of requirements, make material investigations on laboratory scale and small scale (e.g., stiffnesses, durability, temperature sensitivity), perform conceptual designs of a demonstrator, construct a demonstrator, potentially convert into a calibration center, collect/analyze TSDD measurements and measurements with comparison systems, and design a calibration and construction specification. The research should include several tasks: (1) conduct a literature review to identify existing calibration methods and their pros and cons and document the reasons why existing methods do not work and summarize the critical calibration requirements/needs; (2) identify or develop methodologies for effectively calibrating the TSDD devices (identify critical calibration requirements; develop a conceptual design of reliable calibration plan including test sections, material needs, and processes; and evaluate the new process on different pavement types having different structural condition using calibration site data and available field data); (3) provide recommendations for implementation and application of the calibration proposed to demonstrate calibration ability and accuracy; and (4) identify future research needs.

Project 12-128
Flexural Resistance of I-Sections for Skewed and/or Curved Steel I-Girder Bridges

Research Field: Design
Source: AASHTO Committee on Bridges and Structures

Allocation: $500,000
NCHRP Staff: Ahmad Abu-Hawash

Currently, in the AASHTO *LRFD Bridge Design Specifications*, the nominal flexural resistance of web sections in negative flexure in kinked continuous I-girder bridges, horizontally curved I-girder bridges, and straight I-girder bridges with supports skewed more than 20 degrees from normal is not allowed to exceed the moment at first yield at the strength limit state. As interior-pier sections yield and begin to lose stiffness and shed their load, the forces in the adjacent cross-frames will increase. There is currently no established procedure to predict the resulting increase in the forces without performing a refined nonlinear analysis. In horizontally curved bridges and severely skewed straight bridges with discontinuous cross-frames, significant lateral flange bending effects can occur. The resulting lateral bending moments and stresses are amplified in the bottom compression flange adjacent to the pier as the flange deflects laterally. There is currently no means to accurately predict these amplification effects as the flange is also yielding. Skewed supports also result in twisting of the girders, which is not recognized in plastic-design theory. The relative vertical deflections of the girders create eccentricities that are also not recognized in the theory. Similarly, the nominal flexural resistance of composite sections in positive flexure in kinked continuous I-girder bridges and in horizontally curved I-girder bridges, that would otherwise qualify as compact sections, is currently not allowed to exceed the moment at first yield at the strength limit state. The specifications are currently silent with regard to such sections in straight I-girder bridges with supports skewed more than 20 degrees from normal; as such, the decision whether the section should be treated as a compact or noncompact section is left to the judgment of the engineer.

The objective of this research is to determine if the restrictions identified in the previous paragraph can be lifted in determining the nominal flexural resistance at the strength limit state of compact web or noncompact web sections in negative flexure, and composite sections in positive flexure that would otherwise qualify as compact sections, in kinked continuous I-girder bridges, horizontally curved I-girder bridges, and straight I-girder bridges with supports skewed more than 20 degrees from normal. The research should identify any deleterious effects on cross-frames forces, flange lateral bending moments and stresses (and the amplification of those moments and stresses as applicable), and torsional displacements of the girders that may need to be considered should these restrictions be lifted. Reasonable and rational design approaches should be developed to calculate the maximum nominal flexural resistance that can be achieved for each type of section (if any adjustments to the current approaches are necessary), along with a means to consider any other related effects that may need to be considered in the design of the various components of the superstructure system.

The research shall include a parametric study of various practical and realistic I-girder bridge geometries using refined non-linear analyses. It will be limited to sections in negative flexure with

compact or noncompact webs and sections in positive flexure that would otherwise qualify as compact sections if the current restrictions on bridge geometry were not in effect.

Project 12-129
Evaluating Concrete Girders with Noncompliant Shear Details

Research Field: Design
Source: AASHTO Committee on Bridges and Structures
Allocation: $950,000
NCHRP Staff: Ahmad Abu-Hawash

As the U.S. transportation structure ages, the need to develop, use, and implement load rating methods and procedures becomes even more important. In this context, this project focuses on concrete bridges designed prior to the nationwide adoption of AASHTO LRFD Bridge Design Specifications (BDS) first published in 1994 and required to be used in new designs in 2007. Because the current AASHTO LRFD BDS have shear design and detailing provisions that are stricter than the older AASHTO Standard Specifications, girders of the older bridges typically do not meet the requirements of the current specifications. The load carrying capacities of existing prestressed and non-prestressed concrete bridges have to be evaluated by departments of transportation (DOTs) to ensure public safety as shear failures can occur with little to no warning and signs of shear distress may not be visible during periodic inspections. Currently, DOTs evaluate older bridges using methods, such as the Modified Compression Field Theory, that were developed for design purposes. Existing laboratory test data show that the method is appropriate for calculating the capacity of modern bridge members designed according to the current specifications. However, there is a significant lack of data on the capacity and behavior of concrete members that have reinforcing details that are not compliant with the current specifications. Moreover, data is lacking on members that have sizes, cross-sectional shapes, and material grades that reflect actual design and construction practices.

The objective of this research is to gather data and knowledge on large-scale prestressed and non-prestressed concrete girders designed using older versions of AASHTO specifications and therefore may not meet current shear detailing requirements of AASHTO LRFD. This knowledge and data will be used to develop calculation methods and procedures that will aim to be accurate and sufficiently conservative in evaluating the shear capacities of prestressed members in existing bridges.

Project 13-10
Use of UAS to Enhance the Design, Maintenance, Inspection, and Construction of Transportation Infrastructure

Research Field: Maintenance
Source: North Carolina DOT
Allocation: $500,000
NCHRP Staff: Ahmad Abu-Hawash

Unmanned aircraft systems (UAS), commonly known as drones, have witnessed exponential growth in various industries due to their versatility and cost-effectiveness. However, as the utilization of UAS in commercial operations under Federal Aviation Administration (FAA) Part 107 regulations continues to expand, ensuring the safety, reliability, and airworthiness of the UAS fleet becomes an increasingly critical challenge. Maintaining a diverse fleet of UAS from multiple platforms, used across various industries, necessitates the development of a comprehensive maintenance optimization strategy to address potential risks, ensure regulatory compliance, and maximize operational efficiency.

The current problem lies in the lack of a standardized and efficient maintenance approach for UAS under FAA Part 107 operations. Several factors contribute to the challenge:

- Diverse UAS platforms: Part 107 operations encompass a range of UAS platforms with varying sizes, configurations, and operational requirements. Managing maintenance procedures for this heterogeneous fleet becomes complex due to the diverse needs of different UAS models.
- Safety and reliability: Safety is paramount in UAS operations, and ensuring the reliability of each UAS is crucial to prevent accidents and malfunction.
- Regulatory compliance: FAA regulations mandate regular maintenance of UAS to ensure airworthiness and adherence to safety standards.
- Cost-effectiveness: The maintenance of a UAS fleet can be expensive, especially if done without a structured approach.
- Data management and tracking: Keeping track of maintenance records, inspection schedules, and service histories for multiple UAS across different platforms can become cumbersome.

The objective of this research is to develop guidance for state departments of transportation (DOTs) to establish, structure, and execute a UAS (or drone) maintenance program to optimize resource expenditures. The desired output is a guide for state DOT UAS programs to implement a standardized approach to UAS maintenance with reference to specific tools and processes that can support streamlined maintenance management approaches.

Project NCHRP 15-83
Develop a Next-Decade Strategic Research Agenda for Geometric Design of Highways and Streets

Research Field: Design
Source: Washington State Department of Transportation
Allocation: $350,000
NCHRP Staff: Zuxuan Deng

In the last 10 or more years, a significant portfolio of research related to the geometric design of highways and streets has been completed (and many other projects currently in process) through NCHRP that has had a direct, meaningful, and noteworthy impact on the geometric design practice in the United States. However, the determination of the research needs and topics were not done haphazardly; rather, there was a strategic agenda published by *Transportation Research Circular E-C110: Geometric Design Strategic Research* (2007) that served to prioritize and inform the research program. This strategic agenda was informed through previous NCHRP synthesis efforts – initially through *NCHRP Synthesis 299: Recent Geometric Design Research for Improved Safety and Operations* (2001) and then updated with *NCHRP Synthesis 432: Recent Roadway Geometric Design Research for Improved Safety and Operations* (2012) – and in a cooperative manner between the AASHTO and TRB committees.

The objective of this project is to inform the long-range pipeline of research needed to maintain the AASHTO's *A Policy on Geometric Design of Highways and Streets* (the Green Book) as the primary and authoritative source of guidance and information concerning the practice of highway, road, and street design in the United States.

Project NCHRP 15-84
Balanced Roadside Design Guidance for All Road Users

Research Field: Design
Source: Michigan Department of Transportation
Allocation: $500,000
NCHRP Staff: Zuxuan Deng

The AASHTO Technical Committee on Roadside Safety (TCRS) has identified many research needs about vulnerable road user (VRU). The research needs statement has been modified and expanded to incorporate some of the following related research needs: evaluation of bollard devices for pedestrian/bicycle/motorcycle users; mode shift benefits of Complete Streets; protection for people biking on arterial roadways; new metric for VRU comfort on roadways; synthesis of devices for pedestrian/bicycle/motorcycle users and low-speed facilities; investigation of rising pedestrian fatalities; and development of guidance for installation of roadside hardware adjacent pedestrian/bike facilities.

The 2016 AASHTO's Standing Committee on Highway (SCOH) Resolution and the 2022 Administrative Resolution, Council on Highways and Streets / Council on Active Transportation, provided an emphasis on multimodal design, flexibility, and addressing bicyclist, motorcycle, and pedestrian serious injuries and fatalities.

The objective of this research is to align roadside safety design elements complimenting the AASHTO *A Policy on Geometric Design of Highways and Streets* (Green Book), 8th Edition (GB8) urban roadway context classifications while integrating VRU considerations in roadside design.

Project 15-85
Improved Superelevation Design Based on Advancing Technologies

Research Field:	General Design
Source:	Washington State Department of Transportation
Allocation:	$500,000
NCHRP Staff:	Amir N. Hanna

This research will update appropriate values (such as side friction, superelevation, e and f distribution) for use in horizontal curve design. Multiple advancements have affected previous data and models that have been used to establish horizontal curve design guidance. Side friction factors were established in the 1930s and 1940s, and they were reviewed in 2000 under *NCHRP Report 439*, which found the values to be generally consistent with the prior values. With advancements in tire design and manufacturing and pavement wearing surfaces and mixes continuing to develop, a reexamination of appropriate side friction factors for use in design is needed. More sophisticated vehicle dynamics simulation models also have been developed to model the behavior of vehicles in curves.

Current Green Book horizontal curve design is based on the point-mass model. As the vehicle fleet has technologically advanced, the newer vehicle models may be able to refine acceptable driver comfort as it relates to horizontal curvature within superelevation transition areas and when the curve is fully superelevated. The vehicle fleet now includes connected and automated vehicles (CAVs). As the automation technology increases, the vehicles will become self-driving. This research should examine how this change in the vehicle fleet may impact horizontal curves, cross slopes, and vehicle models for such design elements. The research should show how the AASHTO current design vehicle(s) would compare to the proposed design vehicle(s).

Potential tasks include the following:

1. Completion of a comprehensive literature review to identify research on vehicle fleet composition, performance of the vehicle, advanced technologies and their presence in the

vehicle, percentage of vehicles with the advanced technologies (i.e., stability mechanics and other performance/safety innovations), tire/pavement friction based on current tires in production and typical pavement surface parameters, and identify available vehicle models that may be candidates to replace the point-mass model.

2. Evaluate the current research and identify which components need additional research. This could include tire performance/friction factors (wet and dry), pavement wearing surface (type and friction in combination with tire performance), vehicle fleet (which vehicles to use in design: keep two primary categories of heavy vehicles/trucks and everything else, or some other classification, traditional human driven vehicles, CAV with Automation Level up to 3, mixed fleet: human driven and CAV, autonomous vehicles: Automation Level 4/5, stability capabilities).
3. Cross-slope constructability (is 0.2 the appropriate interval for design superelevation? NYSDOT has adopted 0.5 increments).
4. Vehicle operator (should the design parameters be modified if there is a high presence of "older" drivers and what would quantify "high presence," CAVs.
5. Perform the research based on identified needs and make recommendations (revised side friction factors for use in design, revised design superelevation rates, superelevation transitions, appropriate vehicle model, propose new text for the next edition of the AASHTO Green Book's Chapter 3, Elements of Design.

The side friction factors may need to be adjusted due to multiple factors. Both tires and road wearing surfaces have changed, which affect the friction between them. Additionally, vehicle technologies such as electronic stability control have changed vehicle dynamics and may influence speeds that drivers are comfortable at while traversing horizontal curves. Since *NCHRP Report 439: Superelevation Distribution Methods and Transition Design* was published, there have been findings that superelevation following *NCHRP Report 439* transitions may cause greater side forces than expected. More sophisticated vehicle dynamics simulation models are now available that provide advantages over using the point-mass model for design, such as accounting for grade, deceleration/acceleration, and analysis of the dynamics of individual axles.

Changing the design superelevation from increments of two tenths, which may be too precise, needs to be considered. What precision can contractors actually construct? Many believe this is not practical to contractors. Considering performance-based design principles, are there acceptable differences in superelevation from the current design superelevation rate that would be acceptable? Could the design speeds for the various design superelevation rates be modified? The side friction factor also represents the lateral acceleration, so the way lateral acceleration is modeled in horizontal curve design may need to be changed. Since the previous research was completed, there are different vehicle types in the vehicle fleet and a departure from the point-mass model. Are there better models that should be used that work better with the current fleet of vehicles? If there are better models, which should be used and how does that change the equations used for design? The AASHTO *Highway Safety Manual* and *TRB Special Report 214: Designing Safe Roads: Practices*

for Resurfacing, Restoration, and Rehabilitation have shown that the minimum radii in AASHTO's Green Book are not threshold values that correlate to safety or operational problems.

Project 15-86
Pedestrian Sight Distance for Crossing Decisions

Research Field: Design
Source: AASHTO Technical Committee on Nonmotorized Transportation
Allocation: $350,000
NCHRP Staff: Yi Zhao

Transportation professionals have the responsibility to make conditions safe for pedestrians. A better understanding of the sight line conditions that enable pedestrians to cross streets safely could provide the tools necessary to reduce pedestrian crossing injuries and fatalities.

Currently, there is inadequate guidance about how to evaluate pedestrian decision sight distance. Evaluating sight lines for crosswalks is typically done from the perspective of a driver's ability to stop for an object in the road (pedestrian) using stopping sight distance. Sight distance can be assessed by modifying methodologies from the AASHTO Green Book or from the AASHTO Bike Guide. However, the performance criteria are not provided to determine the pedestrian's crossing time (t_g) in the current design guides. Since assumptions are required to perform this analysis, research is needed to form a consensus about how to assess pedestrian decision sight distance.

The objective of this research is to expand content for the AASHTO Pedestrian Guide on sight line evaluation criteria at street crossings.

This topic was identified as a high priority in the Council on Active Transportation Research Roadmap developed through NCHRP Project 20-123.

Project 17-130
Development of Comprehensive Training for the Highway Safety Manual, Second Edition

Research Field: Traffic
Source: AASHTO Committee on Safety
Allocation: $400,000
NCHRP Staff: Yi Zhao

NCHRP Project 17-71A is developing proposed updated content for the AASHTO *Highway Safety Manual* (HSM), second edition The HSM second edition integrates several associated research projects, other related HSM guidance documents and publications, and additional research and analysis performed through NCHRP Project 17-71A. While the HSM second edition is not

intended to be a complete rewrite of the first edition, the HSM has undergone significant changes in content and organization. New content includes additional human factor considerations, areawide evaluation, and systemic safety analysis. Pedestrian, bicycle, and freeway crash prediction methods have changed significantly and will require additional training for existing users.

Training material and tools are needed to support HSM application by state departments of transportation (DOTs) and other practitioners.

The objective of this research is to develop comprehensive training materials for the HSM, second edition. Activities and deliverables may include:

- A comprehensive modular training based on chapters and/or technical use cases, such as planning, project development, and performance-based design decisions.
- A package of electronic analysis tools building on existing tools to illustrate and support use of the HSM, second edition. These tools should be incorporated in the modular training course.
- One pilot offering of the course to obtain feedback from a pool of reviewers that represent expected HSM users.

Project 17-131
Updated Guidance on Reduced Left-Turn Conflict Intersections

Research Field: Traffic
Source: FHWA and North Carolina Department of Transportation
Allocation: $600,000
NCHRP Staff: Yi Zhao

Since the publication of the *Alternative Intersections/Interchanges: Informational Report* (AIIR) by FHWA in 2009, and the *Median U-Turn* (MUT) and *Restricted Crossing U-Turn* (RCUT) informational guides in 2014, dozens of state and local agencies have built these intersections in many different contexts, with valuable experience to share. Several agencies have done formal evaluations and documented their performances. However, this collective experience and knowledge has not been reflected in an updated, comprehensive informational guide.

Similar updates to comparable informational guides, such as *NCHRP Research Report 1043: Guide for Roundabouts* (2023) and *NCHRP Research Report 959: Diverging Diamond Interchange Information Guide; Second Edition* (2021), have proven quite successful, with information from these guides having a profound impact on the state of the practice, eventually influencing updates of the AASHTO Green Book.

The objective of this project is to (1) conduct a systematic review and analysis of emerging alternative intersection and interchange concepts and their variations to understand the latest knowledge, practices, and lessons learned, and (2) develop a report that will focus on updated traffic safety and multimodal elements in planning, analyzing, designing, operating, and evaluating alternative intersections and interchanges.

Project NCHRP 17-132
Tools to Support State DOT Implementation of the Safe System Approach

Research Field: Traffic
Source: Washington State Department of Transportation
Allocation: $1,000,000
NCHRP Staff: Richard Retting

AASHTO has been identifying existing practices for incorporating safety into state departments of transportation (DOTs) decision-making and for implementing the Safe System approach. As the USDOT and others are working to increase awareness and adoption of the Safe System approach, it is important to develop resources to support transportation agency leadership and management, as well as practitioners. The USDOT, in particular the FHWA, has developed a number of resources to support state implementation of the Safe system approach, and AASHTO is working to complement those efforts. Also, several NCHRP projects are focused on implementing the Safe system approach.

The AASHTO Safety Summit in October 2023 (with participation from 400 safety experts, across multiple disciplines, representing 28 AASHTO committees) identified analytical and decision-making tools as a key need. The summit identified existing resources for further dissemination among the states and identified resource needs to develop to fill current gaps. The Safety Action Plan developed as a product of the Summit will provide a detailed starting point for this proposed research.

The objective of this research is to develop resources such as tools, methods, and process models to support consideration of safety throughout the transportation project lifecycle and across state DOT programs using the framework and principles of the Safe System approach. This project will focus on additional tools needed to support the range in project types and tasks, roadway facility types and contexts, user needs, and other factors handled by state DOTs across the country.

Project NCHRP 17-133
Validity of the 85th-Percentile Speed for Freeways, Expressways, and Rural Highways

Research Field: Traffic
Source: Delaware Department of Transportation

Allocation: $500,000
NCHRP Staff: Richard Retting

The validity of the 85th percentile method for determining posted speed limits is a complex and controversial issue. The 85th percentile speed is the speed at or below which 85% of free-flowing traffic travels. It has been used for decades as the basis for setting speed limits. In recent years, there have been mounting calls to eliminate the 85th percentile speed as a basis for setting speed limits, especially in urban areas. Recent research and reasoning for moving away from the 85th percentile in urban areas does not, however, address speed limits on freeways, expressways, and rural highways. Setting safe and reasonable speed limits that encourage compliance without constant enforcement is crucial to reducing crashes and fatalities.

Proponents of the 85th percentile speed argue it is a good measure of the speed at which drivers feel safe and comfortable on a given road, and that setting speed limits at or near the 85th percentile can reduce speed variance and improve safety. Critics argue the 85th percentile speed is not a reliable measure of safe driving. They note the 85th percentile speed can be influenced by many factors, such as traffic volume, road conditions, and the presence of law enforcement. They also argue that setting speed limits at or near the 85th percentile speed can encourage drivers to speed.

The objective of this research is to develop guidelines for state departments of transportation (DOTs) and other agencies with authority to set speed limits on freeways, expressways, and rural highways on the measures to be used as a basis for determining posted speed limits, and specifically whether the 85th percentile speed is still a valid measure for safety and effectiveness of speed limits posted on these facilities. The research should focus on the relationship between the 85th percentile speed and crash rates on these facilities; driver behavior and psychology; the costs and benefits of reducing speed limits; and measures to be used by state DOTs and other agencies as the basis for recommending posted speed limits on freeways, expressways, and rural highways.

Project 17-34
Center Line Buffer Area Safety Benefit Trade Offs

Research Field: Traffic
Source: FHWA – Office of Safety
Allocation: $250,000
NCHRP Staff: Anne-Marie Turner

Roadway departure crashes account for half of all fatalities every year, more than 18,000, with more than 5,000 fatalities resulting from head-on crashes. These crashes occur primarily on undivided, high-speed, rural roads with vehicles traveling in opposite directions, often separated only by a center line pavement marking and possibly a rumble strip. NCHRP Project 17-66 research was published in *NCHRP Research Report 995: Guidelines for Treatments to Mitigate Opposite Direction Crashes*, which provided guidance for selecting appropriate countermeasures for opposite-direction crashes. One countermeasure, center line buffer areas, was found to

significantly reduce fatalities and is being used in locations around the country. NCHRP Project 17-66 developed crash modification factors (CMFs) for center line buffer areas (2 ft, 4 ft, and 6 ft in width). However, challenges arise with the implementation of center line buffer areas when determining where the extra pavement area will come from. In cases where the roadway cannot be widened to accommodate the center line buffer area, a practitioner or designer must decide between narrowing lanes or shoulders. Guidance is needed to inform designers on whether it will be a safety benefit or detriment to narrow lanes or shoulders to accommodate a center line buffer area. Which safety benefit, center line buffer areas, wider lanes, or wider shoulders, will be the governing factor and drive the decision on where to allocate the additional pavement area?

The objective of this research project is to develop recommendations on where additional pavement areas for center line buffer areas will come from. The research project shall determine the tipping point on whether the safety benefit of center line buffer areas is greater than the safety benefit of wider lanes or shoulders.

Project 17-135
Graphic Resource for Practitioners to Illustrate HSM Prediction Method Data Elements and Definitions

Research Field: Traffic
Source: AASHTO Committee on Safety
Allocation: $400,000
NCHRP Staff: Yi Zhao

With the increased emphasis on highway safety, nationally and with many local agencies, more individuals look to the *Highway Safety Manual* (HSM) for guidance on how to reduce fatalities and serious injuries on roadways. However, it may be difficult for new users of the crash prediction methods in HSM Part C to understand the various definitions, facility types, facility features, and input values used in the many safety performance functions (SPFs), adjustment factors (AFs), and crash modification factors (CMFs). This lack of understanding can lead to the improper application of the HSM predictive methods.

The objective of this research is to develop a graphic resource (i.e., a document with many illustrations) to assist practitioners to understand the data elements and definitions used in HSM crash prediction methods.

The graphic resource will serve as a companion document to the HSM, second edition. The document will focus on providing real-world illustrations to help practitioners understand the various prediction method input parameters and data elements. The graphic resource will follow a style and layout similar to the HSM, second edition.

Project 17-136
The Effects of Trees on Road User Safety in Urban and Suburban Contexts

Research Field: Traffic
Source: FHWA
Allocation: $750,000
NCHRP Staff: Anne-Marie Turner

Roadside design guidance typically instructs agencies to limit fixed objects, including trees, along roadways to provide a safer recovery area for errant vehicles. On urban streets, trees are amenities that can provide benefits to pedestrians, bicyclists, residents, and others such as shade, potential traffic calming and speed reductions, air and water quality benefits, and aesthetic appeal. However, trees are fixed objects that can cause serious injury or fatality if struck by an errant vehicle. Public agencies need more refined data on the effects of trees on safety to inform tree planning and landscaping policies, procedures, and practices that support the safety of all roadway users.

The objective of this research is to answer key questions on the impact of trees necessary to implement a Safe System approach to the design and maintenance of urban and suburban roadways with posted speed limits of 35 mph to 50 mph. Answers to the following questions are needed, broken down by speed limits ideally in 5 mph increments (i.e., 35, 40, 45, and 50 mph):

- What impact do trees, based on tree characteristics (size, species, placement), have on operating speeds in urban and suburban contexts?
- What is the safety performance (crash frequency and severity) related to tree impacts?
- What are the trends and risk factors in the crash history (outside of curves, median or outside edge, etc.)?
- What are the roadway context characteristics at tree crash sites resulting in fatalities or injuries (e.g., presence of on-street parking, presence of on-street bike lane, presence of lighting, density of trees, proximity to travel lanes, etc.)?
- What is the frequency and severity of crashes on roadways with trees to similar roadways without trees?
- What are the safety effects of street trees on drivers, motorcyclists, pedestrians, bicyclists, and other users of the roadway?
- How do tree characteristics (size, species, placement/lateral offset) impact the frequency and severity of crashes?

The anticipated deliverables for this research project are an abbreviated literature and synthesis report on the effects of trees in urban and suburban contexts and a final report on the research results.

Project NCHRP 17-137

Crash Prediction Methods for Long-Term Work Zones

Research Field: Traffic
Source: Arkansas Department of Transportation
Allocation: $700,000
NCHRP Staff: Zuxuan Deng

The planning and design of work zones is one of the greatest challenges faced by highway agencies, given the potential operational and safety effects of work zones and the constraints that work zones place on project duration and phasing. The AASHTO *Highway Safety Manual* (HSM) has crash prediction methods for many roadway segment, intersection, and ramp facilities, but none of the available methods address the safety performance of these facilities with work zones in place. As a result, highway agencies rely on judgement and past experience, rather than quantitative safety analysis, in developing geometric designs and traffic control plans for work zones.

There is a clear need to better understand the quantitative safety performance, including crash frequency and crash severity measures for specific work zone features (lane closures, lane shifts, shoulder closures, median crossovers, and detour roadways), geometric design features in work zones (lane width, shoulder width, horizontal curvature) and offsets from the traveled way to traffic barriers and traffic control devices. New knowledge on these topics should be assembled into a quantitative crash prediction methodology that can be used by highway agencies to develop the maintenance of traffic plans for work zones. The methods ultimately developed should be capable of comparing the expected safety performance of the work zone to the safety performance of existing roadway prior to the beginning of work and to assist in planning work zone configurations and project phasing to limit any increase in crashes during the work period.

The objective of this research is the development of crash prediction methods for work zones suitable to guide highway agencies in planning and design of geometrics and traffic control for long-term work zones.

Project 17-138
Pavement Marking Selection for Bridge and Pavement Preservation Treatments

Research Field: Traffic
Source: AASHTO Committee on Materials and Pavements
Allocation: $400,000
NCHRP Staff: Amir N. Hanna

Bridge and pavement preservation is a proactive approach to protecting and maintaining existing bridges and pavements. Numerous preservation techniques are available and. these techniques are

regularly used and improved upon as owners recognize that bridge and pavement preservation is a cost-effective approach. Bridge and pavement preservation treatments can slow the typical deterioration of bridge decks and pavements of all types. Applying a bridge or pavement preservation treatment at the right time, on the right project, with quality materials and construction is a critical investment strategy for optimizing infrastructure performance. Current treatments include crack sealing and filling, chip seals, micro-surfacing and slurry seals, concrete sealers, high friction surface treatments, thin polymer epoxy overlays, bituminous thin overlays including ultra-thin bonded wearing courses, and limitedly open-graded friction courses. Many state departments of transportation (DOTs) have developed guidance documents that assist in selection of bridge and pavement preservation treatments. Typical selection guidelines include treatment descriptions, benefits, applicable pavement conditions, and recommended materials and procedures.

Currently, there is a need for a guidance document on the selection of the optimal pavement marking to be used on the bridge and pavement preservation treatments. Due to the variability in treatment types and pavement marking types, it is necessary to develop and research the performance of the combinations of pavement markings and bridge and pavement preservation treatments. Various pavement marking options include latex paint, thermoplastic, epoxy, modified urethane, polyurea, methyl methacrylate, preformed plastics, and reflectors. This guidance should consider the resultant surface texture (high friction, open graded vs. dense graded), treatment thickness, chemical compatibility of the treatment and the markings, climatic regions (including freeze-thaw), expected life (pavement marking and bridge and pavement preservation treatment), maintenance activities (such as sanding, deicing, and snowplowing), and the time of installation (new vs maintenance). Pavement markings play a major role in delineating the roadway for drivers and user safety. Pavement markings that are effective and long-lasting, because of the satisfactory compatibility with pavement and bridge and pavement preservation treatments, can provide drivers with long-lasting delineation visibility in all driving conditions: daytime, nighttime, and the hardest condition of wet night.

The objective of this research is to determine the optimal pavement marking type for each bridge and pavement preservation treatment type, traffic volume, and, if applicable, anti-icing and deicing strategies. The research should identify the compatibility of the markings and treatment types, the needed film thickness of marking, the optimal retroreflective media, and the expected durability of the marking selected. This project should be divided into two phases. Phase I: Perform a literature review to identify best practices of pavement marking applications on various bridge and pavement preservation treatments. Phase II: Develop a protocol for the field evaluation of marking materials on treatment types, perform field evaluations or test decks, and develop a selection guide for the optimal pavement marking for the various treatment types.

Project 18-22
Concrete Shrinkage Measurement and Management Practices

Research Field: Materials and Construction
Source: AASHTO Committee on Materials and Pavements
Allocation: $600,000
NCHRP Staff: Amir N. Hanna

Shrinkage significantly impacts concrete infrastructure, leading to durability issues like cracking in pavements and structures. A 2022 National Concrete Consortium survey ranked bridge deck cracking as a top research need. *NCHRP Synthesis 500: Control of Concrete Cracking in Bridges* highlighted the necessity for specifications to manage shrinkage cracks and research on shrinkage-reducing admixtures, cementitious materials, and internal curing to mitigate cracking in concrete mixes. Research in concrete shrinkage is crucial for advancing the understanding, improving the performance of concrete structures, mitigating damage and cracking, optimizing construction practices, and ensuring long-term durability. It also enables the development of more accurate predictive models, informed design guidelines, and effective mitigation strategies, leading to safer and more sustainable concrete.

The first step is quantifying shrinkage effectively. Existing test methods have limitations and may not apply to new cements such as AASHTO Type 1L or supplementary cementitious materials such as calcined clay or "green"/special concrete mixtures. Understanding shrinkage impact in these materials is crucial. The second step is developing guidelines to mitigate shrinkage's effects on materials and construction to reduce cracking. Characterizing all shrinkage mechanisms and practical ways to minimize them is essential. Current specifications do not account for field-specific variations in materials, construction practices, and restraint conditions, potentially leading to cracking issues without effective management techniques.

The two objectives of this research are:
1. Test method(s): Develop recommendations for new or (enhance existing) test methods to characterize and measure shrinkage (all types) of concrete that may include new materials or combinations. The recommended outcome should address field verification and the limitations of the existing test methods such as time dependent behavior, duration of testing, environmental factors, sample size, restraint conditions, repeatability and practicality.
2. Guidance manual: Develop design recommendations for pavements and bridge decks given its critical effect due to their restraint behavior, as well as pre-and post-construction guidelines/strategies to reduce the impact of shrinkage to a pre-established minimum shrinkage threshold based on infrastructure restraint conditions to minimize cracking.

Project 20-44(58)
Implementing the research results of NCHRP Research Report 1002, Metropolitan Planning Organizations: Strategies for Future Success

Research Field: Special Projects
Source: NCHRP Research Report 1002
Allocation: $360,000
NCHRP Staff: Sid Mohan

NCHRP Research Report 1002: Metropolitan Planning Organizations: Strategies for Future Success, is a practical resource for metropolitan planning organizations (MPOs) and their state departments of transportation (DOTs) partners to help address their evolving roles and face many of the challenges in the 21st century. It provides strategies for adaptation and improvement that will be effective in a wide range of MPOs that vary in size, structure, resources, and regional context.

NCHRP Research Report 1002 also provides important guidance for MPOs to address issues in the post-COVID era. The topics and solutions addressed in the Toolkit in Chapter 3 of the guidance suggests successful approaches for emergent MPO practices that can enhance the performance of MPOs in our states. However, because the descriptions in the toolkit focus on general ingredients and concepts, operationalizing these solutions in real MPO initiatives is important to demonstrate how the findings are replicable in a practical MPO setting.

To address these issues and challenges, this project aims to (1) conduct educational workshops with MPO leadership in up to four states to disseminate the findings and raise awareness of the toolkit, (2) pilot efforts in each state implementing NCHRP 1002 solutions with their MPOs, and (4) conduct a concluding peer-exchange and MPO playbook to relate lessons learned and practical steps for MPO's to replicate this success (or learn from challenges) elsewhere.

Project 20-131
Identifying Methods to Qualitatively Value Research for Transportation Agencies

Research Field: Special Projects
Source: Maryland Department of Transportation
Allocation: $325,000
NCHRP Staff: David M. Jared

Research in the transportation sector traditionally emphasizes quantifiable benefits of projects, but there is a growing recognition among industry professionals that research impacts extend beyond conventional numerical measures tied to safety, materials, and asset life. At the same time, it can be challenging to translate research outcomes into simple, understandable figures or statistics, so the complete value of research to stakeholders may be obscured. Having a set of agreed methods

ready for communicating broader narratives would help in explaining a research project's contribution to the transportation agency, the wider research community, and the public.

The objective of this project is to develop a guide on qualitative approaches to valuing research project impacts, outputs, and outcomes. Methods and best practices would cover technical areas such as planning, design, construction; focus areas such as safety, resilience, and emerging technologies; and all phases of research from basic through implementation.

The guide can address an array of methods to convey the direct and the ancillary value of research. For example, it would be beneficial to have accepted approaches to (a) valuing research where the null hypothesis is not rejected, such as when a new process or material is not better than the current practice; and (b) valuing a project that simply suggests more research is needed. The guide would be a valuable research management tool to spur the thought process underpinning innovation.

Project NCHRP 20-132
Emergency Management in an Electric Future: Guidelines to Increase Safety

Research Field:	Special Projects
Source:	AASHTO Committee on Transportation System Security and Resilience
Allocation:	$300,000
NCHRP Staff:	Patrick Zelinski

As electric vehicles (EVs) become increasingly popular, several emergency management-related issues have arisen, such as EV hazard events during storage and charging and EV use in extreme weather. Because the goal for many states is to rapidly increase the adoption and use of EVs in personal and public operations, it is essential to manage these EV incidents to keep the public and emergency responders safe and maintain operation of the transportation system. This is a new area of emergency management that would benefit from research on the causes of and best practices for containing EV incidents.

The objectives of this research are (1) to identify the risks of EV incidents and (2) to provide recommendations to mitigate the effects of these incidents. Key components of the research include:

- Identifying plans and designs of storage, parking, and charging facilities than can reduce damage to infrastructure and injuries to workers and the public.
- Providing guidance to emergency responders, especially state DOT responders, on securing scenes, handling battery fires, and moving damaged EVs safely.
- Developing strategies to mitigate the impacts of EV incidents on the transportation system, such as longer closure times for firefighting and infrastructure damage from battery fires.

- Identifying solutions for EV users during situations including extreme weather events, highway closures, battery failures on roadsides, and mass evacuation charging.

Project NCHRP 20-133
Guidelines for AI-Based Decision Supporting System Solutions for State Departments of Transportation

Research Field: Special Projects
Source: Tennessee Department of Transportation
Allocation: $400,000
NCHRP Staff: Roberto Barcena

Artificial intelligence (AI) is rapidly transforming many industries, and the transportation sector is no exception. AI-based decision support systems (DSS) have the potential to revolutionize the way state departments of transportation (DOTs) manage their transportation networks.

AI-based DSS can be used to collect, analyze, and interpret large amounts of data from a variety of sources, such as traffic cameras, sensors, and social media. This information can be used to generate insights and recommendations that can help DOTs make better decisions about everything from traffic management to infrastructure planning.

As transportation systems become more complex and demanding, DOTs need tools that can help them to make better decisions more quickly and efficiently. The objective of this research is to develop guidelines for AI-based DSS solutions for DOTs.

Project 20-134
Best Practices for Confirming Land Ownership of the Right of Way and Impacts to Adjacent Properties

Research Field: Special Projects
Source: AASHTO Technical Council on Right of Way Engineering
Allocation: $600,000
NCHRP Staff: Christopher T. McKenney

Currently, there are no national level parameters in effect for conducting right-of-way (ROW) research. Practices vary in the timing and level of research activity. State departments of transportation (DOTs) may start ROW research during the planning phase or begin after 60% design. Similarly, state DOTs might perform ROW research for all parcels shown on plan or limit full research to impacted parcels only. Property interests, such as easements, may be found on plans or in separate documents, which can be problematic once plans are archived. In addition,

title searches typically start later in project delivery and are frequently inaccurate or incomplete. ROW engineering teams have the skillset to perform chain-of-title research, identifying documents excluded from the title search. Therefore, research is needed to indemnify and unify the various procedures in which state DOTs perform ROW research and offer practical solutions to help organize and streamline state DOT methods.

The purpose of this research is to develop a compendium of best practices and strategies for ROW research in the project delivery process that:

- Documents current ROW research methods from DOTs, which address confirming ownership of the existing ROW and adjacent parcels.
- Examines all common types of property interests that are likely to be found in a design project.
- Assesses levels of ROW research conducted based on scope of design project.
- Recognizes and assesses relationships between ROW engineering staff and other state DOT teams involved in project development and their reliance on each other during the chain-of-title research process.

Project 20-135
Incorporating Public Health Outcomes into the Transportation Planning and Decision-Making Process

Research Field: Special Projects
Source: AASHTO Committee on Planning
Allocation: $450,000
NCHRP Staff: Camille Crichton-Sumners

The integration of public health considerations into transportation planning and decision-making processes is essential for creating sustainable, resilient, equitable, and healthy communities. Transportation systems directly impact public health outcomes, including physical activity levels, air quality, safety, and access to health care. Policies and decisions related to transportation infrastructure, land use, and the built environment can have differential impacts on public health outcomes in various populations, leading to health disparities and inequities. Disadvantaged communities, including low-income neighborhoods and marginalized populations, often bear a disproportionate burden of negative health impacts associated with transportation systems and decisions. Evaluating the effectiveness of policy interventions and best practices for incorporating public health considerations is crucial for improving transportation planning processes.

Several challenges exist in incorporating public health outcomes into the transportation planning and decision-making processes. First, public health agencies and transportation agencies often

operate in silos with limited collaboration and coordination. The lack of interdisciplinary cooperation poses challenges in aligning public health goals with transportation plans and policies. There is limited documented research related to successful collaborative efforts and strategic partnerships between public health agencies and transportation agencies, though the two are closely linked. Additionally, current transportation planning processes often lack evaluation frameworks and methodologies and comprehensive data and metrics to quantify and assess the public health impacts of transportation projects and policies. This lack of data and tools limits the ability of transportation planners and decision-makers to evaluate and prioritize proposed projects and policies based on their potential health outcomes.

The objective of this research is to develop a guide that details how to integrate public health and transportation project decision-making to help state departments of transportation (DOTs) (1) address the social determinants of health in transportation planning and describe how public health will be incorporated into planning documents, (2) implement strategies and tools that better incorporate land use and built environment considerations into transportation planning and identify linkages to public health outcomes, (3) foster effective collaboration between public health professionals and transportation planners, and (4) develop evaluation frameworks and metrics that allow for the assessment of the public health outcomes related to transportation planning and decision-making.

Project 20-136
Use of Data from Sensors Integrated Within Connected Vehicles in Maintenance Management and Pavement Management

Research Field:	Special Projects
Source:	Connecticut Department of Transportation
Allocation:	$750,000
NCHRP Staff:	Amir N. Hanna

With the emergence of vehicles outfitted with road-surface sensing capabilities and connected to the original equipment manufacturer (OEM), the idea of extensive pavement condition monitoring using existing vehicles to augment current standard methods (with specialized equipment) has presented an intriguing opportunity. The advent of smartphones, an analogous technology, has already resulted in work to provide lower-cost pavement evaluation. However, through the last decade there have been significant challenges, including repeatability, reliability, and accessibility. Harmonization of measurements from different sensors is necessary, both in terms of calibration of each instrument and estimates arising from multiple measurements. There is a need to identify potential sensor technologies and conduct benchmarking studies to investigate the possibility to augment standard survey data with OEM-connected sensor data. Because the data collection might not be a dedicated single-pass effort, there is a need to determine the requirements for a crowd-sourcing system that

yields sufficient coverage of the highway network. This research will allow highway agencies to glean additional insights regarding maintenance and rehabilitation of their pavement assets.

The objective of this research is to identify available sensing technologies integrated within connected vehicles, their advantages and limitations, and the pertinent methodology for augmenting standard pavement condition survey data. This research would answer, as a minimum, the following questions: How do currently available OEM-connected technologies relate to standard technology for collecting each pavement condition measure/metric? How can we quantify the repeatability and reproducibility of each to compare across technologies? How can sensor data augment and enhance standard condition data and its application in pavement evaluation, design, maintenance management, and asset management? How can crowd-sourced data be integrated into pavement evaluation, maintenance, and operation?

To answer these questions, the research effort should include the following tasks or activities.
1. Conduct a detailed literature review of existing OEM sensing and crowd-sourcing technologies. Include a focus on data privacy and security issues since this is a known challenge.
2. Establish the current degree of utilization of this data in various management systems.
3. Identify and assess the principal components of the systems to conduct pavement evaluation: (a) sensor hardware and software producing the data and systems for on-board processing, (b) processing and analysis techniques to extract condition measures from the sensor data, (c) methods of data aggregation across calibrated and uncalibrated vehicles and fleets, (d) communication technologies (e.g., Internet of Things or IoT) for transmitting raw and processed data, and (e) data quality characterization and quality assurance, including correlation with reference measurements and repeatability and reproducibility of single-device and different-device measurements made on the same pavement sections.
4. Conduct a proof-of-concept data collection experiment with standard equipment and the new technologies side-by-side on a range of pavements to develop protocols and transformations needed to augment current pavement evaluation methods.
5. Provide guidance (e.g., AASHTO protocol) on how to use this data in state department of transportation applications.

Project 20-137
Compensating Community Members for Participation in Transportation Decision-Making: Emerging Best Practices

Research Field:	Transportation Planning
Source:	AASHTO Committee on Communications
Allocation:	$400,000
NCHRP Staff:	Jennifer L. Weeks

The prospect of compensating participants for public transportation involvement, once a novel idea, has become a serious consideration in recent years. Minnesota Department of Transportation (DOT) has implemented a pilot program and is in the process of creating agency policy and guidance. Washington State DOT is implementing a new state law allowing low-income and community members with relevant lived experience to be compensated for their work as volunteers because "state employees and representatives of advocacy organizations receive compensation from their respective agency or organization for their time and experience." Oregon DOT maintains an Equitable Engagement Payment Program that pays participants for time spent in activities such as advisory committees and workshops. The Puget Sound Regional Council (PSRC) has also implemented an outreach compensation policy.

The need for this research arises from conflicting direction state DOTs receive on public engagement. There is an industry push through federal initiatives such as Justice40 and the USDOT Equity Action Plan to achieve more meaningful, equitable participation in transportation decision-making, and many state DOTs have similar state-level direction. Compensation for engagement is a logical approach to address this need, one that has proven effective in other sectors such as in market research. However, state DOTs and other agencies face barriers to implementing compensation, including state and federal laws, regulations, and policies that limit opportunities for compensation. As an emerging area of practice throughout the country, this topic is prime for national research to help clarify and recommend direction.

The objective of this study is to develop an understanding of the state of practice for participant compensation, assess its broad potential as a strategy for achieving more representative participation, and develop practical recommendations for agencies on the most promising approaches and means of implementation. Research questions for consideration include:

- What constraints (real or perceived) do existing federal and state funding sources place on the use of compensation, and what types of compensation can be provided within those constraints?
- Should there be eligibility requirements for compensation? If so, how should they be determined?
- What form should compensation/reimbursement take?
- What types of internal controls, documentation, and other procedures are necessary?
- What is the effectiveness of participant compensation in achieving more inclusive engagement of underserved and overburdened communities?

Project 20-138
Defining and Assessing Transportation System Health to Achieve a Resilient and Sustainable Transportation System

Research Field: Special Projects

Source: Washington State Department of Transportation
Allocation: $350,000
NCHRP Staff: Trey Joseph Wadsworth

NCHRP Research Report 1042: State Transportation Agency Decision-Making for System Performance: Practitioners Playbook developed an analytic framework for transportation agencies to use for the integration of critical issues into decision-making related to system performance using interactive visualization. The framework helps states to understand the critical linkages, values, and relationships among multiple variables (needs) and provides a method about how to adjust those relationships. This research will build on the framework to define a performance-based process to assist agencies in defining "Transportation System Health." Within a given jurisdiction, unique values, needs, context, and characteristics could be considered. The intent of this effort is to help state departments of transportation (DOTs) understand individual strategic goals, objectives, and performance measures and to use this information to set priorities for programs and projects.

The objective of this research is to develop a method for defining and determining Transportation System Health, in terms relevant for each state DOT's values, needs context, and characteristics useable for ranking and prioritizing programs, projects, and budget. Tasks may include:

1. Review current practices of decision-making tools,
2. Perform gap analysis on system objectives as part of an analytic framework,
3. Determine performance driven and evidence-based methods for defining and characterizing Transportation System Health,
4. Assess and qualify/quantify enterprise and asset risks considerations in Transportation System Health so that decision-making occurs among state DOTs and its partners, and legislative and executive branch agencies, and
5. Rank and prioritize programs and projects based on the optimization of Transportation System Health to determine meaningful and viable processes, methods, and metrics to measure system health ratings. This would be from a state DOT vantage point to positively impact the future performance of the multimodal systems.

Project 22-64
Develop a Methodology for Using ISPEs to Update MASH

Research Field: Design
Source: Michigan Department of Transportation
Allocation: $500,000
NCHRP Staff: Zuxuan Deng

For more than 40 years, one reoccurring theme in each re-writing of crash test and evaluation procedures is the recommendation to conduct in-service performance evaluations (ISPEs) of roadside safety features.

The laboratory performance of roadside safety hardware is tested and evaluated using criteria published in AASHTO *Manual for Assessing Safety Hardware* (MASH). The site location and installation of roadside safety hardware is guided by criteria published in the AASHTO *Roadside Design Guide* (RDG). ISPE criteria has only just now become available under *NCHRP Research Report 1010: In-Service Performance Evaluation: Guidelines for the Assembly and Analysis of Data*. A methodology is needed to implement the changes to MASH based upon the findings of ISPEs conducted using the criteria provided within *NCHRP Research Report 1010*.

National guidance that defines acceptable field performance is currently being developed under NCHRP Project 22-58, "National In-Service Performance Evaluation Guidelines for Defining Acceptable Roadside Safety Hardware" and will provide states departments of transportation (?) with the ability to establish crashworthiness without having to conduct many crash tests. A methodology to implement ISPE findings into crash testing criteria can be used to limit unnecessary updates to MASH to address vehicle fleet changes.

The objective of this research project is to develop a methodology for using ISPEs to update the crash test impact conditions and evaluation criteria currently provided within MASH.

Project 22-65
Updating Full-Scale Testing Evaluation Requirements for Sign Supports, Poles, and Work-Zone Devices Relative to MASH and EN12767

Research Field: Design
Source: AASHTO Technical Committee on Roadside Safety
Allocation: $350,000
NCHRP Staff: Anne-Marie Turner

The AASHTO *Manual for Assessing Safety Hardware* (MASH) test criteria and evaluation thresholds for some tests have historically been conservative to address factors not yet researched and tested, variations between laboratory and field conditions, and other factors. The roadside safety community has been performing research to obtain additional information regarding these criteria and thresholds to determine if current values appropriately account for safety risks to vehicle occupants. Examples include NCHRP Project 17-90 (occupant risk model) and NCHRP Project 22-59 (occupant compartment deformation).

Development of MASH-compliant sign supports, luminaire poles, and work-zone devices has proven difficult due to occupant compartment deformation criteria, roof/windshield/rear window penetrations, and the conservative change in velocity requirements. Evaluation criteria were set low, because of the relative ease in obtaining compliant test results, i.e., low occupant impact velocities and ride-down accelerations, using frangible or slip type bases. The limit from MASH for Occupant Impact Velocity (OIV) is 4.9 m/s for all types of supports. The limit for all other highway safety devices is 12.2 m/s for OIV.

MASH, Appendix Section 2.2.4 notes that, "Energy-absorbing, yielding support structures have been developed as potential replacements for conventional breakaway systems. These devices are designed to decelerate the vehicle to a controlled and safe stop, similar to a crash cushion, rather than permitting the vehicle to break through and continue with minimal reduction in speed…since such a design would not pass occupant risk criteria recommended for breakaway support structures, it should be evaluated according to criteria recommended for a crash cushion."

Europe has developed a test standard to evaluate supports that utilizes the entire spectrum of device types and occupant risk outcomes: EN12767, *Passive Safety of Support Structures for Road Equipment – Requirements and Test Methods*. The EN12767 standard for these classes of devices uses different criteria for evaluation that may be applicable here. They have similar impact speeds, three different energy absorption categories, five occupant safety classes, two collapse modes, and two roof indentation categories. EN12767 accommodates the evaluation criteria in MASH but expands on possible outcomes based on support type to produce several different support categories.

The objectives of this research are to (1) compare the MASH test criteria for sign supports, luminaire poles, and work-zone devices to tests for similar devices in the parallel European standard, EN12767, to determine if it may be appropriate to incorporate concepts in EN12767 into MASH, and (2) draft test procedures for AASHTO consideration for potential inclusion into the next version of MASH.

Project 22-66
Development of Critical Impact Point and Impact Angle Guidance for the Manual for Assessing Safety Hardware (MASH)

Research Field: Design
Source: AASHTO Technical Committee for Roadside Safety
Allocation: $750,000
NCHRP Staff: Anne-Marie Turner

The AASHTO *Manual for Assessing Safety Hardware* (MASH) provides criteria for the full-scale crash testing and evaluation of roadside safety devices such as barriers, terminals, crash attenuators, breakaway structures, and longitudinal channelizers. The crash test matrices include requirements for vehicle type and mass and impact speed based on the desired test level. MASH additionally requires that a roadside hardware device be evaluated at its critical impact point (CIP) or critical impact angle (CIA), depending on the device category. The CIP or CIA is defined as the point or angle that maximizes the potential for failure of the device based on structural loading, vehicle stability, vehicle snagging, or other considerations.

While MASH has specific guidance for the determination of CIPs for several types of barriers (such as post and beam longitudinal barriers) CIP guidance is much more general or nonexistent for many hardware systems. In these cases, MASH recommends that CIP determination be evaluated by computer simulation. However, not all test laboratories have computer simulation capabilities, and MASH recognizes that use of computer simulation solely for the purpose of determining CIPs is often not practical. Further, even if computer simulation is utilized for this purpose, MASH does not detail what factors to consider in the CIP analysis.

This lack of information regarding CIPs and CIAs leads to different interpretations by hardware developers and test laboratories, and results in inconsistency in crash testing that can influence the evaluation of devices in certain hardware categories. Research is needed to develop CIP and CIA guidance for implementation in MASH for device categories that have test matrices that include tests that lack specific guidance on CIP or CIA determination.

The objective of this research is to develop guidelines for selecting CIPs and CIAs in MASH tests for when criteria for CIP or CIA determination is undefined.

Project 22-67
Investigation of 4:1 V-Ditch Traversability and MASH Cable Barrier Test Matrices

Research Field: Design
Source: ASHTO Technical Committee on Roadside Safety
Allocation: $750,000
NCHRP Staff: Anne-Marie Turner

The AASHTO *Manual for Assessing Safety Hardware* (MASH) provides a full-scale test matrix for evaluating cable median barriers on level terrain and sloped median ditches. The matrices define the critical placement of cable barriers and test criteria for 4:1 and 6:1 V-ditches to evaluate cable median barriers at various offsets or anywhere in a median V-ditch. Recent full-scale crash testing of cable median barriers mounted on the far side of a 4:1 V-ditch indicates that the 1100C

small car vehicle may not be able to safely and consistently traverse a 4:1 V-ditch in MASH test no. 3-16.

The 4:1 V-ditch configuration in the MASH 2016 test matrix uses a 46-ft wide V-ditch as measured from slope break point to slope break point. This V-ditch was selected based on preliminary full-scale crash tests of cable median barriers in V-ditches, vehicle dynamics simulations, and LS-DYNA simulations. The 4:1 slope was selected based on the maximum V-ditch slopes desired by state departments of transportations (DOTs). The ditch width was selected based on ditch traversal simulations to provide for a ditch capable of evaluating the maximum vehicle override potential on the front slope, the maximum vehicle underride potential during when a vehicle bottoms out on the backside of the V-ditch, and the maximum vehicle override potential when a vehicle rebounded from the bottom of the ditch and traversed up the backside of the ditch. Additionally, the AASHTO *Roadside Design Guide* (RDG*)* notes that 4:1 V-ditches are not a preferred configuration for median V-ditches, while flat bottom median ditch configurations are at the limit of the preferred configuration guidelines. Thus, the traversability of the V-ditch configuration recommended in MASH 2016 may be near the limit of vehicle stability.

The objective of this research is to further investigate the traversability of 4:1 V-ditches and determine any needed updates to the MASH cable median barrier test matrix to ensure consistent performance of these ditches when evaluating cable median barriers.

Project 23-42
Scoping Study to Identify Curriculum Development Needs for Workforce Development in Transportation Asset Management

Research Field: Administration
Source: AASHTO Committee on Performance-Based Management
Allocation: $250,000
NCHRP Staff: Mike Brooks

Aging transportation infrastructure, increasing travel demands, budget limitations, and new regulations continue to challenge transportation asset management (TAM) professionals. TAM professionals are expected to possess technical knowledge and communication skills to lead their agency implementation efforts. These knowledge areas and skills include, but are not limited to, data collection, filtering, and analysis; visualization; multi-criteria decision-making; optimization; communication; and leadership. Unfortunately, academic programs offered by universities are falling short of providing TAM professionals with the necessary knowledge and skills in their formative years. Asset management is a multidisciplinary field that involves aspects of multiple disciplines. Because of its multidisciplinary nature, asset management does not necessarily fit into traditional university programs that are often structured in domain-specific disciplines. Due to the

limited offerings at educational institutions, a substantial number of transportation professionals are ill-prepared to take on the responsibilities of a TAM professional and struggle with acquiring these skills on the job while balancing the demands from their daily duties. Nonacademic organizations have developed educational and professional development opportunities in asset management to address this demand, but these offerings are often not targeted to applications in transportation and can be viewed as expensive, time-consuming alternatives that only offer partial solutions to specific gaps in knowledge.

The objective of this research is to explore the need to develop new curriculum and/or accreditation programs for workforce development in TAM. The project is structured along four tasks. First, the project will identify the competencies and skills transportation asset managers need to successfully develop and implement TAM. Second, a comprehensive review of existing programs offered by universities and nonacademic organizations will be conducted. Third, a gap analysis will be performed to identify gaps between currently available offerings and the desired competencies. Finally, the study will summarize these gaps and recommend needs for the development of new curriculum and/or accreditation programs for workforce development in TAM.

Project 23-43
Successful DOT Utility Relocation Build America Buy America Practices

Research Field: Administration
Source: AASHTO Committee on Right of Way, Utilities, and Outdoor Advertising
Allocation: $250,000
NCHRP Staff: David Jared

Buy America (BA) law was enacted in 1981, was modified in the Moving Ahead for Progress in the 21st Century Act (MAP-21), and again with Infrastructure Investment and Jobs Act (IIJA), Build America Buy America (BABA) Act. The modifications have imparted new requirements for utility relocations on federally funded state departments of transportation (DOTs) projects. Since state DOTs are working with third party companies and the facilities and subsequent facility relocations are typically not state DOT property, state DOTs often do not have direct control over the materials procurement process. The quality and quantity of useful, available information is not sufficient for state DOTs to have a clear path to compliance. Current practices appear to be non-uniform and inconsistent from agency to agency, as many agencies seek uniform guidance and clearly defined requirements to confidently proceed and know that BABA compliance is reached. Research is needed to identify methods and procedures to develop a centralized compendium that includes relevant FHWA guidance to maximize efficiency and compliance.

The objective of this research is to develop a compendium of current BABA information as it relates to utility relocations, to include:

- National BABA guidance, law, regulation, and policy related to third party utility relocations.
- Case studies demonstrating effective practices, approaches, and techniques for implementing BABA on third party utility relocations.
- Iron/steel and construction material evaluation of BABA subject materials by industry type (electric, gas, telecom, other) facing compliance challenges.
- Solutions-based decision-tree model to include:
    1. Utility relocation agreements standards;
    2. Managing utility company procurement processes;
    3. Education recommendations for utility owners;
    4. Utilizing self-certification techniques;
    5. Step-certification techniques;
    6. Common products with compliance challenges; and
    7. Existing waiver impacts and processes to secure waivers.

Project 23-44
Improving Partnerships Between DOTs and Utility Companies

Research Field: Administration
Source: AASHTO Committee on Right of Way, Utilities, and Outdoor Advertising
Allocation: $500,000
NCHRP Staff: David Jared

Coordination between transportation agencies and utility owners is key to successful implementation of transportation projects and utility accommodation on rights-of-way (ROW). While cooperation and coordination has often been challenging, the combination of several factors has recently created a more difficult environment. This includes staff turnover within transportation agencies and utility companies, increasing numbers and complexity of transportation projects, use of innovative project delivery processes (e.g., public-private partnerships (P3), progressive design-build), and use of ROW for broadband and green energy initiatives. Research is needed to identify strategies to improve partnerships between state departments of transportation (DOTs) and utility companies to enhance coordination and cooperation for high-profile and regular infrastructure projects.

The objective of this research is to develop a strategic guide and structure model based on case studies of successful practices and culture changes at various agencies at the legislative, program, project, and field levels.

Project 23-45
A Knowledge Management Manual for Transportation Agencies

Research Field: Agency Administration
Source: AASHTO Committee on Knowledge Management
Allocation: $500,000
NCHRP Staff: David M. Jared

Since the publication of *NCHRP Report 813: A Guide to Agency-Wide Knowledge Management for State Departments of Transportation* (2015), knowledge management (KM) has gained traction within the transportation community. AASHTO created the Committee on Knowledge Management in 2018, and TRB created the Committee on Information and Knowledge Management in 2019. A growing number of state departments of transportation (DOTs) have begun to implement various aspects of KM, and there is heightened awareness of workforce-related challenges and risks. However, there is not yet a critical mass of state DOTs with active and sustained KM programs.

Stakeholder outreach activities conducted as part of NCHRP Project 23-14, "Research Roadmap for Knowledge Management" found that while *NCHRP Report 813* is viewed as a valuable resource, there is a need for more detailed and practical guidance on organizing and coordinating KM in a state DOT and integrating KM practices into various state DOT functional areas. Agencies also are seeking a DOT-specific maturity model for KM implementation and a way to benchmark and track their KM implementation progress. A KM manual for state DOTs would meet these needs, building on and supplementing the more general, top-down KM implementation guidelines provided by *NCHRP Report 813*. An emphasis on integrating KM practices within different state DOT functions would help agencies to make KM more sustainable by expanding the breadth, coordination, and reach of KM implementation within their organizations.

The objective of this project is to create a KM implementation manual that will help state DOTs to address workforce challenges, gain efficiencies, and improve resilience to meet changing needs.

- The first phase of the project will investigate current practices for knowledge creation, sharing, and application as part of different state DOT business areas and situations and, based on this investigation, develop a KM implementation framework and maturity model. This work will examine and adapt existing public and private sector KM frameworks and models for application within state DOTs.
- The second phase of the project will build on this foundation and develop a manual that can be used by state DOTs for planning, resourcing, coordinating, and executing KM strategies and techniques. The manual will address KM implementation activities in multiple state DOT functional areas. It will illustrate KM applications in response to

multiple situations including new legislative mandates, introduction of new technologies or methods, and changes in remote work policies.

Project NCHRP 23-46
Impact and Opportunity of Artificial Intelligence and Automation on the Transportation Workforce: Exploring Skill Gaps, Competency Requirements, Mindset Shifts, and Transportation Agency Strategies

Research Field: Administration
Source: Ohio Department of Transportation
Allocation: $500,000
NCHRP Staff: Roberto Barcena

Artificial intelligence (AI) and automation have been gradually transforming the transportation sector. Early automation in propulsion and guidance, and the driverless transport of cargo and people, was demonstrated nearly a century ago in some modes. AI has already been implemented in many industries, including finance, healthcare, and manufacturing. Now, it is making its way into the world of transportation.

It is urgent to research the impact and opportunities of AI and automation on the state departments of transportation (DOTs) transportation workforce. The research needs to explore workforce skill gaps, competency requirements, mindset shifts, and strategies for transportation agencies. DOTs and local transportation agencies need to understand and prepare for the transition of the transportation workforce into the era of combined AI and automation.

The objective of the research is to develop guidelines, actionable strategies, and materials for DOTs and other agencies to help them understand, navigate, and succeed in the transformation of the DOT transportation workforce influenced by AI and automation.

Project 23-47
Guide for Successful Strategies and Programs for Pavement Preventive Maintenance Inspector Training

Research Field: Administration
Source: AASHTO Committee on Maintenance
Allocation: $350,000
NCHRP Staff: Amir N. Hanna

The construction and preservation of highway infrastructures requires considerable skilled labor and specialized equipment. Historically, this construction/preservation consisted of the owner

being responsible for the right-of-way acquisition, roadway design, establishing materials requirements and contract specifications, contract procurement, and inspection of the awarded project during and after construction. The contractor provided the equipment, materials, labor, and expertise to construct the project. The agency then provided the preservation of the infrastructure either through in-house methods or through outsourcing. Both the agency and contractor had to staff according to project schedules, volume of and quantity of work items, and expected environmental conditions. Although in the design phase, more latitude was often allowed as schedule slippage could more easily be tolerated by the owner. However, once a contract is awarded, on-time performance becomes a high priority. As such, agencies had to ensure a properly qualified workforce was available to ensure a final product in accordance with project specifications and the contractor's schedule. This is considered part of an agency's fiduciary responsibility.

The objective of this research is to develop methodologies for establishing the necessary inspector staffing levels, deployment strategies, and training and competency requirements for each of the typical pavement preservation strategies. The potential costs and risks associated with inadequate inspection should also be determined.

Project 23-48
Understanding, Creating, and Measuring Public Value; Lessons Learned from Public Agencies

Research Field: Administration
Source: AASHTO Committee on Performance Based Management
Allocation: $300,000
NCHRP Staff: Trey Joseph Wadsworth

Unlike a business providing shareholder value through a monetary exchange of products and services to individual clients or customers for individual consumption, the public sector operates from a monetary public entrustment to provide goods and services for collective consumption. This public investment obligates the public sector to understand the values and aspirations of the served community and be efficient and effective in managing their resources and create public value.

In 1995, Mark Moore developed a public value strategic triangle: (1) legitimacy and support, (2) operational capacity, and (3) public value. "Public value" describes the value of contribution to served communities and broader society. For transportation, infrastructure and services provide benefit to system users and adds value to the public sphere. It represents agency-public consensus of principles and benefits and pertains to the content of service and how it is delivered. When instituted as an organizing principle, public value creation guides administrative policy and management decisions with an aim to increase the value of societal and community benefit. Transportation administrators define and solve problems from a value perspective when deploying

public assets. Evaluating management decisions through a public value lens promotes better understanding and achieving both traditional outcomes and value-based performance expectations.

World Road Association (PIARC) research published in *Measuring Customer Experience and Public Value Creation for Transport Administrators* (2023) focused on understanding how transportation administrations measure efficiency and effectiveness of customer experience and public valuation creation with emphasis on the customer experience component. There remains a need to further develop a framework for the creation and measurement of the public value that considers and emphasizes societal contribution in decision-making. The PIARC research was limited to the evaluation of existing work by transportation administrations and agencies. There are non-transportation public sectors with mature frameworks for creating and measuring public value that transportation administrations can learn from, adapt, and adopt as practice.

To further understand, create, and measure the public value of transportation services and contributions to community and societal goals, this research has two objectives:

1. Identify non-transportation public agencies that proficiently capture and measure public value data and are using it for policy decision-making.
2. Using transportation agencies identified in previous research and non-transportation public agencies identified in Objective 1, review and synthesize public value creation programs, frameworks, and practices in areas that are scalable and applicable by other transportation agencies. The areas represent the dimensions of public value described in Faulkner and Kaufman's *Avoiding Theoretical Stagnation: A Systematic Review and Framework for Measuring Public Value*.

Project 23-49
Anticipatory Knowledge Delivery for State DOTs

Research Field: Agency Administration
Source: AASHTO Committee on Knowledge Management
Allocation: $325,000
NCHRP Staff: David M. Jared

An anticipatory knowledge (AK) delivery system provides targeted guidance to employees based on their roles, triggered by key milestone events such as onboarding, assignment of first project management responsibility, and passage of new legislation. The AK concept continues to be of great interest to state departments of transportation (DOTs). However, these agencies have not institutionalized AK delivery. Guidelines tailored to state DOTs are needed on how to anticipate what employees need to know at different points in time and deliver that information in an automated, convenient, coordinated, and efficient fashion. These guidelines would identify types and sources of information required for a selected set of DOT roles, processes, and milestones.

It would also create model requirements that could be used by state DOTs or their partners to implement an AK system.

The objective of this project is to develop guidelines for state DOTs on implementing an AK delivery system that provides relevant information to employees when they need it. The guidelines will include:

- Identification and documentation of priority roles, business processes, milestones, and events where the AK system would add the most value in a DOT setting;
- Compilation of illustrative information "packets" that the system would distribute in different situations;
- Identification of roles and responsibilities for creating, managing, and supporting a DOT AK system;
- Development of a conceptual data model for an AK system, along with identification of potential linkages to existing information sources in a DOT that could be used to drive information delivery; and
- Development of functional requirements for an AK delivery system that could be used individually or collectively by DOTs to develop and integrate AK delivery system software.

Project 25-72
Field Methods and Interlaboratory Tests to Establish the Accuracy and Precision of Measured Concentrations of Emerging Contaminants in Stormwater Runoff and Stormwater-Treatment System Effluent

Research Field: Transportation Planning
Source: Federal Highway Administration
Allocation: $650,000
NCHRP Staff: Mike Brooks

In the 1990s research on metal-sampling methods in natural waters (Benoit et al. 1997) demonstrated profound and systemic issues with previously accepted methods that invalidated decades of sampling results and led to the end of longstanding water-quality monitoring programs. The history of environmental sampling efforts for metals and other constituents has shown that the methods and materials used for collection, processing, and analysis of water-quality samples can substantially increase or attenuate measured concentrations (FHWA 2003; Horowitz 2013; Jiann et al. 2016). Decisions made about the sampling method, the materials used in sampling equipment, the filters, and other equipment used to process samples, and even the water, detergent, and preservatives used to clean equipment and preserve samples, can affect measured constituent concentrations. Laboratory intercomparison studies have demonstrated that when identical

samples are provided to multiple laboratories for analysis of conventional constituents of interests, results from different laboratories can vary by orders of magnitude (FHWA 2003). Uncertainties for measured stormwater concentrations can be high, even for commonly monitored constituents such as sediment, phosphorus, and nitrogen (Harmel et al. 2006). Efforts to quantify the performance of stormwater treatment measures based on defensible data are critical because of the large life-cycle costs of stormwater management practices (Taylor et al. 2014). Research is needed to determine the methods and materials needed to obtain representative and unbiased concentrations of emerging contaminants in runoff, stormwater treatment system effluent, and receiving waters to support quantitative threat assessments and treatment decisions before large expenditures for monitoring data and treatment system construction are made.

The objective of this research is to evaluate the methods and materials used to collect, process, and analyze stormwater samples for determining concentrations of emerging contaminants such as Perfluoroalkyl and Polyfluoroalkyl Substances, N-phenyl-N'-(1,3-dimethylbutyl)-p-phenylenediamine (6-PPD), 6PPD-quinone, and microplastics in stormwater runoff and stormwater treatment system effluent to establish robust sampling protocols and to establish the uncertainties and detection limits for emerging constituents of concern.

Project 25-73
Successful Community Impact Strategies During the Construction of Projects

Research Field:	Transportation Planning
Source:	AASHTO Committee on Construction
Allocation:	$350,000
NCHRP Staff:	Jennifer L. Weeks

State departments of transportation (DOTs) have been managing ever larger and complex transportation projects as the nation's Interstate and highway system is updated to meet future needs. Many construction projects take place in urban, densely populated areas and, in many cases, within communities that have been traditionally cut off from the benefits of the transportation network and/or negatively impacted by transportation infrastructure. The expectations for state DOTs to provide positive community impacts and mitigate and avoid negative community impacts during construction continue to be high. Examples include providing project-specific, construction-related career development (middle school through post-secondary education), support for participation of local businesses in the construction, mitigation of noise and pollution, ongoing community outreach and communication during the construction project, and the design and implementation of local community-focused project features.

Successful community impact strategies involve skills and expertise not typically included in transportation construction. Research into state DOT practices and requirements related to

community impact of construction projects is needed to develop a guide to the adoption and implementation of appropriate community impact strategies during construction. The information should include recommended strategies and specific practices that would result in successful community impacts from projects that affect them.

Project 25-74
Advancing Methods to Evaluate Greenhouse Gas Emissions During Transportation Decision-Making and Performance Management

Research Field: Transportation Planning
Source: AASHTO Committee on Performance-Based Management
Allocation: $300,000
NCHRP Staff: Mike Brooks

State departments of transportation (DOTs) have access to a growing number of tools that may allow them to evaluate the impact of greenhouse gas (GHG) emissions. However, research is needed to understand how such tools can best be incorporated into transportation decision-making processes and what additional tools may be necessary. Existing tools for transportation GHG strategy analysis have not been developed with transportation programming and project prioritization in mind. The available tools are either designed for strategic level evaluation of policies or project-level evaluation using data more detailed than is typically available during planning and programming. Other common tools for transportation evaluation, including statewide and regional travel demand models and emission factor models such as Motor Vehicle Emission Simulator MOVES, are limited in their ability to evaluate GHG reduction strategies, and typically require substantial modification and/or combination with other tools and methods.

The objective of this research is to advance the practice of incorporating GHG emissions evaluation into transportation decision-making and performance management. This will be accomplished by identifying and building upon the state of practice at state DOTs for considering transportation-related GHG emissions during planning, project prioritization, and performance management. State DOTs have access to certain tools that allow for estimation and evaluation of transportation emissions, but additional tools and methods are needed to inform decision-making and align with state and federal GHG emission-reduction goals.

Project 25-75
Simplified Methodology for Risk-Based Air Quality Assessments of NEPA Alternatives

Research Field: Transportation Planning
Source: AASHTO Committee on Sustainability and Environment
Allocation: $450,000

NCHRP Staff: Mike Brooks

For state departments of transportation (DOTs), comparisons of alternative build and no-build scenarios in project-level air quality analyses typically focus on comparisons of emissions and/or ambient concentrations of specific pollutants, including greenhouse gases, mobile source air toxics, particulate matter, and carbon monoxide. However, the emission and concentration estimates between pollutant classes are not directly comparable and cannot be directly aggregated. This constrains decision-making on NEPA alternatives, as it limits the ability to consider potential multi-pollutant air quality impacts, which may differ substantially by alternative.

One possible solution to this problem is to translate the results for each pollutant class into a common risk-based metric that would allow for aggregation and comparison. Potential synergistic effects could also be considered as part of the aggregation. NEPA alternatives could then be compared on a common basis, i.e., the potential air quality impacts for each alternative in terms of aggregate risk. Risk assessments incorporated into NEPA documentation would enhance transparency and communication to stakeholders, such as environmental justice (EJ) populations, and support informed decision-making on preferred alternatives for which the potential multi-pollutant air quality impacts may differ substantially.

The objective of this research is to develop a simplified means to assess and report the relative risk of potential transportation air quality impacts for NEPA alternatives, including those for EJ populations. The research would produce a simplified, practical, and affordable approach to air quality risk assessment that could be applied at state DOT discretion in NEPA studies.