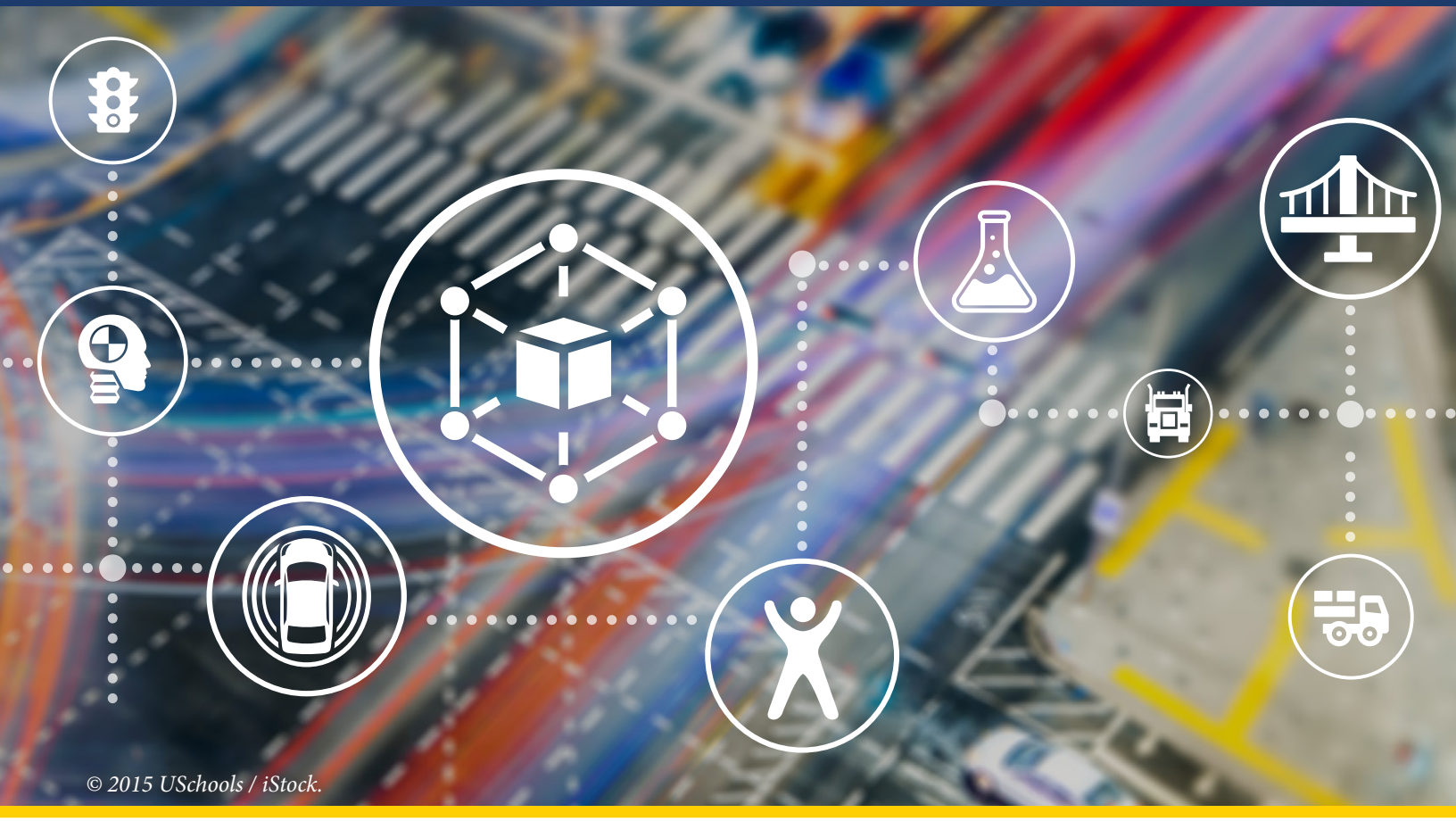
THE FHWA R&T STORY

Innovating the Future of Transportation



U.S. Department of Transportation
Federal Highway Administration

Turner-Fairbank
Highway Research Center

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Introduction: Innovations for a Better Future

The Federal Highway Administration (FHWA) champions research and technology (R&T) innovations to address the critical needs of the Nation's highway system. *The FHWA R&T Story* presents innovations that ensure the safety of vulnerable pedestrians, evaluate concepts for connected and automated vehicles (CAVs), and develop better ways to test for pavement deterioration. These innovations can help renew the highway system, spur economic recovery, reduce inequities, and protect against the impact of future climate scenarios.

Every day, the U.S. highway system safely connects people and moves goods, sustaining the country's economic capacity. This system is a dynamic and collaborative network involving transportation agencies at all levels of government and industry that form the leading edge of the country's advancements in highway infrastructure. Investing in transportation is critical in securing America's economic future.

To advance the transportation system, FHWA focuses on ensuring safety, stimulating economic growth, promoting equity, reducing climate impacts while incorporating sustainability, and leading technological transformation. FHWA is working to:

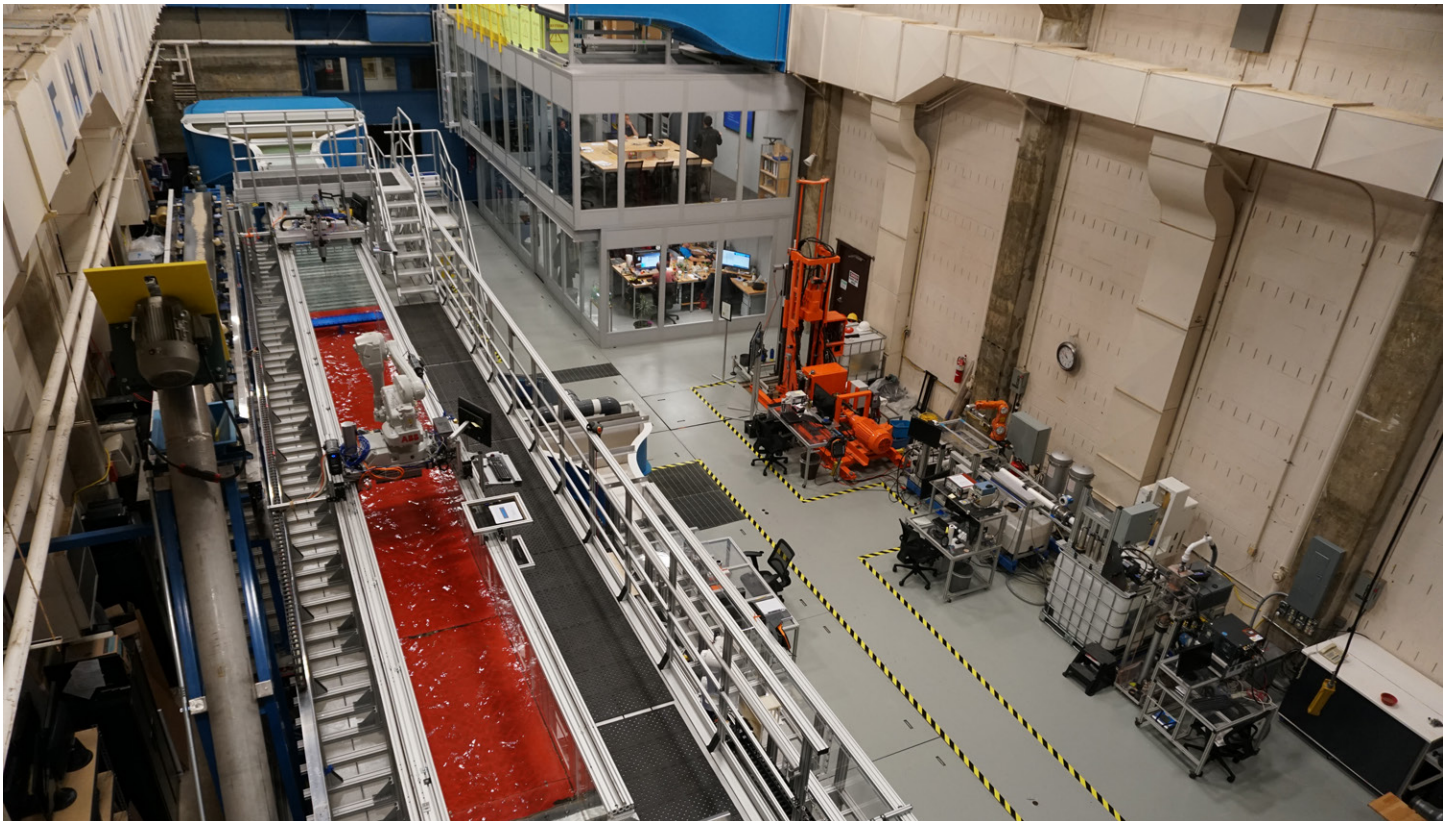
- Address the critical needs of the Nation's current highway system by improving safety, operations, and infrastructure to foster sustainable, equitable economic recovery.
- Accelerate implementation of technologies to meet future highway needs by supporting States and other stakeholders to deliver transformative, cost-saving innovations with long-term benefits.
- Provide clear benefits to the public by highlighting the importance of innovation and its role in fostering equitable economic growth.

Turner-Fairbank Highway Research Center

FHWA's Turner-Fairbank Highway Research Center (TFHRC) plays a vital leadership role in developing and implementing coordinated highway R&T. TFHRC, a Federally owned and operated national research facility in McLean, VA, houses 15 laboratories, data centers, and support facilities. TFHRC conducts exploratory and applied research in the areas of safety, infrastructure, and operations. The laboratories provide a critical resource for advancing the body of knowledge created and developed by these multidisciplinary researchers and engineers.

FHWA advances research innovations that transportation agencies can use to maintain and improve the performance of their transportation systems, with a particular emphasis on proven innovations ready for implementation that will be more robust to future challenges than conventional options. This research helps States with their infrastructure projects while ensuring that the traveling public has multiple mobility options to access jobs, education, and other opportunities.

The projects described in the following pages show how FHWA advances innovations that strengthen the transportation system and advance technologies to meet future needs that deliver clear benefits to the traveling public.



TFHRC conducts innovative exploratory and applied research to improve the safety and resiliency of highways across the United States. The J. Sterling Jones Hydraulics Research Laboratory is one of 15 laboratories at TFHRC.

Source: FHWA.

Key to Icons

Safety | Transformation | Climate Change | Economic Growth | Equity

FHWA programs help support repairs to roadways like this one damaged by extreme weather, allowing health facilities to obtain needed supplies and connecting people to economic opportunities and surrounding communities.

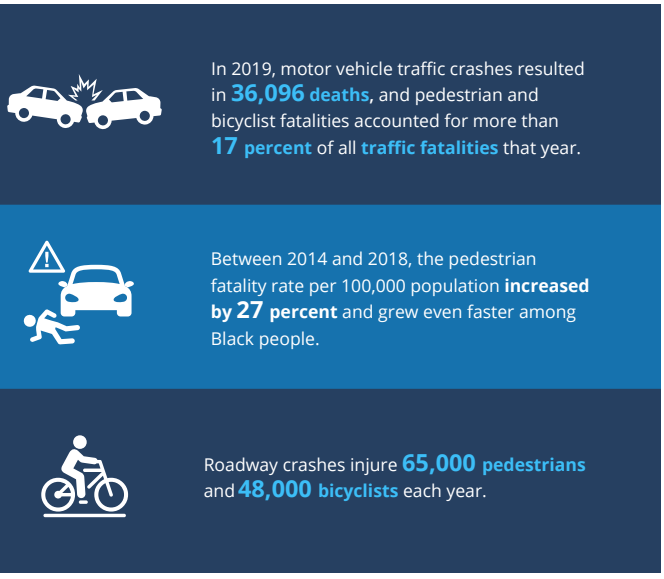
Addressing the Critical Needs of the Nation's Current Highway System

The U.S. public roads system is the Nation's largest public infrastructure system. It consists of more than 4.1 million miles of roadways, more than 617,084 bridges and related structures, and a wide range of traffic control and safety systems.[1,2] It is the economic backbone that moves the vast majority of the Nation's products and enables trade. The highway system powers businesses, connects workers to their jobs, and creates opportunities for historically marginalized communities. However, the economic growth made possible by the highway system has also fueled tremendous increases in the demands placed on it.

Beyond the growing demands on the highway system, the impacts of unprecedented events like pandemics, hurricanes, and wildfires may have lingering effects. The Nation's highways are critical in the short term to mitigate these catastrophic events by ensuring healthcare facilities can obtain needed supplies and damaged roads and bridges can be repaired. In the long term, these highways will be vital to the country's economic recovery by connecting people to opportunities they need safely and fairly. Thus, it will be crucial for transportation agencies at all levels of government to maintain and upgrade the highway system to facilitate a robust and equitable recovery.

Improving Safety Through Innovation

In 2019, motor vehicle traffic crashes resulted in 36,096 deaths, and pedestrian and bicyclist fatalities accounted for more than 17 percent of all traffic fatalities that year.[3] Between 2014 and 2018, the pedestrian fatality rate per 100,000 population increased by 27 percent and grew even faster among Black people.[4] Roadway crashes injure another 65,000 pedestrians and 48,000 bicyclists each year.[5]



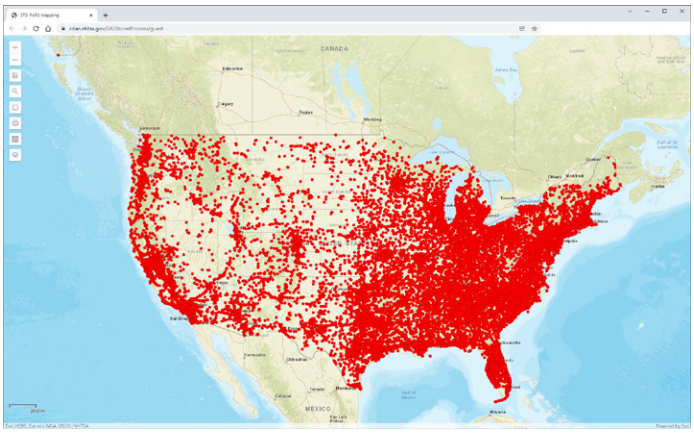
Source: FHWA.

In recognition of the magnitude of this problem, FHWA has encouraged the development of innovative safety technologies and data analysis tools that enable transportation professionals to connect crash causes with effective solutions. These innovations include identifying problem areas for pedestrians and bicyclists, developing analysis tools that allow planners and engineers to better understand and target these problem areas, and evaluating countermeasures to reduce the number of crashes involving pedestrians and bicyclists. FHWA strives to cultivate safer roadways for some of the most vulnerable roadway users, from safer crosswalks and sidewalks to educational and safety initiatives.

Pedestrian Safety

A study conducted by FHWA entitled "Safety Evaluation of Protected Left-Turn Phasing and Leading Pedestrian Intervals on Pedestrian Safety" examined the effects of combining two innovative countermeasures that help protect pedestrians at intersections.[6] Protected left-turn phasing provides a separate traffic-signal phase for left-turning traffic where no pedestrian movement or vehicular traffic conflicts with the left turn.[7] Leading pedestrian intervals allow pedestrians to enter an intersection 3 to7 seconds before vehicles receive a green light.[8] Using state-of-the-art analytical methods, the study developed statistically rigorous crash modification factors (CMFs) for protected left-turn phasing and leading pedestrian intervals.[6] FHWA partnered with various cities that had installed one or both of the countermeasures of interest. These cities included Chicago, IL; New York, NY; Charlotte, NC; and Toronto, ON. FHWA worked with staff in each city to obtain information on countermeasure installation; roadway and intersection characteristics; crash data, including pedestrian-specific crash data; vehicle- and pedestrian-volume data; and signal-timing data.

Another FHWA study relied on geospatial technologies to pinpoint areas of risk. "Identification and Prioritization of High Pedestrian Crash Locations/Areas" documented the methods used to identify and prioritize high pedestrian crash sites and the methods' input data demands.[9] FHWA successfully worked with several cities and States to catalog the criteria needed to identify and rank high pedestrian crash locations. The collection of geographic coordinates (latitude and longitude) for crashes has resulted in extensive geographic information system platforms for displaying the locations and density of crashes on maps.



Original map: © Esri, HERE, Garmin, NGA, USGS. Modifications by the National Highway Traffic Safety Administration to show 2019 fatal crash locations.

Human Factors

Human factors research aims to improve understanding of road-user behavior and incorporate that knowledge into all FHWA strategies for improving safety and enhancing operations throughout the highway transportation system. Human factors research in automation seeks to understand how CAVs can be safely integrated into the Nation's roadway systems by evaluating the human behaviors related to the deployment of cooperative automation.

FHWA conducts human factors research using driving simulators and other innovative tools to integrate CAV technology into the Nation's roadway system.

Source: FHWA.

Cooperative adaptive cruise control (CACC) intends to increase traffic throughput by safely permitting shorter following distances between vehicles. Shorter following distances can help freight firms save money on fuel, which increases the efficiency of goods delivery and aids economic recovery. In 2018, the CACC Human Factors project entitled "Cooperative Adaptive Cruise Control Human Factors Study" involved a series of experiments that examined how CACC affected drivers' workload, propensity to distraction, level of sensory stimulation, ability to avoid a crash, merging abilities, and trust in the system.[10]

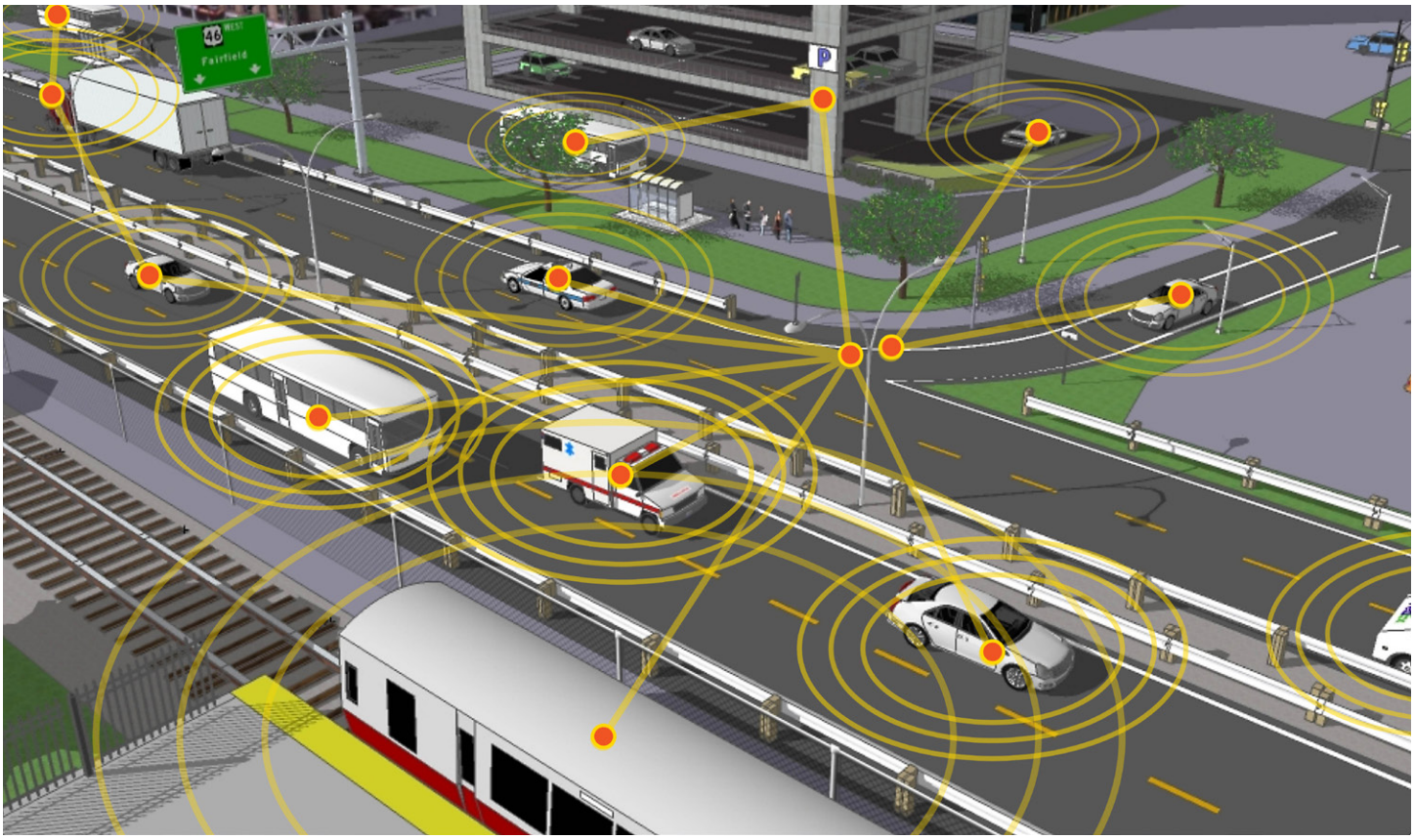
Similarly, researchers working on the ongoing project "Human Factors Issues Related to Truck Platooning Operations" are studying the perceptions of truck platoons and visual indicators/signing related to truck platoons.[11] This project is using a sign laboratory and driving simulator to investigate human factors issues associated with traveling near a truck platoon. The researchers are trying to understand the likely actions of people driving passenger cars in the presence of truck platoons.

Improving Operations Through Innovation

CAV Research

Rapidly emerging automated vehicle (AV) technology, if well deployed, can resolve current and future highway needs. AVs promise increased safety and greater performance through reduced congestion, expanded vehicular capacity, real-time route optimization, and fuel efficiency. FHWA has taken a national leadership role in the safe development, testing, and deployment of AV technology, including CAV research and cooperative driving automation (CDA).

The CARMA℠ Program is a research program designed to develop concepts for CDA. The concepts address everyday traffic situations and provide testing and evaluation of resulting applications. This work uses open-source software to encourage collaboration and participation among a community of engineers and researchers. In 2021, the CARMA team initiated testing of self-driving features to prepare for testing and validation of the cooperative driving use cases of basic travel, work zones, and incident management.



Through the Exploratory Advanced Research Program, FHWA analyzes how artificial intelligence and machine learning can advance communications between vehicles and infrastructure, ultimately improving the safety and efficiency of highway networks.

Source: U.S. Department of Transportation.

Exploratory Advanced Research

FHWA's Exploratory Advanced Research (EAR) Program is studying the development of artificial intelligence (AI) and machine learning (ML) in transportation management systems through its work with universities and industry. This research includes automated traffic imagery analysis, incident detection, traffic control, and traffic signal timing. For example, the EAR Program selected Tufts University to conduct the Traffic Incident Detection and Analysis System study to utilize AI/ML advancements in computer vision techniques, known as ClearVision. The techniques enhance images with object detection and provide object tracking using neural networks, scenario detection algorithms, and a user interface to assist operators. The technology works with existing cameras and equipment, resulting in lower implementation costs. The project could improve image processing, enhance vehicle classification, and automatically identify anomalies to regular roadway performance through innovative AI-based use of existing roadside equipment.

Improving Infrastructure Through Innovation

Today's aging highway system poses daunting challenges for transportation professionals, including a growing need for rehabilitating and rebuilding many highway segments that must continue to meet high travel demand due to increasing congestion, emerging safety problems, and worsening environmental impacts. Keeping bridges in a state of good repair is essential to operating the transportation system efficiently.

Innovative Pavement Research

TFHRC's Concrete Laboratory staff conducts research in many areas related to concrete materials to develop better, more durable, cost-effective, and sustainable infrastructure. Researchers in the laboratory are developing guidelines to apply ultra-high performance concrete (UHPC) to bridge preservation and repair to maintain and improve bridge conditions cost effectively. UHPC is a fiber-reinforced, cementitious composite material with mechanical and endurance properties that far exceed conventional concrete materials. Thus, UHPC enables more durable repairs and extended service life of existing highway bridges.

Researchers at the TFHRC Concrete Laboratory developed standards to help entities apply UHPC to their roadways, like these Vermont construction workers are doing. UHPC provides added resilience over traditional concrete.

© 2016 Vermont Agency of Transportation (VTrans).

Through efforts in FHWA's Office of Infrastructure, Research, and Development's (R&D) laboratories and the EAR Program, researchers are evaluating the effectiveness of the next generation of supplementary cementitious materials (SCMs) in concrete. The project, "Towards Low Embodied Carbon Cement and Concrete in Transportation Projects," takes a multidimensional approach to address the environmental impact of cement-based materials used in transportation infrastructure.[12] SCMs help reduce the use of carbon-intensive cement; for decades, SCMs have proven effective in enhancing the workability and durability of concrete. The Office of Infrastructure R&D is also collaborating with FHWA's Sustainable Pavements Program, Mobile Concrete Technology Center, Resource Center, and other Federal partners to educate stakeholders on ways to reduce the greenhouse gases attributable to the cement and concrete used in their infrastructure.

TRANSFORMING THE WAY SOCIETY MOVES

Advances in technology are leading a wave of transportation transformations. FHWA's EAR Program is studying the development of AI and ML technology in transportation management systems. AI in transportation encompasses a wide area of technology, from advanced driver assistance systems to predictive traffic modeling and control systems. The use of AI to digest and analyze large amounts of data provides broad public benefits, such as improving traffic flows, supporting human decisionmaking in a traffic management center, and performing real-time monitoring.

FHWA has also taken a national leadership role in the safe development, testing, and deployment of AV technology, including CAV research and CDA. Connected vehicles have the potential to transform the way Americans travel through the creation of a safe, interoperable wireless communications network—a system that includes cars, buses, trucks, trains, traffic signals, smartphones, and other connected devices. Connected and automated technologies—including broadband, zero-emissions technologies, and cybersecurity safeguards—are critical underpinnings to a 21st-century transportation system and will help ensure our system is safer, greener, smarter, and more equitable.

Better Pavement Testing

A relatively new procedure, *T 365: Standard Method of Test for Quantifying Calcium Oxychloride Formation Potential of Cementitious Pastes Exposed to Deicing Salts*, published by the American Association of State Highway and Transportation Officials (AASHTO) in 2020, quantifies the amount of pavement deterioration caused by calcium oxychlorides from deicing salts.[13] TFHRC's Concrete Laboratory optimized the procedure for measuring calcium oxychloride by reducing the duration of testing. The reduction of the test duration can potentially drastically cut the test costs for practitioners and make this test more competitive with other available techniques. The T 365 technology can help agencies better assess road conditions and conduct needed maintenance, functions that will be crucial as climate change may worsen the impacts of winter storms.

After a 10-year research effort, the FHWA Chemistry Laboratory has developed a new test method for determining alkali-silica reactivity (ASR) damages on concrete in the form of cracks. A reliable test method to determine an aggregate's potential to form ASR gels in concrete has eluded the transportation industry since the first ASR test methods were proposed in 1947. Many test method variations have been employed over the years. Almost all rely on measuring the physical expansion of concrete or mortar specimens: none work particularly well. The Chemistry Laboratory has developed a new test method that relies exclusively on chemical measurements without concrete or mortar sample requirements; it accurately detects highly reactive and nonreactive coarse aggregates.

Nature-Based Solutions

More than 60,000 road miles in the United States are coastal highways, and these roads and bridges are vulnerable to tides, storm surges, waves, and sea-level rise. FHWA research has explored nature-based solutions for climate resilience. Nature-based solutions mimic characteristics of natural features and processes but are created by human design and engineering.[14] These solutions use natural materials and processes as an alternative to, or an enhancement of, traditional shoreline stabilization and infrastructure protection techniques and have numerous benefits. Not only do these solutions enhance resilience to flooding, wave action, and erosion, but they also facilitate natural ecosystem function, cost less than traditional shoreline armoring, adapt naturally to sea-level rise, and offer recreation and tourism benefits.

FHWA's research and guidance help entities with efforts such as restoring Fourmile Creek in Washington State to its natural floodplain. This project addresses potential environmental impacts expected from upcoming construction projects and reconnects waterways to help with flood control and expand habitat for native species, such as salmon.

© 2020 WSDOT.

To facilitate nature-based solutions for coastal highway resilience, FHWA published an implementation guide to help transportation practitioners understand how and where to use nature-based solutions to improve the resilience of coastal roads and bridges.[15] This guide summarizes the potential flood-reduction benefits of these strategies and reviews the steps of the project delivery process. In particular, the guide describes how to consider nature-based solutions in the planning process, conduct a site assessment to determine whether nature-based solutions are appropriate, and incorporate key engineering, permitting, and monitoring strategies.[14]

Collaborations like the "Netherlands Binational Collaboration: Infrastructure Resilience-Nature-Based Solutions" have also addressed nature-based engineering solutions for infrastructure resilience.[12] Two State departments of transportation (DOTs) participate in this collaboration with the Netherlands. Washington State DOT (WSDOT) has demonstrated innovative stormwater and stream restoration approaches since 2019. North Carolina DOT has spearheaded multiple nature-based flood mitigation efforts, which are also of interest to the Netherlands.

BUILDING FOR A BETTER FUTURE WITH RESILIENT INFRASTRUCTURE

FHWA recognizes that climate variability and change pose threats to U.S. transportation systems. The range of impacts from these threats may include roadway deterioration, flooding, limited waterway access, and weakened structures. Severe conditions may reduce the life of capital assets and increase operational disruptions. Some consequences may require changes in the design, construction, and maintenance of infrastructure.

For example, applying UHPC in bridge preservation and repair and researching novel cementitious materials will help develop better, more durable, cost-effective, and sustainable infrastructure. In addition, to facilitate nature-based solutions for coastal highway resilience, FHWA publishes manuals and guidance designed to help transportation practitioners understand how and where nature-based solutions can be used to improve the resilience of coastal roads and bridges.

For More Information

The following websites provide additional information and further highlight the FHWA activities discussed in this section.

Safety Evaluation of Protected Left-Turn Phasing and Leading Pedestrian Intervals on Pedestrian Safety:

https://www.fhwa.dot.gov/publications/research/safety/18044/index.cfm

https://www.fhwa.dot.gov/publications/research/safety/18059/index.cfm

https://www.fhwa.dot.gov/publications/research/safety/18060/index.cfm

Identification and Prioritization of High Pedestrian Crash Locations/Areas:
https://www.fhwa.dot.gov/publications/research/safety/17107/index.cfm

Cooperative Adaptive Cruise Control Human Factors Study:
https://www.fhwa.dot.gov/publications/research/safety/13045/13045.pdf

Human Factors Issues Related to Truck Platooning Operations:
https://www.its.dot.gov/presentations/avs2019/McHale_Truck_PlatooningAVS2019.pdf

CARMA:

https://highways.dot.gov/research/operations/CARMA-products

EAR Program:

https://highways.dot.gov/research/research-programs/exploratory-advanced-research/exploratory-advanced-research-overview

AI/ML in Transportation Management Systems:

https://www.fhwa.dot.gov/publications/research/ear/18066/18066.pdf

UHPC:

https://highways.dot.gov/research/structures/ultra-high-performance-concrete/ultra-high-performance-concrete

T 365 Standard Method of Test Quantifying Calcium Oxychloride Amounts in Cement Pastes Exposed to Deicing Salts:

https://store.transportation.org/Item/PublicationDetail?ID=4382

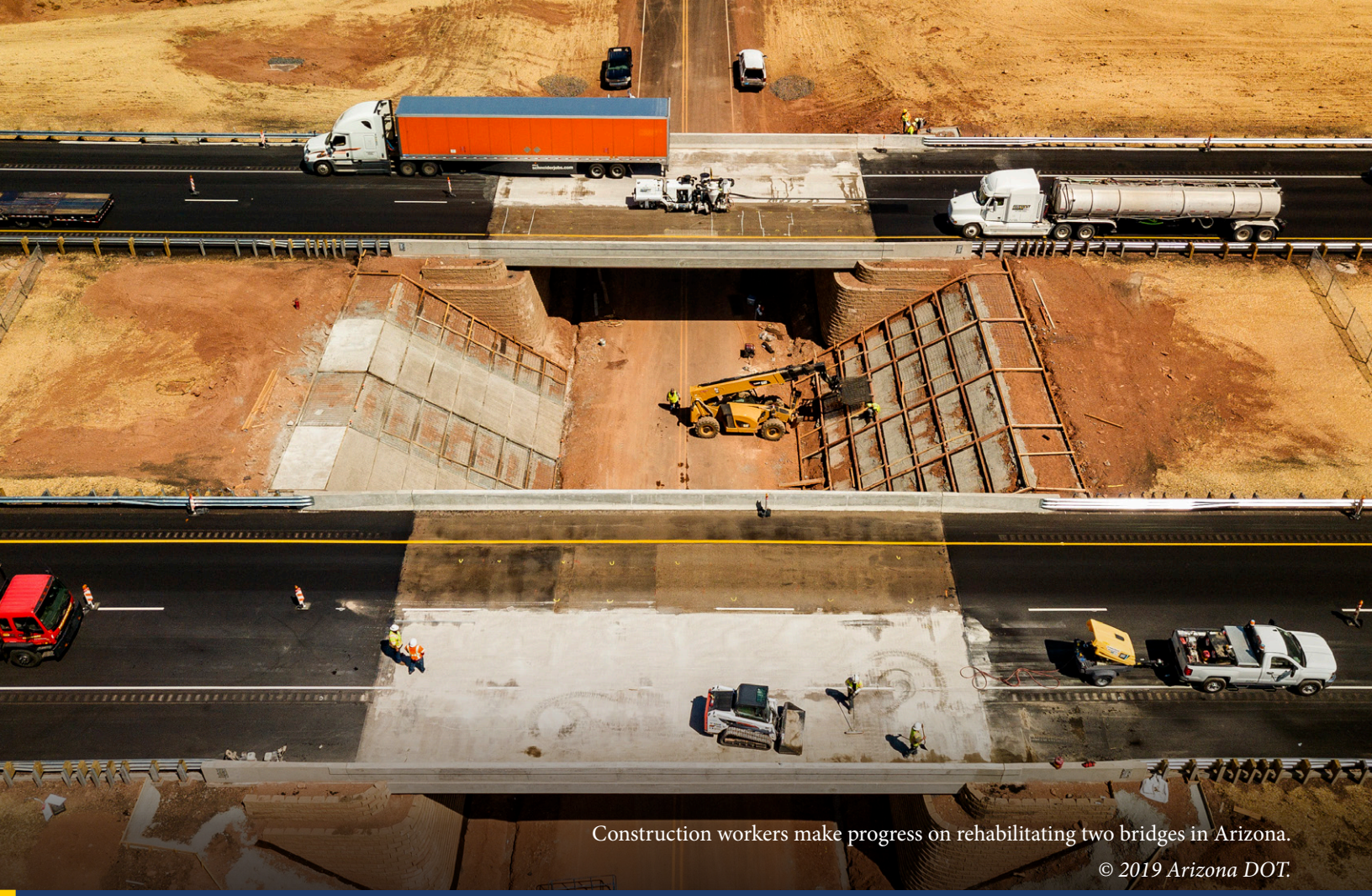
ASR:

https://www.fhwa.dot.gov/pavement/concrete/asr.cfm

Sustainable Pavement Systems:

https://www.fhwa.dot.gov/pavement/sustainability/hif15002/hif15002.pdf

Implementation Guide: Nature-based Solutions for Coastal Highway Resilience:
https://www.fhwa.dot.gov/environment/sustainability/resilience/ongoing_and_current_research/green_infrastructure/implementation_guide/fhwahep19042.pdf



Construction workers make progress on rehabilitating two bridges in Arizona.

Accelerating Implementation of Technologies to Meet Future Highway Transportation Needs

FHWA works with State DOTs and local public agencies to accelerate the implementation of technologies that can meet future highway needs, including virtual public involvement and data-driven strategies for managing traffic incidents. Such innovations have the potential to transform transportation planning and operations. To further the deployment of innovative technologies, FHWA works with transportation agencies to understand their implementation needs and develop tests and tools to monitor highway operations. Accelerated deployment of proven, market-ready technologies and practices will improve safety, reduce environmental impacts, and increase access to economic opportunities.

Technology Deployment Programs

FHWA embraces a culture of innovation and actively supports and advances innovation across the entire breadth of the agency's activities. FHWA has woven innovation into its business practices, from developing new technologies at its world-class TFHRC to the Office of Technical Services and Division Offices, which provide technical assistance to the States and local partners to deploy the innovations.

FHWA has numerous technology adoption programs that support the innovation pipeline, delivering cutting-edge as well as proven technologies. By institutionalizing technology

TECHNOLOGY DEPLOYMENT PROGRAMS

Every Day Counts

5 Rounds of technology transfer completed.

Projects in all 50 States plus Puerto Rico.

- e-Ticketing
- Digital as-builts
- Virtual public involvement
- Strategic Workforce Development

State Transportation Innovation Council

$100 THOUSAND

In provided funds per State per fiscal year

Accelerated Innovation Deployment Demonstration Program (AID Demo)

$86.9 MILLION

Awarded in grant funding by AID Demo

Advanced Transportation and Congestion Management Technologies Deployment

- Reduce costs
- Increase return on investment
- Enhance transportation system operations
- Increase data collection and dissemination
- Accelerate deployment of CAV technologies

Source: FHWA.

adoption programs, FHWA can adapt its support to the most impactful innovations at a given time and thus meet current and future highway transportation needs. The following sections highlight the success of four programs and demonstrate FHWA's commitment to collaborating with State and local entities.

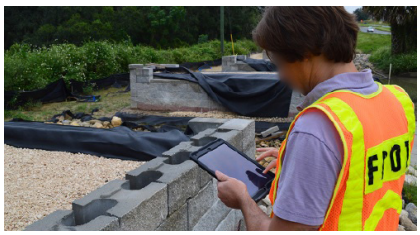
Every Day Counts

Every Day Counts (EDC) is a State-based technology transfer program that identifies and deploys proven technologies that accelerate project delivery, improve safety, and reduce congestion. Every 2 years, FHWA collaborates with State DOTs, local governments, Tribes, and other stakeholders to select innovations to champion. FHWA then works with these stakeholders to identify opportunities to implement these innovations according to States' needs and establish performance goals. These innovations save agencies time, money, and resources, allowing them to deliver more projects and accelerate technology adoption.

Every Day Counts
Innovation for a Nation on the Move

EDC has completed five rounds of technology transfer and has advanced projects in all 50 States plus Puerto Rico. The sixth round of EDC (EDC-6), launched in 2021 and running through 2022, focuses on numerous innovative technologies and strategies, including e-Ticketing and digital as-builts (DABs), virtual public involvement, and Strategic Workforce Development.[16] Details on some of these technologies follow:

e-Ticketing and DABs provide construction crews and relevant stakeholders with a way to electronically produce and share materials, designs, and other project data, streamlining project delivery. The technologies offer other significant benefits as well. e-Ticketing and DABs improve safety by reducing work crew exposure during vehicular traffic, create time savings through reduced processing time and enhanced planning, and make project documentation and data collection more consistent and efficient.[16] These benefits can help agencies realize cost savings and shorten project timelines.



EDC innovations like e-Ticketing help construction workers streamline project delivery and reduce work crew exposure to vehicular traffic.

Source: FHWA.

Virtual public involvement is an innovative form of public engagement that local and State agencies can use to improve transportation projects and build feedback loops between the public and policymakers, helping establish a common vision for transportation. Modern technology and communication allow agencies to use websites, social media

tools, and mobile applications to post information about their activities, reaching a wider audience at a lower cost than traditional public engagement methods. The public can then access online videos, podcasts, crowdsourced maps, and other interactive forums to receive information and provide input, sparking collaboration and ensuring the public's opinions and needs are considered during project planning and development. This engagement also helps identify issues early in the project planning process, accelerating project delivery, and reducing the need to revisit decisions. Virtual public involvement was part of both EDC-5 and EDC-6, where FHWA encouraged new forms of public engagement, such as telephone town halls, online meetings, pop-up outreach, social meetings/meeting-in-a box kits, story maps, quick videos, crowdsourcing, survey tools, real-time polling tools, social media following, visualization, and working with bloggers.[17]

State Transportation Innovation Council

Through State Transportation Innovation Councils (STICs), FHWA puts transportation communities—including State, Federal, and local agencies; industry; academia; and other transportation professionals—in the driver's seat to select innovations that best fit their unique program needs and then quickly deploy those innovations. The involvement of these communities can help States better identify and target innovations, especially when recovering from unprecedented events. The STIC program also provides funds up to $100,000 per State per fiscal year for deliverables, such as developing draft technical standards and guidelines. STICs benefit transportation programs within the State and establish a culture of innovation that promotes progressive practices and advanced technology deployment.

The Ohio DOT (ODOT) used STIC incentive funds to improve the environmental documentation process in Ohio, a key component of project development. ODOT developed guidance to enhance the quality of feasibility studies and alternative evaluation reports as well as streamline the process for producing these documents. The Maryland STIC launched an innovation subcommittee, facilitating technology transfer in the public and private sectors. Establishing this culture of innovation has catalyzed efforts at Maryland DOT (MDOT), including Project Green Light, in which employees pitched ideas in a friendly environment, and the Operations Innovation Showcase, where MDOT highlights innovations developed by State staff.

Accelerated Innovation Deployment Demonstration Program

The Accelerated Innovation Deployment Demonstration (AID Demo) program provides funding to State and local entities to offset risks associated with the initial deployment of innovation, leading to FHWA-State partnerships and accelerated project delivery. Additionally, funding recipients report on experiences and lessons learned from each innovation deployment, which are shared via the program website to assist technology transfer in other States and localities. AID Demo has already awarded $86.9 million in grant funding for projects that improve safety, mobility, project delivery, and other key areas.

FHWA's AID program helps States implement innovative road technologies, like HFST. HFST allows drivers to maintain control in harsh weather conditions.

Source: FHWA.

For example, the AID Demo program helped the Oklahoma DOT install high-friction surface treatment (HFST) on curves at multiple locations in the Oklahoma City metropolitan area. HFST, highlighted in EDC-2, is an innovative approach to restoring and maintaining pavement friction in high-crash areas, allowing drivers to maintain vehicle control in wet and dry conditions.[18] Oklahoma DOT's project was particularly innovative because it was installed using fully automated methods at sites with significantly higher traffic volume than previous HFST deployments. These fully automated deployments reduced disruptions experienced by the traveling public during installation. After an initial evaluation determined the deployments were successful, Oklahoma DOT created a program that systematically applies HFST to high-crash curves throughout the State.[19] Thus, the AID Demo program not only helped Oklahoma DOT improve safety at multiple high-crash locations, but it catalyzed a program for future technology transfer, improving safety across the State.

Advanced Transportation and Congestion Management Technologies Deployment

The Advanced Transportation and Congestion Management Technologies Deployment (ATCMTD) program provides grants to State and local DOTs to deploy advanced technologies rapidly. The program aims to reduce costs, increase return on investment, enhance transportation system operations, improve safety, increase data collection and dissemination, and accelerate the deployment of CAV technologies.

ATCMTD supports various projects and transportation modes across the Nation. Grantees have commenced projects relating to the safety and movement of vehicles, freight, pedestrians, and bicyclists.[20] The ATCMTD program demonstrates FHWA's support for accelerating technology adoption and innovative practices affecting all modes of transportation using the Nation's roadways. Furthermore, FHWA provides support to grantees beyond funding. The agency organizes early deployer cohort meetings to facilitate peer discussion and offer technical support, assists grantees with performance measurement, and creates annual reports detailing program highlights.

Innovation Engagement

FHWA engages State and local stakeholders to accelerate the implementation of innovative technologies. Engagement activities help FHWA understand the complex challenges State and local entities may face when deploying innovative technologies. Through FHWA's support, entities complete projects more quickly and efficiently, improving the safety and performance of transportation systems across the Nation.

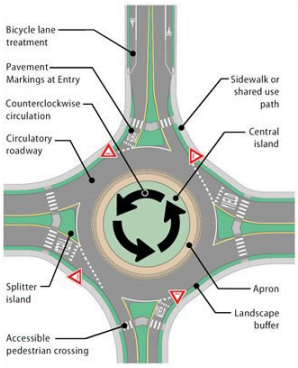
Small Business Innovation Research and Cooperative Research and Development Agreements

Supporting small businesses is one of the keys to the Nation's economic recovery. FHWA's Small Business Innovation Research (SBIR) Program encourages domestic small businesses to engage in research and development addressing high-priority research areas within U.S. DOT. SBIR focuses on technologies with high potential for commercialization that can be sold to States, localities, and other entities.

The SBIR program has invested $50 million in small businesses over the past 5 years, creating many success stories along the way.[21] One company developed a system alerting drivers to their surroundings when switching between an automated driving system and a human driver, which is a challenge to safely deploying AVs on highways.[22] Another project detects damage in structural components with new infrared technologies, allowing for cost savings, safety improvements, and more accurate infrastructure assessments.[22]

RECYCLED PLASTIC MINI-ROUNDABOUTS AS A TRAFFIC CONTROL SOLUTION

Many States and localities have realized the benefits of roundabouts, but roundabout installation typically requires the closure of an intersection and involves cutting the pavement and filling it with reinforced concrete. To address these installation issues while achieving similar benefits, the SBIR program partnered with an engineering company to develop and design low-cost, easily installed mini-roundabouts. Made with recycled plastic, mini-roundabouts consist of precut boards that can be delivered onsite and installed fairly quickly without completely closing an intersection, reducing the impact on the traveling public.



FHWA's SBIR Program has helped States and localities implement roundabouts using recycled materials and with minimal impacts on traffic.

Source: FHWA.

CRADA AS A TECHNOLOGY TRANSFER TOOL

In addition to working with the private sector through SBIR grants, FHWA's TFHRC engages in Cooperative Research and Development Agreements (CRADAs) with the private sector and academia to develop and commercialize new highway-related technologies. FHWA or industry can initiate CRADAs, allowing both sides to optimize their resources, exchange technical expertise in a protected environment, share intellectual property, and accelerate the commercialization of innovative technologies.

Data-Driven Strategies for Managing Disruptions from Non-Recurring Events

In November 2019, FHWA helped organize the Third Senior Executive Transportation and Public Safety Summit, which focused on the state of traffic incident management (TIM) practice, including recent innovative developments. The summit brought together 120 national leaders of transportation, law enforcement, emergency services, and other TIM-related disciplines to discuss supporting innovations and accelerating the adoption and expanding the use of best practices.[23]

FHWA organizes summits and issues guidance to assist with TIM practices across the country. Every minute a lane remains blocked can result in 4 to 10 minutes of traffic delay, making FHWA's leadership in TIM critical in minimizing congestion.

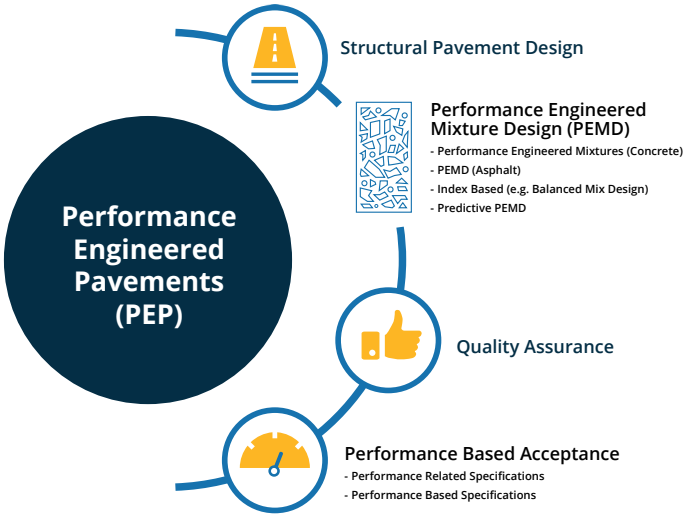
© 2014 WSDOT.

In addition to bringing key TIM stakeholders together, FHWA developed a document entitled *Process for Establishing, Implementing, and Institutionalizing a Traffic Incident Management Performance Measurement Program*, which details an easy-to-apply process for local, regional, or State entities to establish a TIM program.[24] Furthermore, TIM is a part of EDC-6, aiming to support local TIM programs and integrate cutting-edge technology, tools, and training to improve incident management.[25]

Accelerated Implementation and Deployment of Pavement Technologies

FHWA's Accelerated Implementation and Deployment of Pavement Technologies (AID-PT) program seeks to accelerate the adoption of innovative pavement technologies, focusing on advancing performance-related tests and specifications. The AID-PT program serves as the implementation and deployment mechanism for innovations coming out of FHWA's pavement and materials research. A variety of activities are pursued under the program, ranging from webinars and YouTube videos to practical guide documents on pavement technologies.

One specific research area supported through the AID-PT program is performance-engineered pavements (PEP). This initiative incorporates long-term performance into the structural pavement design, mixture design, construction, and materials acceptance of the U.S. asphalt and concrete infrastructure. The primary goal of the PEP initiative is to increase the long-term durability and performance of pavement. This initiative also encourages agencies to identify the prevalent failure mechanisms within their network and assess the available performance tests to address the causes of premature deterioration.



The PEP initiative increases pavement's long-term durability and performance through innovative design, quality assurance, and performance-based acceptance.

Source: FHWA.

FHWA has also facilitated partnerships and outreach to State agencies through the Mobile Asphalt Technology Center (MATC) and the Mobile Concrete Technology Center (MCTC). These mobile technology centers have provided onsite, hands-on assistance to almost every State in the Nation. Test procedures that support PEP are one of many technology deployments that the centers have promoted. Other focuses include demonstrating available but underutilized concrete technologies and deploying technologies capable of measuring pavement materials' uniformity in realtime.

FHWA deploys MCTCs like this one to provide hands-on assistance to States across the Nation, including performing demonstrations of available technologies.

Source: FHWA.

Preparing for Future Transportation Options

FHWA works with State and local agencies to support the development of tools and products for the testing, evaluation, and deployment of future transportation options on the Nation's roadways. State and local agencies use analysis, modeling, and simulation (AMS) tools to evaluate operational improvements to their transportation systems. FHWA has already developed an AMS framework that identified the needs and gaps in current capabilities to support the evaluation of CAVs on roadways. This framework allows FHWA to support State and local agencies in developing interoperable data exchanges between vehicles, other road users, and infrastructure-based components.[26] FHWA is also updating its *Manual on Uniform Traffic Control Devices* (MUTCD) to integrate CAVs safely into the current transportation network.[27,28]

FHWA is preparing for other innovative future transportation options, including multimodal shared mobility options such as ridesourcing, bikesharing, and scootersharing. Such options can better connect people to economic and educational opportunities. An example of FHWA's leadership in integrating shared mobility was the development of a primer called *Shared Mobility: Current Practices and Guiding Principles*.[29] The primer provides an overview of different shared mobility options being deployed across the Nation and sets the foundation for future work in the area.[29] Local, regional, and State entities that seek to deploy shared mobility or already have forms of shared mobility in their jurisdictions will find this overview useful.

FHWA provides resources to support multimodal deployments, including bikeshare and scootershare. Above, bicyclists in the Nation's capital travel safely alongside vehicles.

© 2010 Kevin Kovaleski.

For More Information

The following websites provide additional information and further highlight the FHWA activities discussed in this section.

EDC:

https://www.fhwa.dot.gov/innovation/everydaycounts/

Virtual public involvement:

https://www.fhwa.dot.gov/innovation/everydaycounts/edc_5/virtual_public_involvement.cfm

STICs:

https://www.fhwa.dot.gov/innovation/stic/

AID Demo:

https://www.fhwa.dot.gov/innovation/grants/

ATCMTD:

https://www.fhwa.dot.gov/fastact/factsheets/advtranscongmgmtfs.cfm

SBIR Program:

https://highways.dot.gov/research/opportunities-partnerships/opportunities/small-business-innovation-research

CRADA:

https://highways.dot.gov/research/opportunities-partnerships/opportunities/cooperative-research-development-agreement-crada

Data-Driven Strategies for Managing Disruptions from Non-Recurring Events:

https://rosap.ntl.bts.gov/view/dot/27120

Preparing for Future Transportation Options:

https://www.transportation.gov/av/3/preparing-future-transportation-automated-vehicles-3

MATC:

https://www.fhwa.dot.gov/pavement/asphalt/trailer/

MCTC:

https://www.fhwa.dot.gov/Pavement/concrete/trailer/index.cfm

Shared Mobility: Current Practices and Guiding Principles:

https://ops.fhwa.dot.gov/publications/fhwahop16022/fhwahop16022.pdf

MUTCD:

https://mutcd.fhwa.dot.gov/

TIM Practice:

https://ops.fhwa.dot.gov/eto_tim_pse/about/tim.htm

Performance Engineered Pavements:

https://www.fhwa.dot.gov/pavement/materials/hif20005.pdf

FHWA's leadership on Complete Streets and multimodal systems helps people travel efficiently and safely, such as these pedestrians, bicyclists, transit riders, and drivers traveling in Washington, DC.

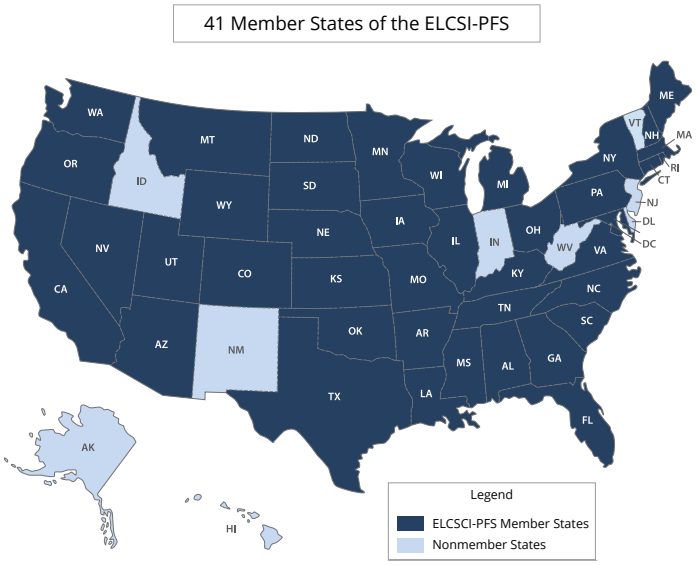
© 2017 MWander.

Providing Clear Benefits to the Public

FHWA strives to ensure that the public benefits of transportation investment are realized as quickly and efficiently as possible. FHWA, working with State and local agencies, has significantly reduced injury crashes, demonstrated the benefits of improved pavement designs, and reduced the time needed for many projects to conduct environmental reviews. In addition, reimagining how our streets operate and whom they serve can spur more equitable economic growth. Throughout the innovation lifecycle, FHWA seeks to capture successes and lessons learned to build evidence that informs future policymaking and strengthens trust in research.

Safety Benefits

Safety is FHWA's top priority, and FHWA works with its State, local, and private sector partners to deliver numerous safety programs and technologies. These programs and technologies impact safety in a variety of ways, and understanding the exact benefits of these strategies is crucial. To this end, FHWA established the "Evaluations of Low Cost Safety Improvements Pooled Fund Study" (ELCSI-PFS), a research program focused on developing reliable estimates of the effectiveness of various safety improvements.[30] This effort is supported by 40 States, and the research methodology relies on before-and-after data to determine the efficacy.

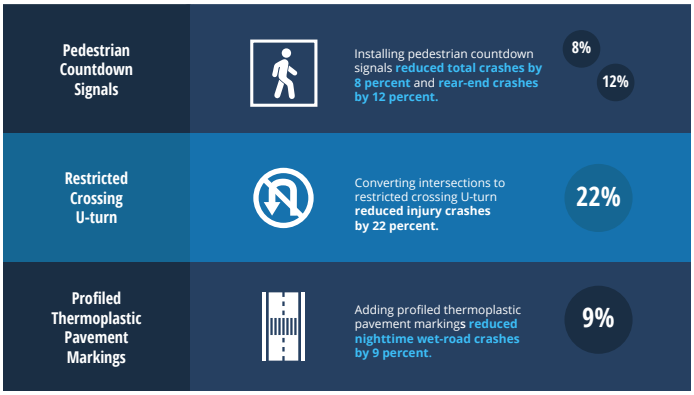


Original map: © lesniewski / AdobeStock.com. Modifications by FHWA to show participation in the Evaluation of Low Cost Safety Improvements Pooled Fund Study.

Each study under the ELCSI-PFS aims to provide a CMF and a benefit/cost analysis for the targeted safety strategy. A selection of findings from completed studies follows:

- Including pedestrian countdown signals reduced total crashes by 8 percent and rear-end crashes by 12 percent.[31]
- Converting a conventional intersection to a restricted crossing U-turn generally reduced injury crashes by 22 percent.[32]
- Adding profiled thermoplastic pavement markings reduced nighttime wet-road crashes by 9 percent.[33]

ELCSI-PFS has demonstrated clear benefits for a variety of low-cost safety strategies, and the research effort is ongoing. Such safety strategies facilitate the expanded safe movement of people and goods.



Source: FHWA.

Complete Streets

With its Complete Streets initiative, FHWA aims to make roads safe for all travelers, including pedestrians; bicyclists; car, truck, and bus drivers and passengers; and more. Research has shown that Complete Streets can reduce vehicle-related crashes, as well as pedestrian and bicyclist risk.[34] Complete Streets also promotes equity by protecting disadvantaged people who often travel via transit, on foot, or by bicycle. The initiative encourages active travel modes, which benefit the health of individuals, who are exercising while traveling, and the planet, by reducing vehicle exhaust emissions.

FHWA is initially focusing on improving the safety of arterials and making it easier for States and local agencies to build Complete Streets. FHWA will revise policies, provide technical assistance, and promote peer learning to help advance safety for all road users. In the long term, FHWA will seek to ensure that performance metrics are comprehensive in tracking safety for everyone, not just motor vehicles.

FHWA's *Bikeway Selection Guide* helps practitioners implement bicycle infrastructure, such as protected bike lanes in Seattle. The guide includes tips on how to help advance equity throughout the deployment process.

© 2014 Seattle DOT.

FHWA can draw on multiple existing resources to help inform decisions on roadway design that consider roadway users beyond vehicles. FHWA's *Bikeway Selection Guide* provides two valuable resources for practitioners on this topic: *Traffic Analysis and Intersection Considerations to Inform Bikeway Selection* and *On-Street Motor Vehicle Parking and the Bikeway Selection Process*.[35,36,37]

Traffic Analysis and Intersection Considerations to Inform Bikeway Selection features a section on equity-focused design principles to help agencies "prioritize accessibility, safety, and equity for all users" when designing intersections.[36] The companion guide—*On-Street Motor Vehicle Parking and the Bikeway Selection Process*—encourages agencies to consider race, equity, and social justice in the planning and public policy discussion when considering bikeway type selection in the context of on-street parking. It outlines an eight-step process to help advance transportation equity by incorporating equity into all aspects of the transportation planning, design, and implementation process. The guide includes multiple case studies to demonstrate flexible solutions that accommodate all users.

KEEPING EVERYONE SAFE

FHWA's *On-Street Motor Vehicle Parking and the Bikeway Selection Process* includes a case study in which an agency in Portland, OR, wanted to implement a separated bike lane. However, this type of bikeway would have eliminated the on-street motor vehicle parking that was serving many Black-owned businesses along the street. The agency chose to implement a buffered bike lane to improve safety for bicyclists while maintaining access to the local businesses. This example highlights how street design can have broad equity implications and how FHWA resources seek to help local practitioners make safe and equitable decisions for their roadways.

An additional resource is FHWA's report *Accessible Shared Streets: Notable Practices and Considerations for Accommodating Pedestrians with Vision Disabilities*.[38] Complete Streets should meet the needs of all users, including those with disabilities. FHWA's guide provides an overview of existing legal requirements, best practices on tactile walking surface indicators and detectable edges, ideas for addressing accessibility in planning and design, lessons learned from Complete Streets implementation, and a toolbox of strategies for designing Complete Streets. For this research effort, FHWA used an extensive stakeholder engagement process to ensure that researchers understood the needs of pedestrians with vision disabilities.

Curbside Management

FHWA is also advancing research on curbside management. Improper curbside management can slow the movement of people and goods, limit access, and reduce safety. Curb space must serve more than just cars—pedestrians, public transportation riders, freight and delivery drivers, transportation network service, and micromobility riders all should be considered in curbside management. Local planners must develop ways to manage all types of demand on their streets.

FHWA, in collaboration with the Institute of Transportation Engineers, has published a research report on curbside management to help communities manage their curb-space considerations. The report explores various solutions to optimize curb productivity while still maximizing safety.[39] At its core, curbside management is about improving mobility and safety for all through optimized curb-space use.

Infrastructure Benefits

FHWA research innovations seek to improve all aspects of highway infrastructure, from investing in the early stages of the construction process to improving the long-term performance of the country's highway systems. For example, with highways continuing to face the risk of climate-related disasters, the Nation's highway infrastructure must become more climate resilient over time. Numerous infrastructure research efforts have benefited both State DOTs and the public.

Structural Design of Pavement

For pavement structural design, FHWA activities seek to advance understanding and improvement of pavement lifecycle costs, as well as improve design methods for preservation, maintenance, and rehabilitation. One technology being studied is continuously reinforced concrete pavement (CRCP). CRCP is used by several highway agencies in the United States, typically for heavily trafficked roadways, and has become a pavement of choice for long-life performance. CRCP can potentially provide long-term "zero-maintenance" service life under heavy traffic load and challenging environmental conditions. FHWA's TechBrief in this area *(Continuously Reinforced Concrete Pavement Performance and Best Practices)* offers guidance on optimizing several key design features of CRCP, including longitudinal steel content, simplified details for terminal ends, improved transverse construction joint detail, shoulder type, and concrete slab/base interface.[40]

When built correctly, CRCP experiences little degradation in ride quality over time, meaning maintenance costs are low. The low maintenance costs lead to an overall lower lifecycle

cost compared to alternatives, saving agencies money in the long run. CRCP also has a higher capacity for truck loading and traffic volumes, which can improve the transportation of goods and people across the country.[41]

Long-Term Infrastructure Performance

FHWA's Long-Term Infrastructure Performance (LTIP) Programs seek to advance understanding of how and why highway pavements and bridges perform as they do. The program consists of two related efforts: pavement performance through the Long-Term Pavement Performance (LTPP) Program and bridge performance through the Long-Term Bridge Performance (LTBP) Program. Previously two independent research projects, the LTIP and LTBP were transitioned by FHWA into an integrated program to leverage synergies between them.

These programs, conducted in collaboration with the State DOT infrastructure owners, characterize and monitor in-service highway pavement test sections (LTPP) and bridges (LTBP). Such monitoring allows agencies to assemble the data needed to improve infrastructure design and advance the understanding of highway infrastructure performance necessary to manage transportation assets effectively.

Some of the specific outputs and activities of the LTPP and LTBP programs include:

- LTBP InfoBridge™, FHWA's LTBP Program web portal, is a centralized gateway to performance data and information.[42] It provides an efficient interface with visualization capabilities enabling users to perform bridge analytics.
- "Transportation Pooled Fund Project TPF-5(283): The Influence of Vehicle Live Loads on Bridge Performance" seeks to quantify the influence of vehicular live loads—with particular emphasis on truckloads—on the long-term performance and durability of highway bridges.[43] Balancing the needs of the freight industry, which include being able to easily ship large quantities of goods across the country, with preserving bridge infrastructure for as long as possible is important.
- LTPP InfoPave™ is a web portal that meets a primary objective of the LTPP Program by providing access to data and information on the performance of in-service pavement test sections in North America.[44] This information includes pavement roughness measures, deflection testing, skid information, and more.

FHWA's LTBP Program provides critical data and performance measurements to preserve bridge infrastructure across the country. The Navajo Bridge, which crosses the Colorado River's Marble Canyon in Arizona, is one of only two roadway crossings of the Grand Canyon.

These research efforts focus on improving infrastructure to work better for its users and deliver findings to relevant audiences.

Evidence-Building for Policymaking

FHWA accelerates delivery of highway projects, builds evidence to facilitate continuous learning and better decisionmaking, and conducts rigorous evaluations to improve future research and policy.

FHWA NEPA Assignment

In the fourth round of EDC (EDC-4), FHWA worked with State and other transportation agencies to understand the delays that occur during the National Environmental Policy Act (NEPA) process and develop tools to streamline environmental permitting.[45] State, local, and other agencies indicated various challenges in environmental permitting, including a lack of coordination with resource agencies involved in permitting and duplicative efforts that reduce efficiency. FHWA established the integrating NEPA and permitting approach to help agencies communicate better and conduct environmental permitting processes concurrently.

As part of this approach, FHWA originally developed an online collaboration tool called eNEPA. This tool has since been rebranded and improved. In early 2021, FHWA's Office of Planning, Environment, and Realty released its Interagency NEPA and Permitting Collaboration Tool (INPCT), the improved version of eNEPA.[46,47] INPCT is designed to help NEPA practitioners efficiently manage the environmental review and permitting processes for all types of transportation projects.

The tool makes it easier for project managers, environmental planners, and resource/regulatory agency staff to exchange documents. They can also share comments in realtime, strengthening the interagency collaboration process. INPCT centralizes many elements of a NEPA review, which improves the management of the process as a whole. Users can track project and permitting schedules and critical milestones, send meeting invitations, manage documents, and even track mitigation commitments.

Data and Analysis

Through its research programs, FHWA produces several datasets and reports that various transportation practitioners rely on to make decisions. Without precise data about highway conditions, travel behaviors, traffic bottlenecks, and more, it would be difficult to make appropriately targeted decisions to achieve the greatest benefit for the public.

One such data product is the Freight Analysis Framework (FAF).[48] The FAF, produced through a partnership between the Bureau of Transportation Statistics and FHWA, integrates data from various sources to create a comprehensive understanding of freight movement among States and metropolitan areas by all modes of transportation. FAF incorporates data from agriculture, extraction, utilities, construction, services, and other sectors. Transportation practitioners can immediately download summary statistics from FAF, which provide information such as the weight/value of shipments within, from, or to a State and the top five trade partners by weight or value for trade leaving a State.

FHWA's FAF integrates various data sources to facilitate freight movement across the United States.

© 2012 Todd Lappin.

Furthermore, survey data on the public's travel behaviors can supplement these types of travel statistics. Conducted by FHWA, the National Household Travel Survey (NHTS) is the authoritative source on the travel behavior of the American public.[49] The NHTS includes daily noncommercial travel by all modes, including the characteristics of the people traveling. It is the only source of national data that allows researchers to analyze patterns in personal and household travel.

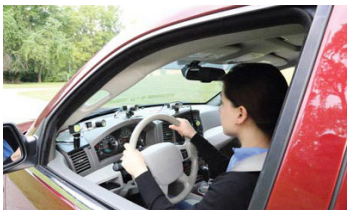
The NHTS collects data directly from a stratified random sample of U.S. households. NHTS survey questions cover a broad array of topics, including household mobility, energy consumption, travel of specific demographic groups, safety, and planning applications. For many States and metropolitan planning organizations (MPOs), the NHTS is a critical data source. States and MPOs use NHTS data to develop, calibrate, or validate State and MPO travel-demand models. These models inform long-range transportation planning, and they support corridor-level, interchange, and transit infrastructure and planning projects. Beyond the transportation needs of States and MPOs, stakeholders in fields as diverse as public health, energy, environment, and survey methods and analysis use NHTS data.[50]

FHWA combines insights from the FAF, NHTS, and other sources to develop its biennial Conditions and Performance (C&P) report. The C&P report provides decisionmakers with an objective appraisal of the physical conditions, operational performances, and financing mechanisms of highways, bridges, and transit systems based on the current state of these systems and their projected future state under a set of alternative investment scenarios. The C&P report offers a comprehensive, data-driven background to support the development and analysis of legislative, budget, and program options for all levels of government.[51]

Another valuable data source produced by FHWA is the Naturalistic Driving Study (NDS) data.[52] The NDS data comes from the Second Strategic Highway Research Project and generates insights into driving behavior. The NDS provides information on what preceded both crashes and near-crash events, and it also identifies driver behavior in real-world driving conditions.

FHWA projects that will utilize NDS data include:

- "Investigating How Multimodal Environments Affect Multitasking Driving Behaviors": This study will use NDS data to examine multitasking behaviors, meaning any activities not related to driving. The study will focus mainly on driver behavior in environments with large numbers of pedestrians and cyclists.
- "Incorporating the Impacts of Driver Distraction into Highway Design and Traffic Engineering": This research aims to use the NDS data to analyze the impacts of driver distraction on perception-reaction time and deceleration rate. The results of the research will influence recommendations for relevant design parameters.



FHWA's NDS analyzes the causes and impacts of driver distraction to reduce crashes and improve safety on roadways throughout the Nation.

Source: FHWA.

- "Freeway Guide Sign Performance at Complex Interchanges—Reducing Information Overload": This study will identify performance-based guidelines for guide-sign design at complex freeway interchanges to reduce the difficulty of navigating complex interchanges.

NDS data provide valuable benefits to the public by giving researchers a better understanding of driver behavior. FHWA's research in this area will lead to new guidance and strategies to minimize crashes and near-crash events, improving safety on roadways throughout the country.

Climate change data are also useful for infrastructure planning. The Coupled Model Intercomparison Project (CMIP) Climate Data Processing Tool's purpose is to provide climate projections at a local level that will be relevant and useful for transportation planners.[53] Planners use these climate projections to understand what changes may be needed to ensure that transportation infrastructure and services will be resilient to future impacts of climate change. For example, the tool can provide the projected severity and frequency of extreme heat days for a given geographic location in 2050 and 2100. Having this type of information empowers transportation planners to make decisions that will ensure the longevity of transportation infrastructure. Without this type of data, it would be challenging for planners to predict what types of improvements would be necessary to maintain their transportation systems.

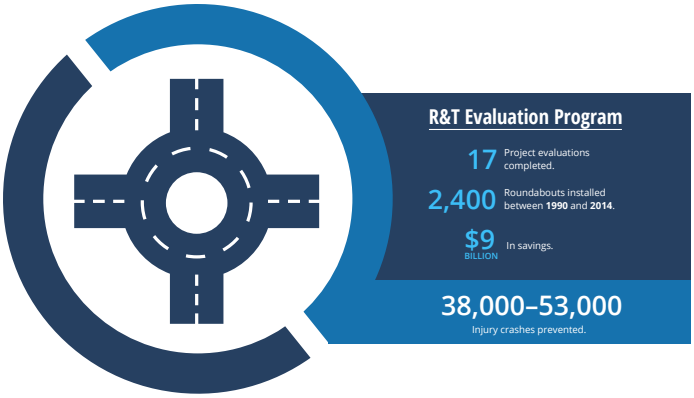
The Pathway to Advancing Novel Data Analytics (PANDA) is a new laboratory at TFHRC seeking to develop, test, and apply novel analytics. This effort will benefit the

public through improved data analysis. State and local decisionmakers frequently use data and analytics created by FHWA, and PANDA can potentially expand further the assistance FHWA can provide to local practitioners.

R&T Evaluation Program

FHWA initiated the R&T Evaluation Program in 2014 to assess and communicate the benefits of FHWA's R&T efforts and ensure that the organization is expending public resources efficiently and effectively. With the passing of the Foundations for Evidence-Based Policymaking Act of 2018, it is now essential that government agencies conduct evaluations to generate evidence for policymaking.[54] The R&T Evaluation Program was developed with support from the Transportation Research Board R&T Coordinating Committee.[55]

Since 2014, the R&T Evaluation Program has completed 17 project evaluations, working with research program areas across FHWA. These evaluations have yielded numerous findings and recommendations of importance to FHWA, States, and other transportation stakeholders. For example, the R&T evaluation of FHWA's roundabouts research found that FHWA's investment in roundabouts research greatly increased awareness of the technology among States and agencies, influencing attitudes on how to use roundabouts as a safety countermeasure and leading to more adoptions of the technology. The evaluation estimated that the approximately 2,400 roundabouts installed in the United States between 1990 and 2014 helped prevent between 38,000 and 53,000 injury crashes, resulting in total societal cost savings over that period of approximately $9 billion.[56]



Source: FHWA.

FHWA's R&T evaluation of roundabouts informed practitioners of roundabouts' safety benefits, leading to increased adoption. This roundabout in Vermont helps vehicles navigate safely through a complex intersection.

© 2015 VTrans.

STIMULATING ECONOMIC GROWTH

From workforce development to infrastructure improvements to data collection on freight movements, FHWA research touches on economic development goals in numerous ways:

- Reliable freight movement data provided by the FAF give State and local planners insight on what roads may need improvements to ensure freight moves unimpeded across the country.
- Innovative infrastructure research ensures that roads can safely carry truck traffic and help sustain economic growth.
- Curbside management increases the efficient movement of people and goods.
- Workforce development efforts help provide necessary jobs, benefiting both the workers and the travelers who rely on the construction that maintains the roads.

The movement of goods and people is vital to economic development. Well-maintained infrastructure is one of the many elements necessary to ensure that the United States will have sustained economic growth for many years to come.

With the Nation's infrastructure increasingly in need of rapid renewal, States need to have the tools to assess the risks of rapid renewal—risks that may differ from those of conventional works. The R&T evaluation of FHWA's work on managing risk in rapid-renewal projects found that FHWA support allowed States to expose more of their staff to rapid-renewal risk management tools and host their own risk-management training events. For States adopting rapid-renewal risk-management techniques, the evaluation found that those States saved significant amounts of time and money constructing their projects, ultimately resulting in less disruption for the traveling public.[57]

Workforce Partnerships

It would not be possible to deploy many of FHWA's research initiatives without a strong construction workforce. The Highway Construction Workforce Partnership (HCWP) strives to increase the capacity and capability of the workforce by enhancing the number of individuals trained and hired in highway construction.[58] This initiative is also present in EDC-6 as Strategic Workforce Development. As part of the EDC-6 initiative, a toolkit was developed to provide resources and innovative strategies for organizations looking to fill construction jobs.

HCWP seeks to identify, train, and place workers into highway construction jobs. This program helps both the recruited workers as well as the Nation at large. Workers receive valuable construction jobs, and travelers across the country benefit from the construction efforts that are only possible with a large construction workforce. This program is vital to ensuring that the highway construction workforce will remain robust long into the future.

The Strategic Workforce Development initiative helps develop qualified and well-trained highway workers to meet labor needs for future highway construction projects.[59] FHWA conducted a 2-year pilot across 12 locations, partnering with other government agencies and organizations to explore how industry representatives could collaborate with the public workforce system to improve their recruiting, training, and retaining of highway construction workers. The pilot led to a playbook titled *Identify, Train, Place*, which transforms lessons learned from the pilot into simple, repeatable "plays" that States and localities can use.[60] Additionally, FHWA launched a thorough outreach campaign called Roads to Your Future, which includes free customizable messaging and marketing

FHWA's HCWP and Strategic Workforce Development initiative helps train and develop highway workers to increase workforce capacity and capabilities. This effort is critical to meeting labor needs for current and future highway projects.

© 2010 East Fork Bitterroot Road Recovery Act Project.

materials to recruit the next generation of highway construction workers.[58] Overall, the Strategic Workforce Development initiative helps employers hire qualified labor to implement new highway infrastructure while also improving American workers' access to good jobs.[59]

As part of a plan to engage historically Black colleges and universities (HBCUs) in research, FHWA conducted outreach to inform HBCU faculty and students about the NRC (formerly the National Research Council) Research Associateship Program (RAP) at FHWA and promote access to research at TFHRC. FHWA aims to establish and strengthen relationships with HBCUs, leading to increased HBCU involvement with NRC RAP and enhanced HBCU awareness of other FHWA research programs. These efforts promote diversity and inclusion within NRC RAP and highlight HBCU-specific programs and expertise in transportation fields. FHWA has conducted informational interviews with faculty and staff at eight HBCUs—Hampton University, Howard University, Jackson State University, Morgan State University, North Carolina A&T State University, Prairie View A&M University, Tennessee State University, and Florida A&M University. FHWA has organized findings and created a list of action items to continue HBCU engagement.

For More Information

The following websites provide additional information and further highlight the FHWA activities discussed in this section.

ELCSI–PFS:

https://highways.dot.gov/research/safety/evaluations-low-cost-safety-improvements-pooled-fund-study/evaluations-low-cost-safety-improvements-pooled-fund-study-elcsi%E2%80%93pfs

Complete Streets:

https://www.transportation.gov/mission/health/complete-streets

Pavements:

https://www.fhwa.dot.gov/pavement/

LTBP:

https://highways.dot.gov/research/long-term-infrastructure-performance/ltbp/long-term-bridge-performance

LTPP:

https://highways.dot.gov/research/long-term-infrastructure-performance/ltpp/long-term-pavement-performance

FHWA InfoMaterials™:

https://infopave.fhwa.dot.gov/InfoMaterials

FHWA InfoBridge™:

https://infobridge.fhwa.dot.gov/

Transportation Pooled Fund Project TPF-5(283):

https://highways.dot.gov/sites/fhwa.dot.gov/files/docs/research/publications/multimedia/2516/trb2014pooledfundupdate.pdf

FHWA NEPA Assignment:

https://www.environment.fhwa.dot.gov/nepa/assignment.aspx

FAF:

https://ops.fhwa.dot.gov/freight/freight_analysis/faf/

National Household Travel Survey:

https://nhts.ornl.gov/

C&P Report:

https://www.fhwa.dot.gov/policy/23cpr/

R&T Evaluation Program:

https://highways.dot.gov/research/research-development/rt-performance-evaluation/rt-evaluation

Conclusion

FHWA R&T innovations strive to ensure the traveling public's safety, stimulate economic growth, promote equity, reduce climate impacts, and foster transformational technologies. From testing new countermeasures to protecting pedestrians to accelerating bridge construction on high-volume roads to developing policy recommendations from the NHTS, FHWA is engaged in numerous innovative activities that have a tangible impact on the safe, equitable movement of people and goods. Despite the challenges the country faces, FHWA's spirit of innovation and collaboration with partners will ensure that the transportation system advances the Nation's economic recovery and a better future for all.

FHWA's leadership and formation of strategic partnerships help advance mobility and economic opportunity across the country. Above, workers construct Jeff Todd Way, a new connector road built through a collaborative effort between FHWA; the U.S. Army; the Virginia DOT; and Fairfax County, VA.

© 2014 Jeff Todd Project Construction.

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Recommended citation: Federal Highway Administration, *The FHWA R&T Story: Innovating the Future of Transportation* (Washington, DC: 2022) https://doi.org/10.21949/1521726.

Publication No. FHWA-HRT-22-035
HRT-01/01-22(200)E

U.S. Department of Transportation
Federal Highway Administration

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