# PUBLIC ROADS

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Summer 2024


## Visionary and Inventor Garrett A. Morgan

**Also in this issue:**

- How Modern Cybersecurity Supports and Enhances Transportation Systems
- Explore the Role and Benefits of Human Factors Research
- Smart Community Resource Center Serves as Key Information Hub

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PUBLIC ROADS

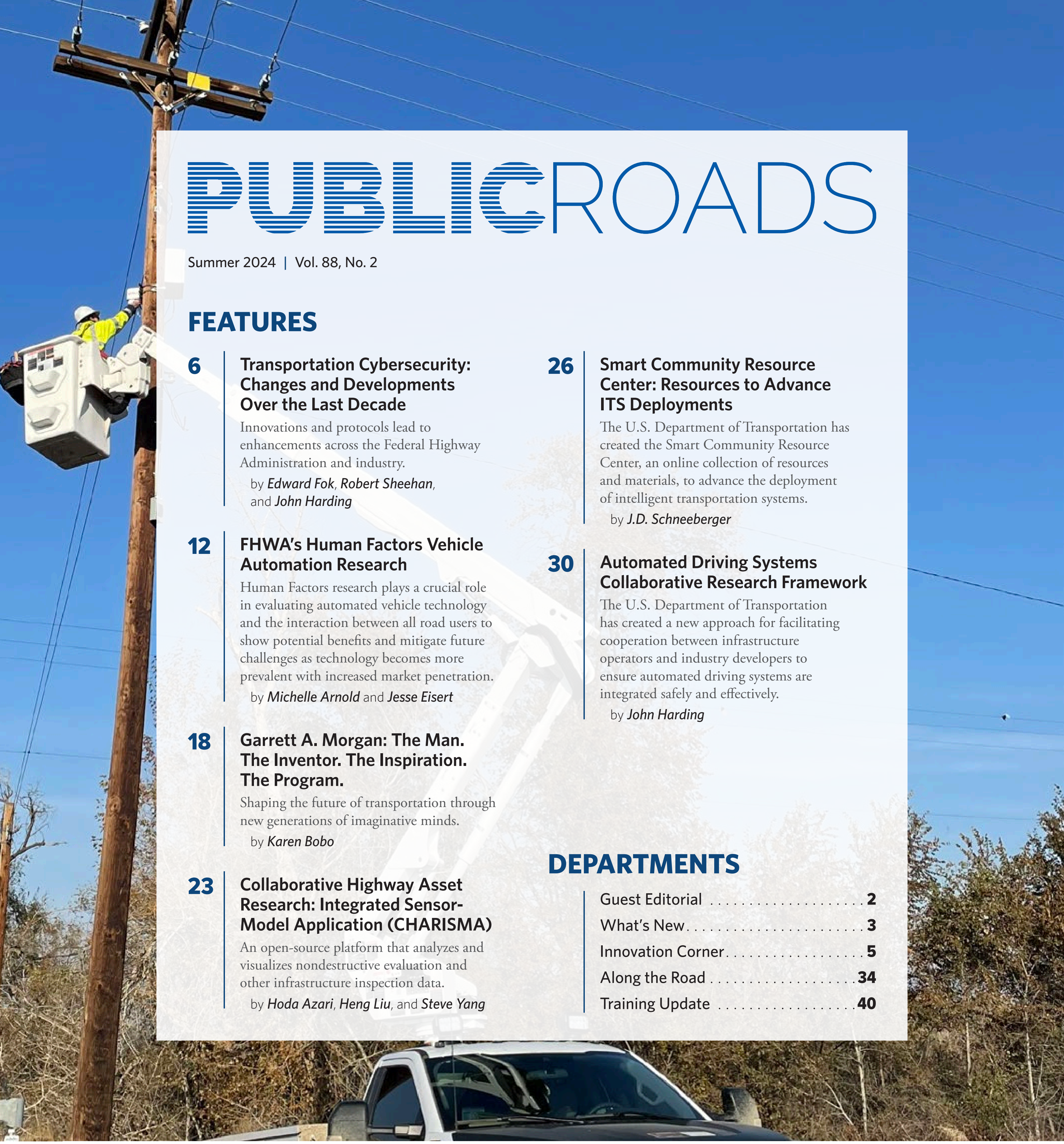
Summer 2024 | Vol. 88, No. 2

## FEATURES



## DEPARTMENTS





**ABOVE:** Installation of the MUST device along a rural road in Washington State.
*© 2023 Yakama Nation.*

Recommended citation: Federal Highway Administration, *Public Roads*, Summer 2024 (Washington, DC: 2023) https://doi.org/10.21949/1521581

**COVERS:** Garrett A. Morgan's influence on the world of transportation, health, and safety cannot be understated. From the patent for his three-position traffic signal to the smoke hood, Morgan's vision is still alive today.
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Schatz Strategy Group
D. Davis; A. Jacobi; A. Lax; J. Love; C. McCoy; M. Mitchell; R. Nemec; T. Tolbert; C. Williams

*Public Roads* (ISSN 0033-3735; USPS 516-690) is published quarterly by the Office of Research, Development, and Technology, Federal Highway Administration (FHWA), 6300 Georgetown Pike, McLean, VA 22101-2296. The business and editorial office of Public Roads is located at the McLean address above. Phone: 202–493–3382. Email: tamara.mccrae@dot.gov. Periodicals postage paid at McLean, VA, and additional mailing offices (if applicable).

POSTMASTER: Send address changes to *Public Roads*, HRTM-20, FHWA, 6300 Georgetown Pike, McLean, VA 22101-2296.

*Public Roads* is sold by the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402. Requests for subscriptions should be sent directly to New Orders, Superintendent of Documents, P.O. Box 979050, St. Louis, MO 63197-9000. Subscriptions are available for 1-year periods. Paid subscribers should send change of address notices to the U.S. Government Printing Office, Claims Office, Washington, DC 20402.

The electronic version of *Public Roads* can be accessed through the Turner-Fairbank Highway Research Center home page (https://highways.dot.gov/research).

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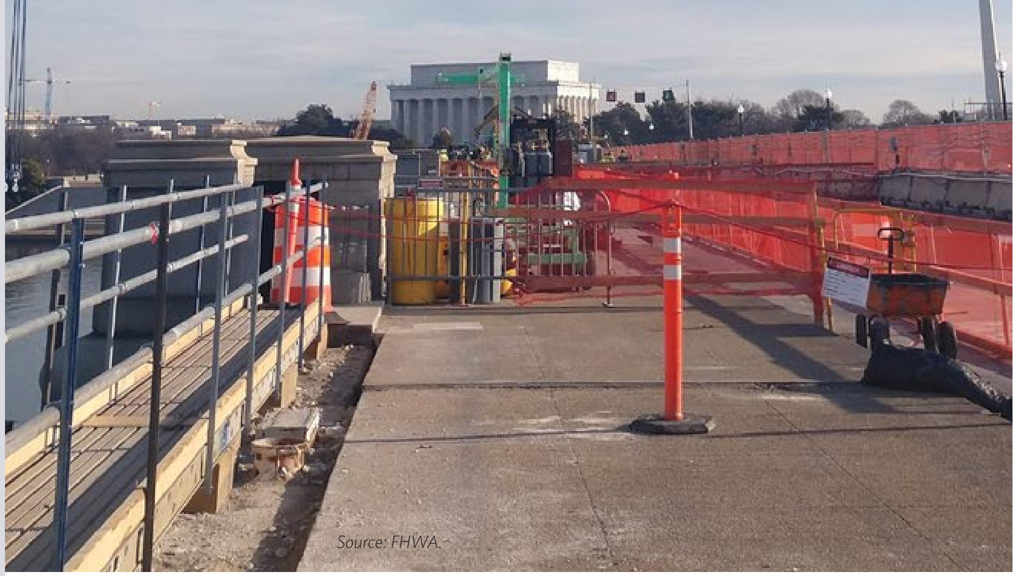


Source: FHWA.


# Standing on the Shoulders of America's Inventor Giants

The 11th edition of the *Manual on Uniform Traffic Control Devices for Streets and Highways* (MUTCD) was published in the Federal Register on December 19, 2023, roughly a month following the 100th anniversary of the patent for a three-phase traffic signal issued to inventor and entrepreneur Garrett A. Morgan. The MUTCD is an evolving document as engineering standards change, and the updates provide not only more flexibility and innovation to improve travel for pedestrians, bicyclists, and drivers, but also forward-looking technologies, such as automated vehicles. This new edition reflects technological advances based on agency experience, experimentation, and community feedback that are in alignment with the U.S. Department of Transportation's National Roadway Safety Strategy.

After witnessing a traffic crash, Morgan identified an opportunity to improve traffic safety by adding a third position to the traffic signal's moving arms to indicate that the traffic movement was about to change, thus better managing road user expectations to begin slowing to a stop. He later sold the rights of his patent to General Electric.

With his patented device, Morgan was part of the community of American inventors, implementers, and entrepreneurs who addressed traffic safety and operations in the fledgling period of automotive transportation—a period that saw early U.S. traffic control devices emerging due to the proliferation of automobiles among horse-drawn buggies, pedestrians, trolleys, and bicyclists on the streets.

While Morgan's invention was not the first traffic signal or semaphore in the United States (then typically operated manually by police officers), nor was it the first to incorporate a third-phase indicator, we can also celebrate the first electric traffic signal light developed in 1912 by police detective Lester Wire in Salt Lake City, UT (namesake of the Utah Department of Transportation's library), as well as policeman William Potts' first three-color traffic signal display in Detroit, MI, in 1920. These three inventors serve as sterling examples of American inventiveness in the profession of transportation.

We can also applaud that Garrett Morgan's creativity and business skills contributed to inventing a smoke protection hood as a breathing apparatus for firefighters to guard against suffocation while performing their dangerous duties. In 1914, Morgan filed for a patent for his smoke hood and formed a company to sell the equipment nationally. I find inspiration from his inventiveness to protect firefighters. It energizes me as the highway operations community today advances traffic incident management techniques and technologies to protect our roadway first responders that include firefighters, emergency medical technicians, law enforcement, transportation, towing, and others from being struck and killed or injured in the line of duty by inattentive drivers.

Morgan and the many of the United States' other inventors and practitioners from over 100 years ago added their ideas, concepts, tools, and techniques to improve the efficiency of their jobs, save lives of responders and travelers, empower communities, and create new businesses and product lines that furthered the economy. Morgan inspires me for his persistent ability to address needs and identify opportunities, develop technologies in diverse fields, and recognize how to transform them into business enterprises and assets.

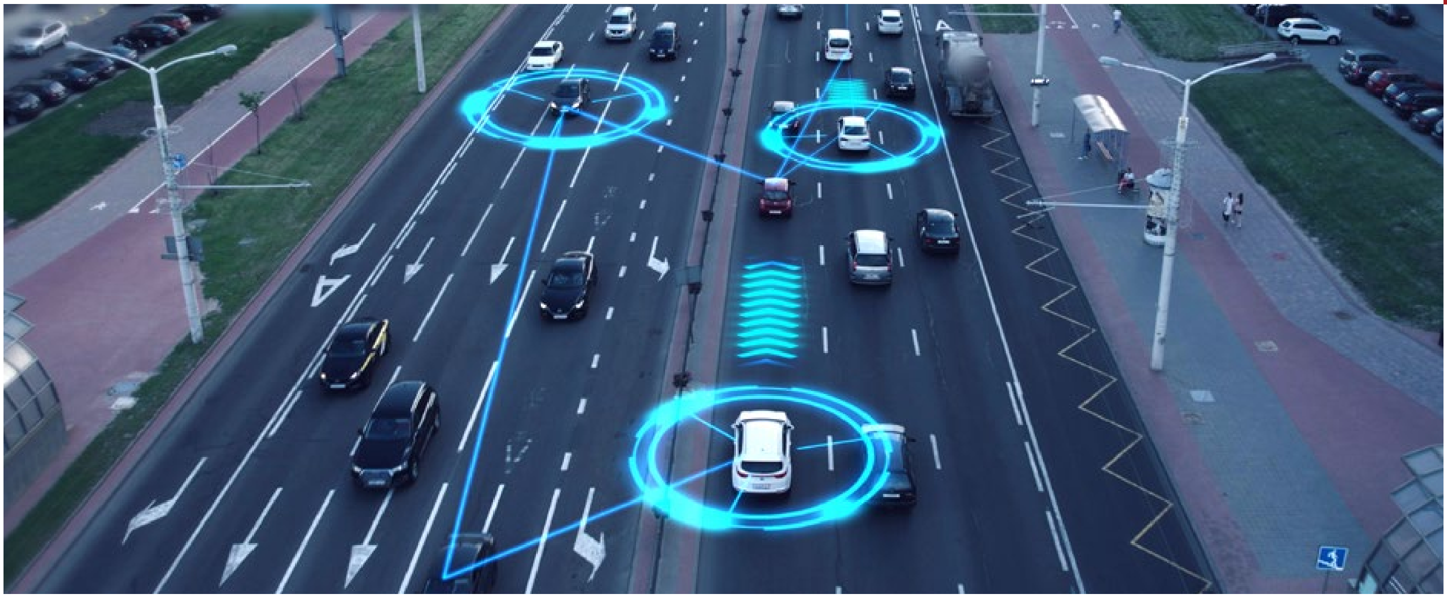
The Federal Highway Administration has a program bestowed in his honor, the Garrett A. Morgan Transportation Technology Education Program, to improve the preparation of students—particularly women and minorities—in science, technology, engineering, and mathematics. Enjoy all the interesting articles in this issue of *Public Roads*, especially Karen Bobo's article, "Garrett A. Morgan: The Man. The Inventor. The Inspiration. The Program."

We must honor and reflect on those who came before us, using their stories, their examples, their perseverance, and their commitment to making positive contributions to their communities. Garrett Morgan, Lester Wire, William Potts, and others inspire me to remain steadfast for the many needs, challenges, and opportunities we address in transportation. If they were with us today, I can imagine them creatively working on digital connectivity of the infrastructure with road users, speed safety camera deployment, safely incorporating scooters into the travel mix, Complete Streets, and vehicle automation. We stand today on a strong foundation of inventiveness for transportation safety and reliability—on the shoulders of giants!

**Martin C. Knopp**
Associate Administrator
Office of Operations
Federal Highway Administration

**TOP:** From the traffic signal to the smoke hood—now called a respirator—ingenuity and innovation play a major role in safety today. *FHWA collage. Image sources: U.S. Patent and Trademark Office, www.uspto.gov; Rawf8 / AdobeStock.com; Cleveland Press Collection, Michael Schwartz Library Cleveland State University; mario beauregard / AdobeStock.com.*

**INSET:** *Source: FHWA.*



# Postevent Connected-Vehicle Data Exploration—Lessons Learned

by **SHUQING WANG**, **TIANJIA TANG**, **BRIAN BROTSOS**, and **DAVID WINTER**

"As more connected and autonomous vehicles are getting adopted and operated on public roads, the amount of data generated by such vehicles is becoming more abundant. How to take advantage of such data to make public travel safer and more efficient is critically needed," says Brian Cronin, acting director, Intelligent Transportation Systems (ITS) Joint Program Office (JPO), U.S. Department of Transportation.

The Federal Highway Administration's Office of Highway Policy Information (HPPI) explored the original equipment manufacturer (OEM) and the USDOT ITS JPO connected-vehicle (CV) pilot project data. CV data are created for in-situ and real-time vehicle travel usage. However, postevent analyses of CV data offer significant and valuable information to facilitate the development of safer and more efficient roads. This short briefing introduces the CV data, their highly valuable information, the analytical platform and tools needed to analyze them, and data quality issues for both decision-makers and data analysts.

## Data Variables

Variables contained in any dataset offer a good indication of its value. The CV dataset HPPI explored came from two different sources: OEMs and the ITS JPO CV pilot. The OEM CV data are divided into two categories: vehicle movements and driving events. Vehicle movements have 14 specific variables, including ignition switch status, vehicle geolocations, speed and heading. The driving event dataset has over 40 variables that record different events and maneuvers, including vehicle movements (such as acceleration/deceleration and windshield wiper status), fuel level, odometer reading, and seatbelt statuses of both driver and front passenger.

Variables from the ITS JPO pilot CV datasets varied depending on the sites (Florida, Wyoming, and New York City) in which the pilots were conducted. Regardless of the sites, the ITS JPO pilot CV data had the vehicle movement variables, including speed, acceleration, and deceleration information HPPI intended to explore. However, the ITS JPO CV data did not contain information on seatbelt or wiper usage.

Overall, the explored CV data offer abundant variables enabling unique and otherwise nonexistent and relevant information extraction. The CV data show high potential value.

## CV Data Size

The CV data are voluminous. For example, the OEM CV data for Florida, in one day, and with about 10-percent vehicle penetration rates, is approximately 60 gigabytes (GB). For the ITS JPO CV pilot data, the three sites generated over 33 GB per day. As a reference, the FHWA National Bridge Inventory annual data is approximately 1.5 GB, and the FHWA Highway Performance Monitoring System annual data is about 4 GB.

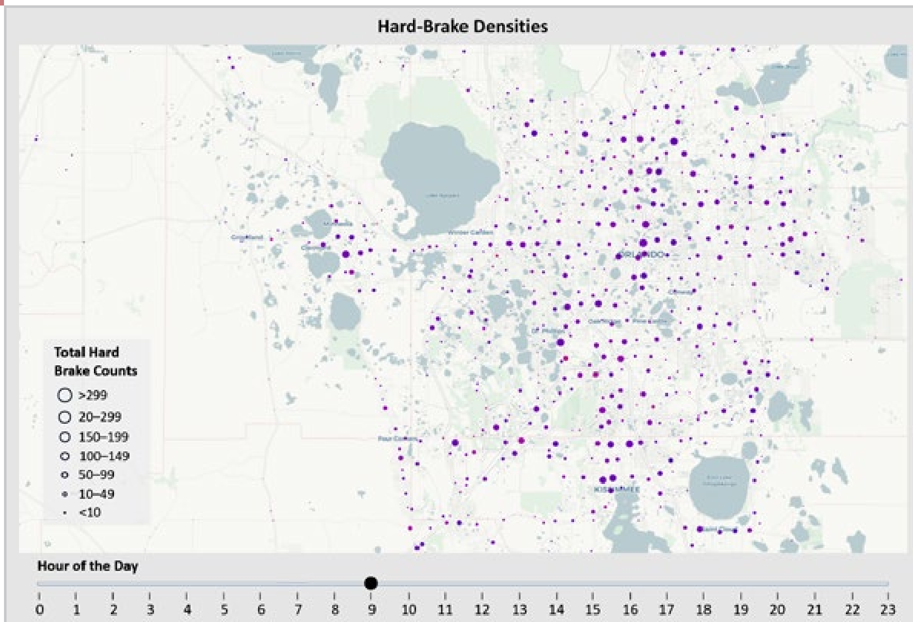
Attention should be directed to the data size issue from the start of any CV data project. Decisions related to whether an entity should acquire, own, or have access to such data should take this issue into full consideration.

## Information Explored

HPPI hypothesized for this study that roadway geolocations experiencing a high frequency of extreme vehicle maneuvers may have potential geometric and other infrastructure or operational deficiencies. The identification of such potential deficiencies can facilitate solutions and strategies to improve roadway safety and operational efficiency.

OEM and ITS JPO pilot CV data enabled HPPI to identify such geolocations. The criteria used for the identification include sudden acceleration (hard pedal) and sudden deceleration (hard brake). Such maneuvering events can be easily identified in the OEM data, as the OEM data already tagged such events. For the ITS JPO pilot CV data, HPPI applied a deceleration rate of 3.4 meters per second squared (11.1 feet per second squared). The frequency can be ranked by per linear distance, per square area, or a normalized frequency (number of events divided by the annual average daily traffic) to account for the flow density differences among different roadways. In addition to the longitudinal brake and acceleration variables, the ITS JPO pilot CV data also have lateral acceleration information, which offers insight into vehicle stability during turning maneuvers. All the analyses are

**ABOVE:** Connected vehicle technology and its related data are changing the face of transportation. *© AlinStock / AdobeStock.com.*




also coupled with speed and other environmental factors, such as precipitation and headlight status. For example, the graph on hard-brake densities shows a hard-brake density distribution together with average travel speed over the entire area of Florida.

The second major exploration of the CV data was seatbelt usage. Seatbelt data collection is highly complex, often relies on surveys or observations, and is expensive. The OEM CV data offer seatbelt usage information in a highly detailed manner. For example, seatbelt usage for drivers and front passengers can be computed by distance and time traveled during a trip, regardless of the number of unbuckled or buckled events. In addition, seatbelt usage during a journey can be fully studied in sync with vehicle speed and any other vehicle movement data (e.g., acceleration and deceleration).

## Data Analytical Platform

CV data are big, regardless of the angle from which it is reviewed. It is critical to select the right data analytical platform that supports broad program languages (e.g., Python, Standard Query Language, and R). HPPI analyzed OEM CV data and ITS JPO CV data through two different Databricks platforms (one provided by Wejo and one provided by the Turner-Fairbank Highway Research Center (TFHRC)). The latter platform should directly access the ITS JPO CV data sources through its cloud-based storage, as they are separated from the platform.

## CV Data Quality

During the HPPI CV data exploration, the research team discovered that both the OEM and the ITS JPO pilot CV data had data quality issues even though they were machine generated. This issue is a reminder that users of such data should conduct data quality reviews from the start.

## Conclusion

HPPI's initial exploration of postevent CV data shows these data's significant value in terms of deriving relevant but otherwise nonexistent information to enable safer and more efficient roads. The use of CV data to identify roadway geolocation where extreme vehicle maneuvers occurred and how drivers and frontal passengers used their seatbelts is unprecedented. Post-CV data analysis and exploration require a broad team effort given the data's complexity, size, analytical expertise needed, and subject matter knowledge desired.


## Acknowledgement

Wejo provided sample CV data and a Databricks platform for the Florida case evaluation. ITS JPO provided a portion of the CV data used in the analysis in this exploration. For the ITS JPO CV data analysis, TFHRC provided the Databricks platform through its Path to Advancing Novel Data Analytics Laboratory. FHWA and all its offices and units do not endorse products or manufacturers. Trademarks or names appear in this article only because they are considered essential to the objective of the document.



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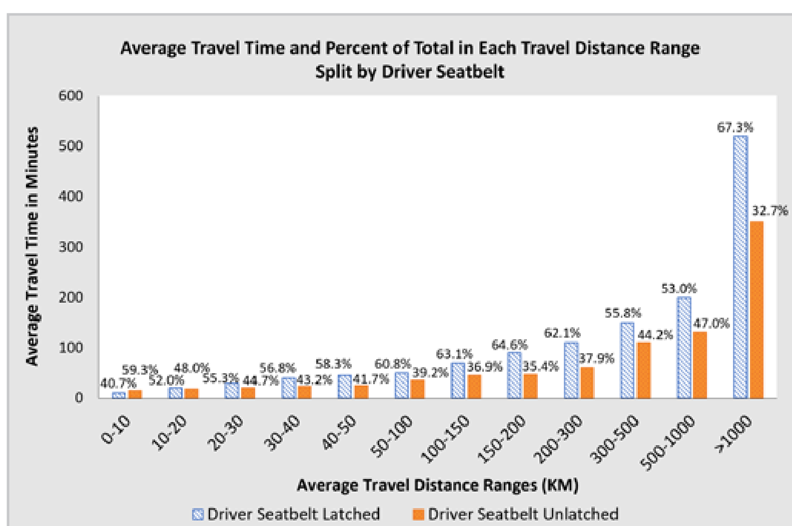
**TIANJIA TANG,** P.E., Ph.D., is the chief of FHWA's Travel Monitoring and Surveys division. Dr. Tang has a B.S. in civil engineering from the University of Central Florida and a Ph.D. from the University of Arkansas. He is a registered professional engineer in the State of Georgia.

**BRIAN BROTSOS,** B.S., is an FHWA chief data officer managing digital solutions and data strategy. Brian has a B.S. in computer science from DePaul University.

**DAVID WINTER,** P.E., is the director of FHWA's Office of Highway Policy Information. David is a registered professional engineer in Nebraska and Maryland, and has a B.S. in industrial engineering from the University of Nebraska.


For further information, please see the full report at *https://www.fhwa.dot.gov/policyinformation/pubs/hpl24012/* .




**ABOVE:** Hard-brake densities per 4 km² by hour of the day. *Source: FHWA.*

**RIGHT:** Driver seatbelt usage by travel distances. *Source: FHWA.*

# Build a Better Mousetrap Winner's Success Leads to Innovation Expansion

by **TRINETTE BALLARD**

The Confederated Tribes and Bands of the Yakama Nation is expanding the use of their 2023 Build a Better Mousetrap (BABM) Innovative Project Award thanks to a Federal grant award from the U.S. Department of Transportation. The Yakama Nation, a federally recognized Tribe that manages approximately 1,200 miles (1,931 kilometers) of public roads in Washington State, was recently awarded funding through the USDOT's Strengthening Mobility and Revolutionizing Transportation (SMART) Grant Program. The competitive program provides $500 million over five years to help State, local, and Tribal governments advance innovative solutions for better rail crossings, safer road intersections, improved transit accessibility, and more, according to U.S. Transportation Secretary Pete Buttigieg.

The Yakama Nation's innovation, the Mobile Unit Sensing Traffic (MUST) device, monitors traffic, detects dangerous events, and provides real-time warning messages to rural road users. Implementation of the device addresses significant challenges faced by Tribal and rural communities such as a lack of real-time traffic and safety data, particularly on low-volume rural roads. The scarcity in data hinders the Yakama Nation's effective planning and decisionmaking processes.

Former Assistant Director of the Northwest Tribal Technical Assistance Program, HollyAnna DeCoteau Littlebull, who worked with researchers from the University of Washington Smart Transportation Applications and Research (STAR) Laboratory on the MUST device, says, "Everything was outdated. The data was like five years or older. We knew that the trending issues did not accurately reflect the data that we had."

The MUST device was customized specifically for use along Tribal and rural roads with limited infrastructure support, including limited Internet connectivity. The device is equipped with camera, environment sensor, computing, and communication capabilities. With the new USDOT's SMART grant, the Yakama Nation's Department of Natural Resources (DNR) "proposed to expand the current MUST deployment from one intersection to the critical intersections and road segments of the entire corridor of US 97 from Toppenish to Union Gap," says Wei Sun, Ph.D., cofounder and chief executive officer of a private spinoff company that focuses on leveraging artificial intelligence and edge computing for safer and more efficient transportation. "The team is currently kicking off the SMART Stage 1 project, which is expected to last approximately 18 months," according to Sun.

In addition to traffic and roadway conditions monitoring and alerting, the Yakama Nation's DNR engineering team has been working on virtual traffic management centers, low visibility and heavy fog situations, and wildfire detection and alerting using the MUST device.

"This project was truly a team effort between the University of Washington, Washington State Department of Transportation, and the private sector. Even though we were different entities, we were a real team and that's what it takes to solve problems," says Littlebull.

The BABM national recognition program highlights locally relevant, innovative solutions, and provides a platform to share innovations to everyday challenges that local and Tribal transportation professionals encounter on local roads. These local road solutions range from the development of new project delivery or design processes to the invention of new tools, equipment, or modifications that increase efficiency, enhance safety, reduce cost, and improve the quality of transportation on local roads.

For more information on the Yakama Nation's MUST device, visit: https://www.aiwaysion.com/technology.

For more information on BABM, visit: https://www.fhwa.dot.gov/clas/babm/ or contact Trinette Ballard, 850-553-2207, Trinette.Ballard@dot.gov. For details on the Yakama Nation and the other winners from 2023, see the Autumn issue of *Public Roads* at https://highways.dot.gov/public-roads/autumn-2023/innovation.

For announcements on the 2024 BABM winners, see the Innovation Corner in the upcoming Autumn 2024 issue of *Public Roads*.

**TRINETTE BALLARD** is a Local Aid Support program manager in the Office of Transportation Innovation and Workforce Solutions and has been with FHWA for 16 years.

**ABOVE:** Installation of the MUST device along a rural road in Washington State.
**INSET:** MUST device.

# TRANSPORTATION CYBERSECURITY:

## Changes and Developments Over the Last Decade

### Innovations and protocols lead to enhancements across the Federal Highway Administration and industry.

by **EDWARD FOK**, **ROBERT SHEEHAN**, and **JOHN HARDING**

Transportation systems must be resilient to deliver safe and efficient infrastructure. Security is a component of resilience. In the last decade, the transportation professions have tackled the challenge of the modern cybersecurity landscape. As modern transportation infrastructure increasingly relies on cyber physical components to maximize available physical infrastructure, the path taken over the past 10 years has improved the resilience and security of the transportation system. Emerging technologies in automation and machine intelligence offer an opportunity to continue improving safety and mobility on available physical infrastructure.

"The threat to roadway cybersecurity comes from malicious attack, operational errors, and lack of system reliability," says FHWA Director of Field Service—North Bob Arnold. "A multiprong approach to combat this must include operator awareness, developing best practices, and advisory capabilities. If done well, the public will never know it's been successful; that should be the goal."

In the past, our most frequent cyber incidents were pranksters changing construction zone traffic signs. Today, we face risk from criminal organizations who are targeting nonfinancial organizations with ransomware. We have seen studies—and fortunately these are only studies—predicting the potential for massive disruption in urban areas by bad actors just targeting strategic locations in the transportation system. Security researchers have also demonstrated that poor organizational practices have enabled vulnerabilities that could lead to an immediate threat to travelers' safety on the roadway. The surface transportation systems are also in the crosshairs of nation-state cyber threat actors. While there have not been any known attacks against our transportation system by a foreign nation, we are certain attackers affiliated with nation-state actors have been taking a very close look at our connected field devices.

Since the last article on this topic in 2015, new technologies have helped both infrastructure owner operators and cyber

Cybersecurity plays a major role in the protection of transportation networks and assets around the world.
*© Saulo Collado / AdobeStock.com.*

threat actors. Systems using machine learning and artificial intelligence (AI) offer significant advances in detection and decision support systems. AI systems can be trained to perform tedious tasks—such as system log reviews—to improve frequency and accuracy of abnormality detection. Attackers have demonstrated the use of AI systems—trained with software codes—to automatically generate new malware codes. This effectively lowers the technical skills needed to conduct certain types of cyberattacks, making it possible for larger volume of varied and sophisticated malware systems that defenders need to protect themselves against. Generative adversarial networks can be used for high-quality audio generation that cybercriminals have used to commit scams. (For more information on generative adversarial networks, visit: *https://www.govinfo.gov/content/pkg/USCODE-2022-title15/pdf/USCODE-2022-title15-chap117-sec9204.pdf*.) The same tools will be invaluable for use in social engineering attacks, and attacks that target personnel and staff, instead of cyber systems.

## Improved Collaborations

Over time, FHWA has seen improved collaboration between transportation operations and information technology departments in more agencies. We have seen the early benefits of this collaboration from incident responses in San Francisco, CA, and Texas. In both cases, the information technology (IT) department protected the transportation system during a cyberattack, limiting the disruption to operationally critical systems to a minimum while halting the greater cyberattack and returning the system to normal function. In the past decade, FHWA has consistently messaged its desire to see agencies develop close collaboration between transportation operations and their IT support teams. The two examples highlight close teamwork between transportation operations staff and IT specialists. This involves transportation operations staff helping IT specialists familiarize themselves with how critical operational technologies are different from common enterprise technologies. Additionally, IT specialists can recommend processes and information technologies tools that are compatible with the capabilities of the operational technologies systems.

"Across State, local, territorial, and Tribal transportation (SLTT) agencies, there is a notable shift in agency mindset from a presumption of trust to a presumption of no trust resulting from the FHWA's operations cybersecurity working group efforts to raise ITS cybersecurity awareness," says Marisa C. Ramon, a private research institute senior research engineer. "For several years, the group has produced detailed documents and tools that aid SLTTs take actions now that increase their cyber readiness, inform their cyber response and management strategies, and raise operations staff cybersecurity awareness."

FHWA has always focused on reducing vulnerabilities of the transportation systems to attacks and speeding up information dissemination when security incidents involved multiple agencies such as SUN_HACKER, an attacker who hacked numerous changeable message signs in 2014, and NotPetya, a fast-spreading ransomware. As an agency focused on surface transportation operations, FHWA does not have the ability to monitor threats or sustain support 24 hours a day, 365 days a year.

In 2018, legislation created the Cybersecurity and Infrastructure Security Agency (CISA). CISA addresses a critical gap that exists in the early warning of threats against the Nation's transportation infrastructure and has the staff to support round the clock operation. CISA has access to information that can offer advanced warning of impending threats—obtained through classified national technical means—that FHWA cannot openly share with its public sector colleagues. To remedy this, FHWA is collaborating with CISA by sharing our transportation domain expertise to help their specialists assess risk and identify mitigation steps that FHWA can share with its public sector colleagues. The FHWA Office of Intelligence, Security and Emergency Response manages the collaboration between CISA and FHWA.

Created in 2014, the FHWA operations cybersecurity working group continues to support FHWA leadership in developing information and identifying best practices to help State and local transportation agencies improve their transportation cybersecurity capabilities. Some FHWA division offices are developing cybersecurity incident reporting guidance in their stewardship agreements with State department of transportation partners. For example, the New Jersey Department of Transportation, as part of its emergency reporting procedures covered under FHWA Order 5181, will be reporting cyber incidents that could affect their operations.

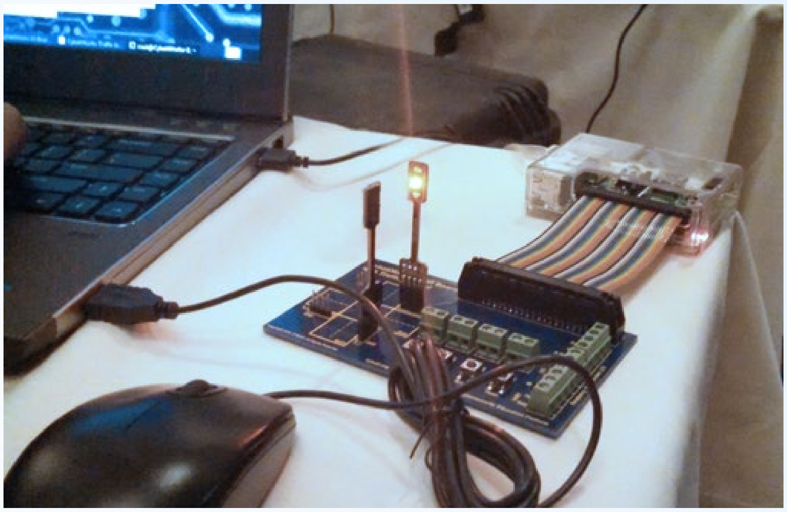
**INSET:** Automated vehicles are quickly becoming more common, as seen in this car stopped at a traffic light in San Francisco, CA. *Source: FHWA.*

## FHWA Resources

Educating operating staff on the importance of cybersecurity is an ongoing challenge at the operating agencies level, especially for smaller transportation operators with limited resources. The National Highway Institute now has an online course to introduce new transportation staff to the challenges of securing transportation systems. The course is based on an instructor-led workshop the operations cybersecurity working group delivered in person to State and local agency colleagues in the past. By providing this material in an online, self-paced course, FHWA can improve access to relevant information in a timely manner to those new to the subject of cybersecurity and transportation at other agencies.

FHWA is developing a self-paced wargaming exercise where agencies can test their knowledge and procedures on how to respond to a cybersecurity incident. The wargame is designed for a small agency or an individual to take part in without an external party serving as the referee. While this wargame will not be as comprehensive or resource intensive as large-scale cybersecurity exercises, it plays an important role in helping smaller agencies test their own cybersecurity capability and procedures.

FHWA currently has a set of cyber incident communication recommendations available for agencies to use as a guide to develop internal policies on how to respond and communicate with their internal and external partners. The recommendations were developed in response to the 2014 "SUN_HACKER" incident where it was a sheer stroke of luck that FHWA identified that the threat actor operated across multiple State lines. Since publication of the incident, FHWA has seen improved cooperation between IT departments and transportation operations agencies in many localities. These recommendations are still useful in helping operating agencies connect with their IT partners to support each other efficiently during a cybersecurity incident.



**ABOVE:** Hackers use a model of traffic signal controllers to attempt the hack of traffic signals from the DEFCON conference in 2015. Fortunately, hackers used the wrong model as traffic signal controller surrogate, so no impact was made on any systems. It did, however, show the level of interest in transportation from the cyber world. *Source: FHWA.*

## Tools to Improve Awareness

To help agencies improve awareness of the vulnerabilities within their transportation management systems, FHWA created a penetration testing guide for operating agencies to test their transportation operational technology networks and systems for vulnerabilities. FHWA also produced a document to help traffic management center operators apply commonly accepted best practices to improve security within the management center. While these recommendations already exist within common IT best practices, this guidance helps the transportation operators better understand how those IT best practices apply to them. In many instances, having basic understanding of threats and vulnerabilities will help transportation engineers and managers have more productive discussions with their agencies' IT administration to develop better policies and procedures.

FHWA continues to update transportation-focused standards to address long-standing vulnerabilities within partner agencies that threat actors can exploit. Most notably, FHWA is creating a transportation-specific profile for the National Institute of Standards and Technology (NIST) cybersecurity framework that agencies of all sizes can use to improve their organizational cybersecurity preparedness. FHWA is also developing numerous tools that will help smaller agencies improve their understanding of the cybersecurity challenge. To expedite assistance to smaller agencies, FHWA created example procurement specifications for devices that those agencies purchase. These specifications, published in January 2024, make cybersecurity features into an essential element that is required for the devices during the acquisitions process. These changes also help device manufacturers and vendors that address cybersecurity concerns sell their products. These device manufacturers and vendors had told FHWA that it is difficult for them to compete in a market that favors the lowest cost, but technically feasible option. By providing security guidelines to the smaller agencies, FHWA helps to level the playing field for manufacturers and vendors who sell to smaller agencies while also improving cybersecurity throughout the public sector. The specifications document, *Procurement Language, Cybersecurity, Apps, Intelligent Transportation System, ITS*, is available at https://rosap.ntl.bts.gov/view/dot/73792.

Field personnel also need help securing these increasingly sophisticated and complex field devices, such as advanced traffic controllers and roadside units, to make them safe and secure from potential threats and vulnerabilities. As a result, FHWA is developing a functional prototype application for transportation device manufacturers. This application will keep sensitive security and intellectual property information private and make the devices current with the best security practices recognized by the original manufacturers.

This functional prototype application is also intended to address the need for field personnel access to vendor specific security settings. The application will demonstrate to field personnel the usefulness of such information and show manufacturers both the potential customer needs of such an application and how layers of security build into it help protect intellectual property. All developmental information will be available to any equipment manufacturer who wants to build their own version based on this functional prototype application. It is hoped that this approach will shorten the time to adoption and deployment of this type of application.

The National Transportation Communication for Intelligent Transportation Systems (ITS) Protocol (NTCIP) was created in 1996 to enable interoperability between components and devices within a closed and private transportation communication network. Today, many of these

Agencies across the country use technology at control centers to monitor for potential threats or incidents.
*© chiew / AdobeStock.com.*

closed and private networks have added open connections to support modern operation and maintenance. Due to the open connections and increased risk from cyber threat actors, the original standards are no longer adequate. FHWA and the ITS Joint Program Office (JPO) funded development of NTCIP 9014 to help guide the individual NTCIP working groups in determining the best ways to update their products and meet the current security challenges.

A similar effort is also underway to reduce the vulnerability of the advanced transportation controller to cyber threats.

"The Advanced Transportation Controller (ATC) Cybersecurity Project began in late 2021 and is supported by the USDOT [United States Department of Transportation]. It is supported by the Institute of Transportation Engineers (ITE), the American Association of State Highway Transportation Officials (AASHTO), and the National Electrical Manufacturers Association (NEMA). The project's primary purpose is to identify and address cybersecurity needs in the ATC family of standards made up of the ATC 5201 Controller Standard, the ATC 5401 Application Programming Interface (API) Standard, and the ATC 5301 Cabinet Standard," says Ralph Boaz, president of a private consulting firm. "Collectively, these standards represent the latest national standards for transportation field cabinet systems (TFCSs). Most of the issues addressed in the ATC Cybersecurity Project will also apply to other ITS standards and specifications. The primary goal of the project is the development of a cybersecurity standard."

The update to the ATC standard was identified after the Transportation Research Board's (TRB) National Cooperative Highway Research Program 3-127 project uncovered critical vulnerabilities. The update applies a system engineering process, taking in the known threats and controller functions, and determining how the specifications could be modified to reduce the number of vulnerabilities that could disrupt ATC operations.

## Challenges Ahead

"When I started working with FHWA and the ITS JPO on cybersecurity in 2017, the awareness of cybersecurity issues in the operational technologies deployed by transportation agencies was at best mixed," says Raymond Resendes, senior cybersecurity advisor for Research, Development and Technology at the USDOT Volpe National Transportation Systems Center. "Today, when I engage with SLTT leadership and staff at TRB, AASHTO and other venues, I see the operations cybersecurity working group efforts have helped achieve widespread understanding of the importance of cybersecurity in transportation agencies' ability to achieve their mission."

Developing a cybersecurity aware workforce in transportation will continue to be an important goal for DOT. Public agencies will always have financial and human resource constraints and will frequently prioritize safety and mobility over other goals. The workforce developed with improved cybersecurity awareness can help transportation professionals at the State, local, Tribal and territory level to correctly identify their security needs and goals and allocate resources appropriately. Many of the resources developed so far and cited previously are aimed at elevating the capabilities of these transportation workforces.

Software continues to be a powerful tool to deliver transportation services but still represents a major challenge to infrastructure resiliency and security. Increased sophistication of software tools will present challenges for troubleshooting, configuration, and life cycle management for many contractors and agencies. The addition of adding modern data intensive neural-network and machine learning assisted transportation tools further increases both the reward and the challenges to responsible contractors and public agencies. Use of such tools by cyber threat actors also increases the risk from attacks to the transportation system. Software written by machine learning systems can increase the technical ability of cyber threat actor groups as cited earlier. A challenge in this area is how consultants and public agencies can use modern machine learning systems to improve operating codes and use managed system configuration and life cycle to negate advantages to the threat actors.

Increasing connectivity between transportation users (vehicles, vulnerable road users, and other innovative modes such as micromobility devices) and traditional infrastructure (such as traffic signal systems) can further improve safety and mobility but also present new challenges. The data exchange between these disparate connected systems assumes some fundamental building blocks that have been around but were never critical to operations. Building blocks such as common precision time references, and reliable and consistent performances of precision satellite-based navigation systems such as the Global Positioning System are increasingly critical for transportation safety and mobility. While operations of these systems are beyond the ability of surface transportation system owner and operators, they are susceptible to reliability and security risks. Independent owner operators will need to understand the status and health of these systems so they can better determine what connected services can be delivered reliability to meet their expected safety and mobility performance.

## Next Steps

Taming the cybersecurity risks to and within transportation systems resembles a cross-country marathon rather than a sprint, and methodical planning designed for long-term results that are proactive and focused on the future and not merely stop-gap measures meant for reactive events. FHWA's ultimate vision, however, is a transportation system that stands resilient against cyberattacks. The three following goals have emerged from that vision:

- Increasing State and local agencies' senior leadership understanding as to why cybersecurity is important and their roles and responsibilities in its development.
- Improving FHWA, State and local staff's cybersecurity knowledge, skills, and abilities, so they can establish protocols to defend, respond to, and recover from cyberattacks.
- Enabling stakeholders to identify, mitigate, and report cyber threats and vulnerabilities.

To achieve these goals, FHWA must maintain a consistent level of effort to develop the workforce and maintain tools to meet an ever-changing environment. FHWA must continue to cultivate a culture that supports transportation cybersecurity and increases capabilities within FHWA and among State and local stakeholders. FHWA will continue to work with its existing partners, such as NIST, the Institute of Transportation Engineers, ITS America, and SAE International, while looking for new partners, such as CISA. These partnerships bring valuable insights that will lead to the formation of national standards and policies for reducing future cyber threat vulnerabilities in the transportation system.

For more perspective on FHWA's challenges in cybersecurity—over the last decade—and a look back at FHWA's goals for transportation cybersecurity in 2015, visit the September/October 2015 issue of *Public Roads*: https://highways.dot.gov/public-roads/septemberoctober-2015/taming-cyber-risks. For more information about CISA, visit: https://www.cisa.gov/.

**EDWARD FOK** helps agencies deploy technologies to solve mobility problems and watch for emerging challenges and opportunities for FHWA. Ed holds multiple engineering licenses and degrees from the University of California and University of Southern California.

**ROBERT SHEEHAN** is a program manager for Architecture, Standards, and Cybersecurity with ITS JPO. Bob led the development of the AI for the ITS Program.

**JOHN HARDING** leads a team that advances the safe and effective integration of emerging technologies such as connected and automated vehicles into the U.S. roadway system for FHWA.

For more information, see https://www.its.dot.gov/research_areas/cybersecurity/ or contact ITS_CybersecurityResearch@usdot.onmicrosoft.com.

A complex network of several transportation systems can be managed from one location.

# FHWA's Transportation Pooled Fund Program

TPF

Source: FHWA.

## Leveraging Resources to Achieve Common Research Goals

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TPF TRANSPORTATION POOLED FUND

# FHWA's Human Factors Vehicle Automation Research

**Human Factors research plays a crucial role in evaluating automated vehicle technology and the interaction between all road users to show potential benefits and mitigate future challenges as technology becomes more prevalent with increased market penetration.**

by **MICHELLE ARNOLD** and **JESSE EISERT**

**ABOVE:** Connected vehicle technology helps improve safety, and advances innovation for future generations of drivers. *Source: USDOT Intelligent Transportation Systems Joint Program Office.*

With the adaptation of Vision Zero, the goal of the Federal Highway Administration is to reduce roadway deaths to zero. To help move the Nation to zero roadway deaths, FHWA has adopted a Safe System Approach for the Nation's transportation network. The Safe System Approach takes a holistic view of the entire transportation network and considers how safety can be achieved at multiple levels rather than focusing on a single part of the system. The FHWA Human Factors team is a natural extension of the Safe System Approach because the team often considers multiple aspects of the transportation system when conducting research. One important field where FHWA's Safe System Approach can be applied is automation research.

"Vehicle operators are exposed to ever-increasing levels of automation. FHWA's human factors research will inform safety and operations professionals about the opportunities and challenges associated with the transition from manually driven to fully automated vehicles. It is imperative that we pursue research that addresses human adaptation toward increasing levels of automation," says James Pol, technical director of FHWA's Office of Safety and Operations Research and Development.

As the Nation moves toward partial and full automation in transportation, human factors research plays a significant role in assessing the overall interaction of road users, vehicles, and the infrastructure, which will provide increased safety on the Nation's roadways. Automated vehicles provide several safety benefits from a human factors' safety perspective, such as potentially reducing fatalities and serious injuries due to human error; however, understanding the issues and challenges that automation brings for all road users is essential. FHWA's Human Factors team conducts research using a variety of research tools, including a highway driving simulator (HDS),


field research vehicles (FRVs), and virtual reality (VR) technology. The following sections will explain each tool, the type of behaviors each tool can evaluate, and some studies that have applied these tools.

## HDS

The Human Factors team has a fully-interactive high-fidelity driving simulator used to conduct research and to study drivers' reactions in a fully controlled, simulated environment. Seven high-definition projectors generate roadway scenes with a 220 degree field of view. The view from the vehicle's rearview and side-view mirrors are generated using a computer. The simulator has a six-degree-of-freedom motion base allowing for a realistic immersive environment. In addition to the motion-based system, the simulator's sound system provides engine, wind, and tire noises, and other environmental sounds.

The driving simulator has a 120-hertz eye-tracking capability, which allows researchers to investigate where participants are looking when they drive through various roadway scenarios. Additionally, the HDS allows for constant monitoring of a driver's decisions concerning speed, acceleration, braking, lane position, following distances, merging behaviors, distance from other road users (vehicles, pedestrians, bicyclists), and sign compliance. Physiological measures, such as heart rate, are also captured as a way to test variables during stressful driving situations. Finally, through the use of questionnaires, the Human Factors team can capture a driver's perceptions, such as trust, distrust, misuse, and abuse of various automated systems. By looking at all of these behaviors, the researchers can obtain an understanding of how drivers use an automated system.

Because the HDS can simulate various levels of vehicle automation or manual driving, the HDS has been used for a variety of research related to automated vehicles. One automated vehicle study conducted using the HDS is "Response to Emergency Vehicles When Driving in a Mixed Fleet," which evaluated the impact of connected vehicle alert messages on drivers' responses to emergency vehicles. The participants' vehicle connectivity was manipulated so that half the participants received an in-vehicle alert that an emergency vehicle was approaching. Connected and automated vehicle (CAV) market penetration was also manipulated to create an environment where none, some, or all of the surrounding traffic responded to a connected vehicle (CV) with a vehicle-to-vehicle emergency vehicle alert. The results of this study showed that CV alerts were effective in getting the participants to yield to an approaching emergency vehicle. Driving with CV alerts led to increased pullover rates, reduced speeds, and pulling over sooner compared to participants without CV alerts.

Another study, "Automated Vehicle Driver Behavior While Passing a Bicyclist," was conducted in parallel to the CAV study. This study looked at how driving automation influenced the passing behaviors of drivers when approaching a bicyclist on either a shared or dedicated roadway. The study also looked at whether cooperative driving automation (CDA) messages helped support safer passing behavior. The research team anticipates this study will be published in late 2024.

One published study, "Driver Adaptation to Vehicle Automation: The Effect of Driver Assistance Systems on Driving Performance and System Monitoring," assessed the effect of varying levels of vehicle automation on driver performance over time. Participants gained experience with driver assistance systems across four sessions in the driving simulator. The specific driver assistance systems that were manipulated between subjects included cooperative adaptive cruise control (CACC), lane-keeping assist, (LKA), a combination of CACC and LKA (CACC + LKA), and a control condition with no driving assistance features. Driver performance metrics, eye tracking, and physiological data were collected to assess how driver behavior changes as the driver adapts to automation. The results of the study showed that driver assistance technology could potentially provide useful benefits to drivers even after drivers have adapted to the technology with repeated use. Participants who used the technology were able to do so in a way that allowed them to direct more of their attention to the road ahead, and driver adaptation was not associated with impaired responses to emergency events.

**LEFT:** The Safe System Approach principles and elements.
*Source: FHWA.*

The FHWA Human Factors team's highway driving simulator.
*Source: FHWA.*

A recent study evaluated the impact of infrastructure-to-vehicle messages about an upcoming lane closure on move-over behavior and safety. This study, "Lane Change Response to Infrastructure Warning About Lane Closure in a Mixed Vehicle Fleet," specifically assessed the potential value of adding CDA technology to a changeable message sign (CMS) by comparing the responses of cooperative automated driving system (C-ADS)-equipped vehicles that receive information about an upcoming lane closure via CDA to that of conventional drivers who receive the information via CMS. The message type was manipulated, such that half of the participants received information that prompted an immediate change in C-ADS behavior and half did not receive the message. Drivers' acceptance and trust of C-ADS behavior was examined as a function of both the source and content of the traveler information available to the driver.

## FRV

The Human Factors team uses field research vehicles to conduct research on real roadways to better understand driver behavior and performance. A FRV is outfitted with a data logger with controller area network interface. The FRV is also outfitted with the CARMA Platform℠ and has the capability to conduct SAE International® Level 2™ vehicle research assessing different driver behaviors related to automation.

Similar to the HDS, each FRV is equipped with an eye-tracking system with three face cameras mounted on the dashboard of the vehicle and infrared light sources. The cameras track the head position and gaze of the driver without interfering with normal driver behavior. Three additional cameras mounted on the exterior of the vehicles' roofs, directly above the driver's position capture a panoramic, forward view of the driving scene. Participants' eye gaze information is synchronized with this panoramic view to determine where the driver is looking during the driving session. The FRV can also receive signal phase and timing (SPaT) information from nearby intersections. Lastly, like the HDS, the Human Factors team can record various vehicle kinematics (speed, braking, and steering input) and can ask participants about their experience through questionnaires. The specific questions and vehicle kinematics vary depending on the aim of the research.

A study called "Cooperative Driving Automation Alerts During Rainy Weather Condition" used an FRV to evaluate the modality of a CDA alert and evaluated the most effective and preferred alert by drivers. The CDA alert informed drivers about the potentially compromised visibility and slippery road surface conditions in three modalities: auditory, visual, and a combination of both. Using speed, following distance, braking, and steering use, the researchers assessed the participants' driving performance. On a post-experiment questionnaire, participants reported their preferred mode and utility of adaptive cruise control (ACC) and CDA technology. Results of this study are anticipated to be published in fall 2024.

In another study, "Exploring the Effects of Vehicle Automation and Cooperative Messaging on Mixed Fleet Eco-Drive," a FRV was used to assess the behavior of drivers, either driving with ACC or manually, who followed a lead vehicle that demonstrated eco-driving strategies. Eco-driving strategies are intended to reduce fuel use by optimizing speed profiles through efficient use of acceleration, deceleration, and idling at a stop. Participants would receive CDA messages that provided SPaT information and information about the lead vehicle's behavior. The FRV was used to create speed and acceleration profiles of the drivers to see if the various CDA


The FHWA Human Factors team's CARMA vehicle is used to conduct field research.
*Source: FHWA.*

messages helped create smoother driving profiles. Additionally, post-driving questionnaires were used to assess the utility and overall safety gains of the CDA messages.

A project awarded in 2023, "Enhanced Lighting Treatments for Improving Vulnerable Road User Detection Within Mixed Fleets," will also use FRV to assess the effects of varying lighting levels on vulnerable road user detection within a mixed-vehicle fleet. This project will see how various lighting treatments can help improve various vulnerable road users' detection not only by conventional vehicles, but also by automated vehicles. Results from this project are anticipated to be published in spring 2025.

## VR Tools

VR tools are still new and emerging technology; however, they allow the Human Factors team to conduct research looking into vulnerable road users. Currently, the Human Factors team has two different ways of researching how pedestrians interact with automated technologies: using a two-lane roadway and using an omni-directional treadmill. The two-lane roadway is a full-sized two-lane road that participants can cross. To recross the roadway, the participants are turned around by the researchers. The omni-directional treadmill allows for multiple crossings. Both systems use VR headsets that put participants in an immersive, computer-generated, three-dimensional environment where they can interact. The headsets provide high-resolution organic light-emitting diode displays and provide a 110-degree field of view. Two sensors mounted on opposite corners create virtual areas participants can walk around in.

These headsets are also equipped with eye-tracking capabilities, which allow insights into where the participants are looking and how long they are looking there. In addition to eye tracking, the Human Factors team can capture information about how long it takes participants to cross an intersection, their walking pattern, gait, distance to other road users, and other relevant crossing behaviors. Lastly, like the driving simulator and FRV, the research team uses questionnaires to assess various subjective measures like trust and safety perception.

One current study, "Ensuring Cooperative Driving Automation (CDA) Vehicles and Vulnerable Road Users (VRUs) Safety Through Infrastructure: Phase 2," will use the two-lane road to assess how pedestrians (young and old) respond to a CDA-enabled infrastructure-based alert system. This study aims to see if providing pedestrians with a warning about an impending conflict will help keep them safe when crossing an intersection.

## Conclusion

Each research tool offers its own unique range of advantages and limitations to conducting human factors research. One of the primary advantages of the HDS and VR tools is that they allow the Human Factors research team to put road users in scenarios that could be dangerous in real life. This practice enables the team to understand how a new system or technology will impact various road users' behavior and if it has a safety benefit. The HDS and VR tools also allow the research team to test new and future automated systems, keeping the research on the forefront of innovation.

Using the HDS and VR tools has some limitations, however, such as not reflecting some drivers' real-world behavior because it is simulated. Additionally, the participants who sign up to be in the research study may not be the most representative sample of the population. Another limitation of the HDS and VR tools is that currently all the behaviors of other vehicles and road users is coded and constant so their behavior may not perfectly reflect the choices made by real road users or automated systems. Currently, the Human Factors research team is working on reducing this limitation by integrating the CARMA Platform into the HDS so it will behave like an automated vehicle. Additionally, the research team is looking into distributed simulation, which would allow other road users (pedestrians, vehicles, and bicyclists) to actually be controlled by other, independent participants.

FRVs tend to have different advantages and limitations compared with the HDS and VR tools. One advantage of field research is that the research team is collecting data in an environment that is the same or similar to real-world driving, which increases the validity of the study. On the other hand, experimental control cannot be contained as efficiently as it can be controlled in the simulator. Other extraneous variables may have an effect on the results of the study that researchers cannot control. As far as safety is concerned, conducting data collection in the real world does not allow for a controlled environment without risk. Using simulation, virtual reality, and field equipment provides complimentary research tools for the Human Factors program that provide a unique opportunity to see how vehicle automation has an effect on all road users and serves an important role in transportation research while minimizing risk to participants and researchers.

"Human Factors research will continue to play a pivotal role in automation research. As artificial intelligence systems continue to grow, it will be imperative that these systems are designed in a manner that not only optimizes performance but is also accepted and understood by users," says FHWA Chief Scientist Craig Thor.

**MICHELLE ARNOLD** leads a variety of human factors research and manages the FHWA HDS laboratory contract. She received her Ph.D. in psychology from Western Michigan University.

**JESSE EISERT** leads various human factors research at FHWA, including automation and how it interacts with vulnerable road users. He received his Ph.D. in psychology from George Mason University.

For more information about the Human Factors research team, see *https://highways.dot.gov/research/laboratories/human-factors-laboratory/human-factors-team-members*, or contact Jesse Eisert, 202-493-3284, *Jesse.Eisert@dot.gov*, or Michelle Arnold, 202-493-3990, *Michelle.Arnold@dot.gov*. For more information about the Human Factors team research tools, see *https://highways.dot.gov/research/laboratories/human-factors-laboratory/research-tools*.

A member of the FHWA Human Factors team uses a virtual reality omni-directional treadmill.
*Source: FHWA.*

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# Garrett A. Morgan:

## The Man.
## The Inventor.
## The Inspiration.
## The Program.


Shaping the future of transportation through new generations of imaginative minds.

Morgan with his medal for bravery for helping to rescue several workers from a waterworks tunnel that extended four miles (6 kilometers) into Lake Erie.

*© Cleveland Public Library/ Photograph Collection.*

by **KAREN BOBO**

## The Man |

Garrett Augustus Morgan, Sr., was born in Paris, KY, on March 4, 1877, as the seventh of nine children. He was born of mixed-race heritage: His mother—Elizabeth Reed—was a freed slave of Native American and African descent, and his father—Sydney—was a freed slave and the son of Confederate Army General John Hunt Morgan.

Morgan spent his early childhood working with his brothers and sisters on the family farm and attended grade school until the age of 14. Like many African Americans of his generation whose circumstances compelled them to begin working at an early age, Morgan's formal education ended after elementary school. He left Kentucky while still a teenager, moving north to Cincinnati, OH, in search of employment. Eager to continue his education and expand his knowledge, the precocious teen hired a tutor and continued his studies in English grammar. As a dexterous adolescent, Morgan worked as a handyman for a wealthy Cincinnati landowner.

He married Madge Nelson in 1896; they divorced two years later in 1898. He remarried in 1908 to Mary Hasek, a seamstress who immigrated to the United States from the modern-day Czech Republic; they remained married until he died on July 27, 1963. Together, they had three children.

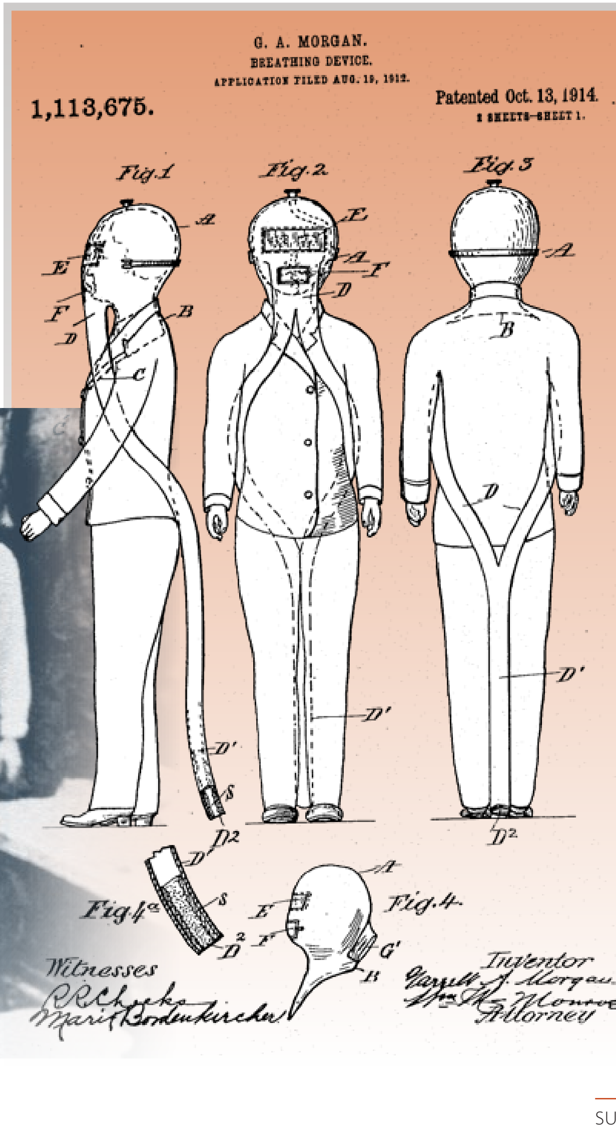
## The Inventor |

In 1895, Morgan moved to Cleveland, OH, where he worked in factories as a sewing machine repairman for a clothing manufacturer. Morgan's first invention—a belt fastener—was born with him experimenting with gadgets and materials to improve the sewing machines' performance, which would help the machines run more efficiently. In 1901, he sold the belt fastener. Morgan gradually lost interest in repairing other's inventions and became interested in developing his own.

Hence, Morgan opened his sewing machine repair shop in 1907. It was the first of several businesses he would establish. For example, in 1909, alongside his wife Mary, Morgan expanded his enterprises to include a tailoring shop, employing 32 workers. The shop made coats, suits, and dresses (for adults and children), all sewn with equipment the budding inventor had made himself.

He also invented a hair straightening cream, which was born from his experiments to create a chemical solution to reduce the frictional heating created by sewing machine needles against fabric. In 1913, Morgan established the G.A. Morgan Hair Refining Company, where he sold his hair cream invention. The company, his longest-running business venture, was a financial success, allowing him to, years later, purchase acres of land and build the Wakeman Country Club for African Americans—one of the first such clubs in Ohio. The country club was equipped with a boxing ring, training facilities, a restaurant, and greenspaces for horseback riding.

In 1914, Morgan received a patent for his invention of a breathing device, a smoke protection hood, a known precursor to the gas masks used during World War I to protect soldiers from toxic gases used in warfare. Having worked in sewing machine factories, Morgan knew how dangerous and common industrial fires were for employees and rescue workers. The smoke hood he invented sought to change that. It would later earn him the first-place prize at the Second International Exposition of Safety and Sanitation in New York City. It was also used to rescue construction workers trapped in a water intake tunnel underneath Lake Erie in 1916. Some of the initial rescue workers, encountering the toxic fumes from an earlier explosion that trapped the workers, were killed. In being familiar with his invention, members of Cleveland's




With the breathing device he invented, Morgan and his brother helped rescue construction workers from underneath Lake Erie in 1916.

An illustration from Morgan's patent for his breathing device. The patent was issue on October 13, 1914.

**FAR LEFT:** *© Cleveland Press Collection, Michael Schwartz Library Cleveland State University.*

**LEFT:** *Source: United States Patent and Trademark Office, www.uspto.gov.*

The oldest treatment facility in the Cleveland Water system was renamed the Garrett A. Morgan Water Treatment Plant in honor of the important role Morgan—pictured in his invention—played in the 1916 rescue efforts of men trapped beneath Lake Erie following an explosion.

*© Cleveland Press Collection, Michael Schwartz Library Cleveland State University.*

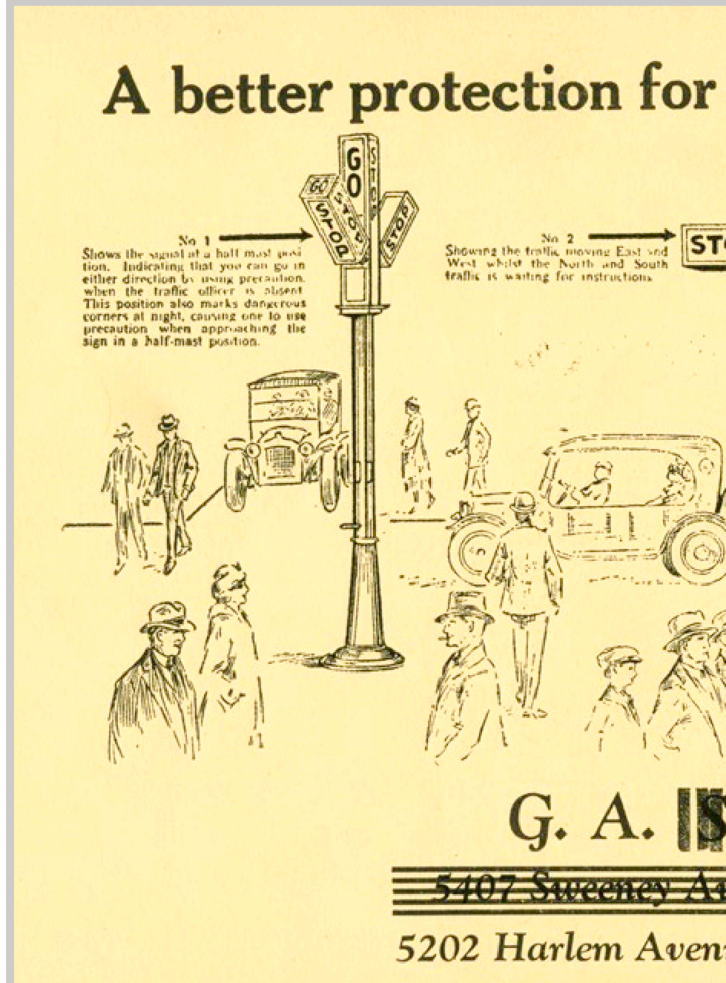
police department called upon Morgan to use as many of his safety hoods as possible. Morgan, his brother, neighbor, and others loaded his car with the hoods and rushed to the scene. Alongside volunteers, Morgan and his brother participated in the rescue efforts, donning the smoke hoods to retrieve those who did and did not survive.

Like many inventors, Morgan developed and marketed his products; however, given racial prejudice during that time, his commercial marketing strategies were hidden under disguise—as much as they could be. For example, in marketing the smoke hood, Morgan hired a white man to act as the salesman while he conducted the demonstrations (with the hood on). But in helping with the 1916 rescue efforts, many learned the race of the inventor of the smoke protection hood. As a result, sales of the hood decreased, and neither Morgan nor his brother were credited for their assistance. Nonetheless, Morgan won a government contract with the U.S. Navy for the safety hoods during World War I, which helped further the success of his invention and protected soldiers from the toxic gases used in warfare.

In 1920, Morgan started the *Cleveland Call*, a weekly newspaper. As the years progressed, he became widely known and respected as a prosperous and generous businessman. His prosperity enabled him to purchase a home and an automobile, which led him to be the first African American in Cleveland to own a vehicle. After witnessing a horrible crash between an automobile and a horse-drawn carriage at an intersection, Morgan invented and patented a three-position traffic signal in 1923—the Nation's first such patent.

## Additional Inventions by Garrett A. Morgan

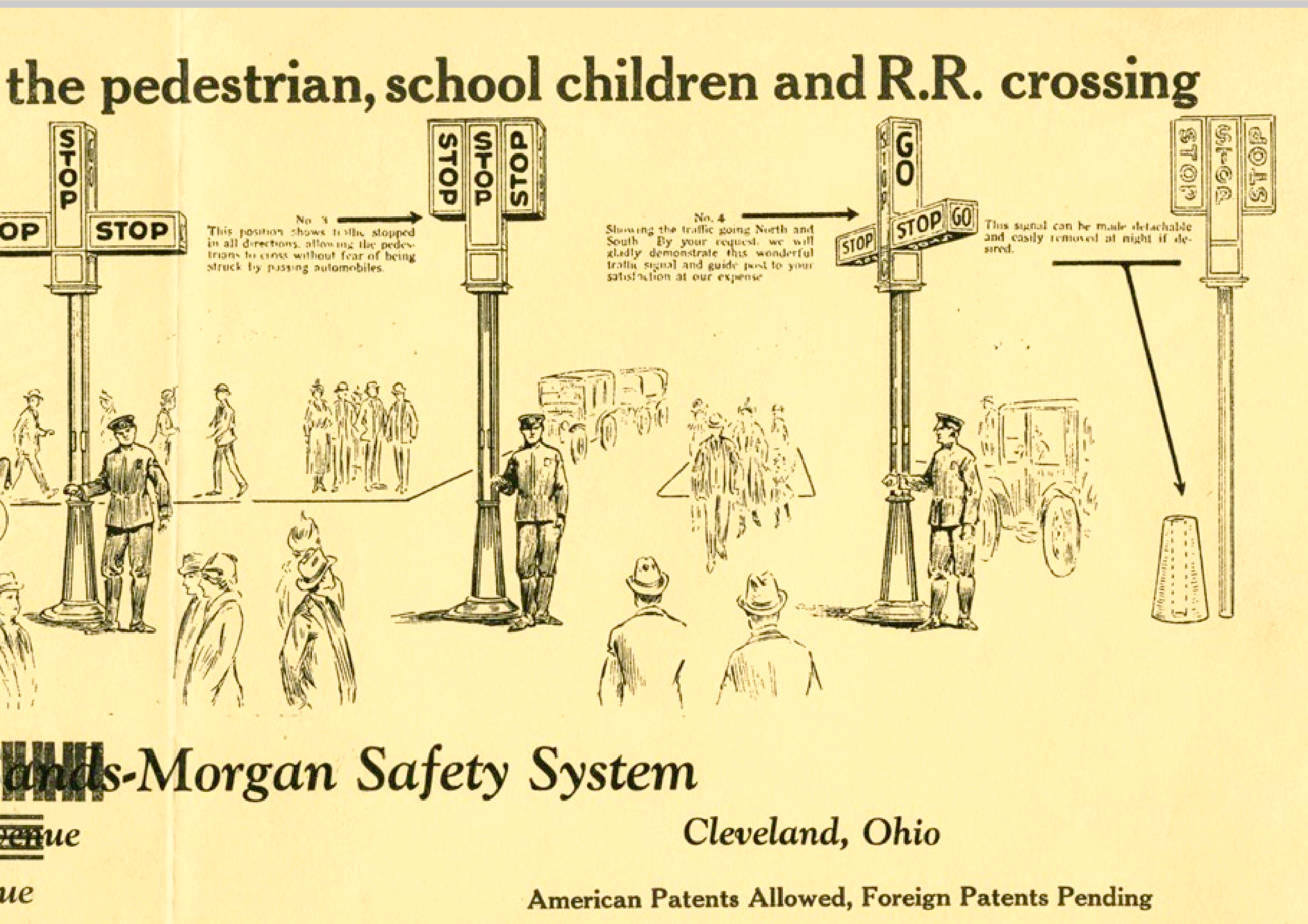
- Friction drive clutch for vehicles
- Cigarette extinguisher
- Zigzag stitching attachment for sewing machines
- Hair coloring
- Hair straightening/de-curling comb
- Women's hat fastener
- Automatic cooker




## The Inspiration

The first American-made automobiles were introduced to U.S. consumers shortly before the turn of the 20th century. At the time, it was not uncommon for bicycles, animal-driven carts, and vehicles to share and travel in the same area as pedestrians; crashes frequently happened. Prior to Morgan's patented invention, many traffic signals featured only two positions, stop and go, and some were still manually operated and did not have an interval between stop and go (like the modern-day all-red interval). The absence of an interval between stop and go allowed for collisions at busy intersections during the transition from one position to another as well as from one street to another.

Morgan's traffic signal, powered by batteries and electricity from overhead wires, was a T-shaped pole unit featuring three positions: stop, go, and an all-directional stop position. The all-directional stop position paused traffic in every direction before allowing travel to resume on either of the intersection's perpendicular roads. This feature, which also utilized bells to signal that the post was changing directions, allowed pedestrians to cross the roads more safely. "Consideration of all modes of travel and improving safety for everyone, especially with an emphasis on vulnerable road users, continues in today's development of traffic control devices," says Martin Knopp, associate administrator for the Federal Highway Administration's Office of Operations. During times of minimal traffic, Morgan's signal was positioned at half-mast, alerting approaching motorists to proceed through the intersection with caution—having the same signaling effect as the flashing red and yellow lights used today.

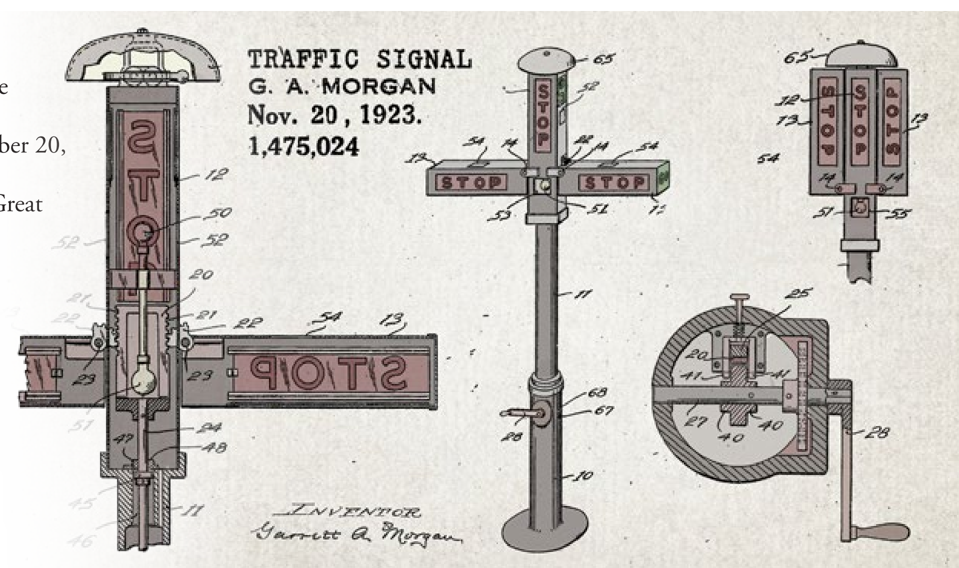



An advertising sheet for Morgan's traffic signal system depicts exactly how his invention could be used to assign right-of-way to vehicles, pedestrians, and other road users.

*© Western Reserve Historical Society.*

Morgan was the first to apply for and receive a U.S. patent for the three-position traffic signal device. The patent was granted on November 20, 1923; Morgan later had his three-position traffic signal patented in Great Britain and Canada.

Morgan was a frontrunner of modern intelligent transportation systems, creating a precursor for the modern-day traffic light signal system used around the world. He sold the rights of his traffic signal to the General Electric Corporation for $40,000 in 1923, which equates to approximately $730,000 today.




The Morgan traffic signal was a T-shaped pole unit with stop, go, and an all-directional stop positions powered by batteries and electricity.

*Source: United States Patent and Trademark Office, www.uspto.gov.*

## The Program |

Morgan, one of America's most talented inventors, was the inspiration behind the creation of the FHWA Garrett A. Morgan Technology and Transportation Futures Program, a national transportation education initiative founded in May 1997 by former Secretary of Transportation Rodney E. Slater. The purpose of the program was to prepare youth to establish a career within the transportation workforce of the 21st century.

In 2005, Congress elevated the program to a new level by authorizing its establishment as the Garrett A. Morgan Technology and Transportation Education Program (GAMTTEP) via the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (Public Law 109-59). With a similar purpose to the original initiative, GAMTTEP's goal is to improve the preparation of students, particularly women and minorities, in science, technology, engineering, and mathematics through curriculum development and other activities related to transportation. FHWA is currently revamping its GAMTTEP to ensure it meets the educational needs for the transportation workforce of the future and plans to publish a Notice of Funding Opportunity later in 2024.

## Conclusion

In further acknowledging and celebrating Morgan's contributions to roadways, transportation safety, and traffic management, the U.S. Department of Transportation celebrated the 100th anniversary of his traffic signal patent in November 2023. As a part of the celebration, Morgan's granddaughter Sandra Morgan was on hand for a ceremony in his honor. As with his version of the traffic light, she believes each of her grandfather's creations fulfilled a need. "At the heart of it, Garrett A. Morgan was a gifted problem solver. His inventions provided practical solutions and made significant contributions to the public safety issues of the day," she says.

Morgan has received several awards and acknowledgments for his inventions. In addition to his prize-winning award for inventing the breathing device at the Second International Exposition of Safety and Sanitation, Morgan was nominated for a Carnegie Medal and a Medal for Bravery from the City of Erie for his bravery in the Lake Erie disaster in 1916. Shortly before his death, Morgan was awarded a citation by the U.S. Government for his version of the traffic light signal, and in 2005, he was inducted into the National Inventors Hall of Fame. By patenting and marketing his traffic signal and smoke hood, Morgan positively impacted the world. In tribute, a number of U.S. roadways, facilities, and learning institutions bear his name—including a Cleveland water treatment plant and the Garrett Morgan School of Engineering and Innovation—for the innovative ways he made the world a safer place.

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**KAREN BOBO** serves as chief of the Workforce Programs Division in FHWA's Office of Administration. She has held other leadership and technical positions throughout her career, including over 30 years of experience with FHWA.

For more information, see ***https://www.fhwa.dot.gov/innovativeprograms/centers/workforce_dev/***.


In Ohio, where Morgan lived, several historical markers appear along roadways, highlighting his inventions, businesses, and service to the community. *© Christopher Busta-Peck / Hmdb.org.*


Enhancing highway infrastructure data analysis through an open-source platform.
*© VideoFlow / AdobeStock.com.*

# Collaborative Highway Asset Research: Integrated Sensor-Model Application

**An open-source platform that analyzes and visualizes nondestructive evaluation and other infrastructure inspection data.**

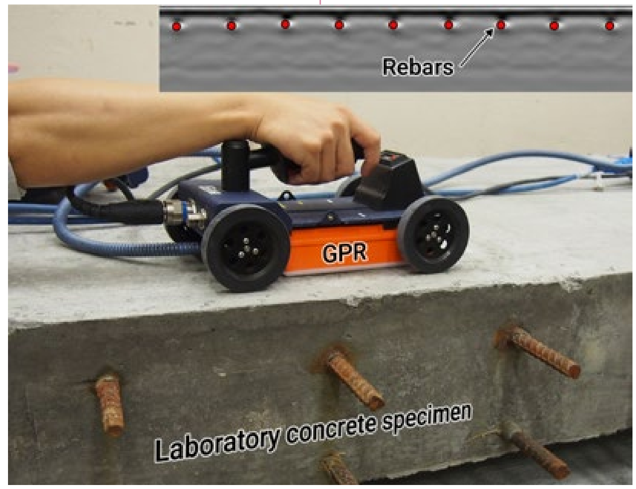
by **HODA AZARI**, **HENG LIU**, and **STEVE YANG**

Technology innovation in sensing, computing, and robotics has significantly bolstered the transportation sector over the past decades, from intelligent construction to nondestructive evaluation (NDE). Technology is a primary driving force that provides advancements to support the Nation's highway infrastructure assets that span more than 2.7 million miles of paved roads, 620,000 highway bridges, and 470 tunnels. While technologies have changed dramatically over the years, the core mission of the Federal Highway Administration remains to serve as a pillar of safety, strength, and efficiency for surface transportation. In alignment with FHWA's mission, the FHWA NDE program is dedicated to conducting state-of-the-art research, development, and implementation of emerging NDE technologies to assess the Nation's highway infrastructure assets.

After collaborating closely with stakeholders such as State departments of transportation (DOTs), American Association of State Highway and Transportation Officials (AASHTO), Federal agencies, industry, and researchers, the FHWA NDE program recognized that introducing and researching emerging NDE technologies within the highway infrastructure domain was not a simple research challenge. Instead, the research required a sophisticated understanding of engineering needs in daily operation and management; technology integration and development; and partnership across Government, academia, and industry. In response, the FHWA NDE program has formulated a strategic plan to guide the collaborative efforts and program actions.

## Motivation for CHARISMA

One strategic initiative of the FHWA NDE program was to develop the FHWA InfoTechnology™ platform, which is a Web-based information platform that can help practitioners select practical NDE solutions for their engineering needs. It provides high-level introductions to NDE technologies such as visual, acoustic, electromagnetic, electrochemical, and other testing methods. This platform links various engineering needs in the condition assessment of highway infrastructure assets, such as delamination in concrete and corrosion in steel, to suitable and applicable NDE technologies.




GPR scanning for rebar mapping in a concrete specimen at the FHWA NDE Laboratory. CHARISMA offers raw data and algorithms to generate the rebar mapping results shown at the top.
*Source: FHWA.*

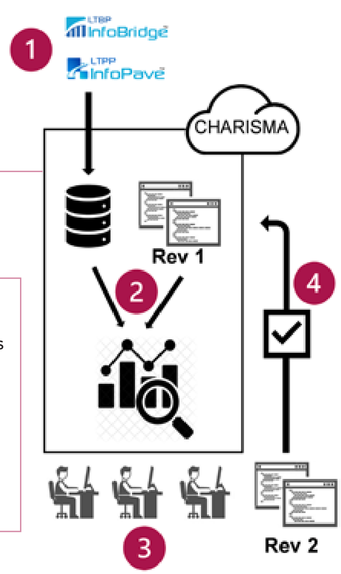
In addition, the FHWA NDE program recognized a lack of NDE standards and technical guidelines in procuring NDE services for State and Federal agencies, which could result in large performance variations across technology and service providers. Without testing standards in place, uncertainty exists whether the performance variation is due to inconsistent implementations of an NDE technology or human factors during operation. Mitigating human factors during operation may be achieved by setting personnel requirements for certifications or using robotics. To address consistent application of NDE, FHWA is developing guidelines to streamline the procurement process for NDE services and working to ensure a consistent implementation of NDE technologies across vendors.

In 2022, to promote collaboration and develop NDE standards, the FHWA NDE program launched the Collaborative Highway Asset Research: Integrated Sensor-Model Application (CHARISMA) project. CHARISMA is an open-source software platform that facilitates the analysis and visualization of NDE and infrastructure inspection data and fosters collaboration among Government agencies, academia, and industry.

This ongoing project at FHWA's Turner-Fairbank Highway Research Center (TFHRC) aims to foster highway research innovations and the development of NDE standards. The FHWA NDE program is working closely with collaborators from AASHTO, ASTM International, the American Society for Nondestructive Testing (ASNT), and other communities toward developing NDE standards and technical references. For instance, the FHWA NDE program has partnered with the ASTM digital imaging and communication in NDE (DICONDE) committee to establish a standardized data format for NDE data storage.

## CHARISMA Design and Prototype

CHARISMA's design process consists of two equally important functions: one performed by the FHWA NDE program and the other by the NDE community, including technology developers and researchers. The FHWA NDE program shares data and algorithms produced in house and from sponsored research projects. The role of the NDE community is to use the work and, because it is open source, enhance it if needed. The interaction is an iterative process that aims to converge well-accepted NDE practices, which will be proposed as NDE standards to AASHTO, then ASTM International, and ASNT.




CHARISMA's design involves a four-step collaboration between the FHWA NDE program and the NDE community. First, the user downloads data from FHWA InfoBridge™ or InfoPave™ (step 1). Then the FHWA NDE program provides the first version of algorithms to process and visualize the data (step 2). In the meantime, the NDE community can revise the algorithm (step 3) and submit it to CHARISMA as an improvement (step 4). The revision is an iterative process.
*Source: FHWA.*

CHARISMA currently uses a GitHub repository to share algorithms produced by the FHWA NDE program. The repository is open to the public, ensuring free access and transparency to the NDE community. The repository now hosts algorithms of five popular NDE technologies used for concrete and steel testing: impact echo, ground penetration radar (GPR), phased array ultrasonic testing, half-cell potential, and electrical resistivity. Readers may refer to the FHWA InfoTechnology website (see Resources sidebar) for introductory descriptions of each NDE technology. The GitHub repository will be regularly updated.

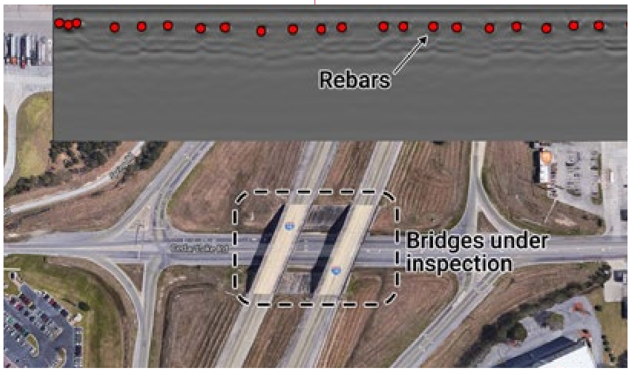
The FHWA NDE program team recognizes that transparency and reproducibility are two important factors in advancing NDE practices, in addition to other equally important factors such as ease of use, the ability for nonexperts to interpret the data, and costs. Thus, CHARISMA provides validated source code so that users can generate transparent and reproducible NDE results. In addition, CHARISMA contains case studies that provide necessary information regarding:

- How to set up CHARISMA.
- How to use CHARISMA for NDE data analysis.
- How to understand the source code, such as the description of each parameter.

For example, one case study conducted at TFHRC involves using GPR for rebar mapping in concrete bridge decks. The basic principle of GPR for rebar mapping involves sending a short pulse of electromagnetic wave into a testing subject. The received reflection wave analysis contains rich information on the testing subject, including the rebar location. Processing GPR data typically requires multiple steps of sophisticated data analysis. CHARISMA provides all source codes for the necessary steps to transform GPR raw data into processed information on rebar location. The FHWA NDE program team validates the source codes by applying the algorithm to process NDE data collected from laboratory testing and field inspections.

## Next Steps

Moving forward, CHARISMA plans to expand its case study series and technology pool, including sharing advancements in artificial intelligence (AI) research to aid defect mapping and other infrastructure applications. Ongoing AI research conducted at the FHWA NDE Laboratory involves fabricating multiple concrete specimens with pre-embedded defects, which can provide high-quality labeled NDE data to train and validate various AI models. CHARISMA will share these valuable resources with the NDE community to advance future analysis methods and AI research.




GPR scanning for rebar mapping in a field inspection of a highway bridge. CHARISMA offers raw data and algorithms to generate the rebar mapping results shown at the top. *© 2019 Google. Annotations by FHWA.*

"Through CHARISMA, the FHWA NDE program aims to collaborate with stakeholders, share knowledge, and drive innovation in the field of NDE technologies, ultimately leading to enhanced infrastructure assessment and management practices," says Director of the Office of Infrastructure Research and Development, Dr. Jean Nehme. This collaboration is imperative to develop standardized NDE data collection, storage, analysis, and interpretation. Dr. Nehme continues, "This platform could be a valuable resource for researchers, practitioners, and other stakeholders involved in the evaluation and management of highway infrastructure."

In addition, CHARISMA represents a crucial step toward standardized NDE practices essential for maintaining consistent quality in NDE services and fostering innovation in highway infrastructure research. Shane Boone, senior vice president of NDE at Bridge Diagnostics Inc., states, "Through collaborative efforts, CHARISMA aspires to drive advancements in NDE research, improve infrastructure assessment practices, and contribute to the overall efficiency and safety of our highway systems." The FHWA NDE program will continue to work with AASHTO, ASTM International, ASNT, and other organizations to develop standardized NDE practices.

CHARISMA is built with transparency. "By establishing an open and collaborative environment, CHARISMA strives to facilitate knowledge sharing, innovation, and the effective utilization of NDE technologies across the industry," says Anne Rearick, director of bridge management for the Indiana DOT. The FHWA CHARISMA program serves as a cornerstone of advancing NDE in the daily operation and management of highway infrastructure.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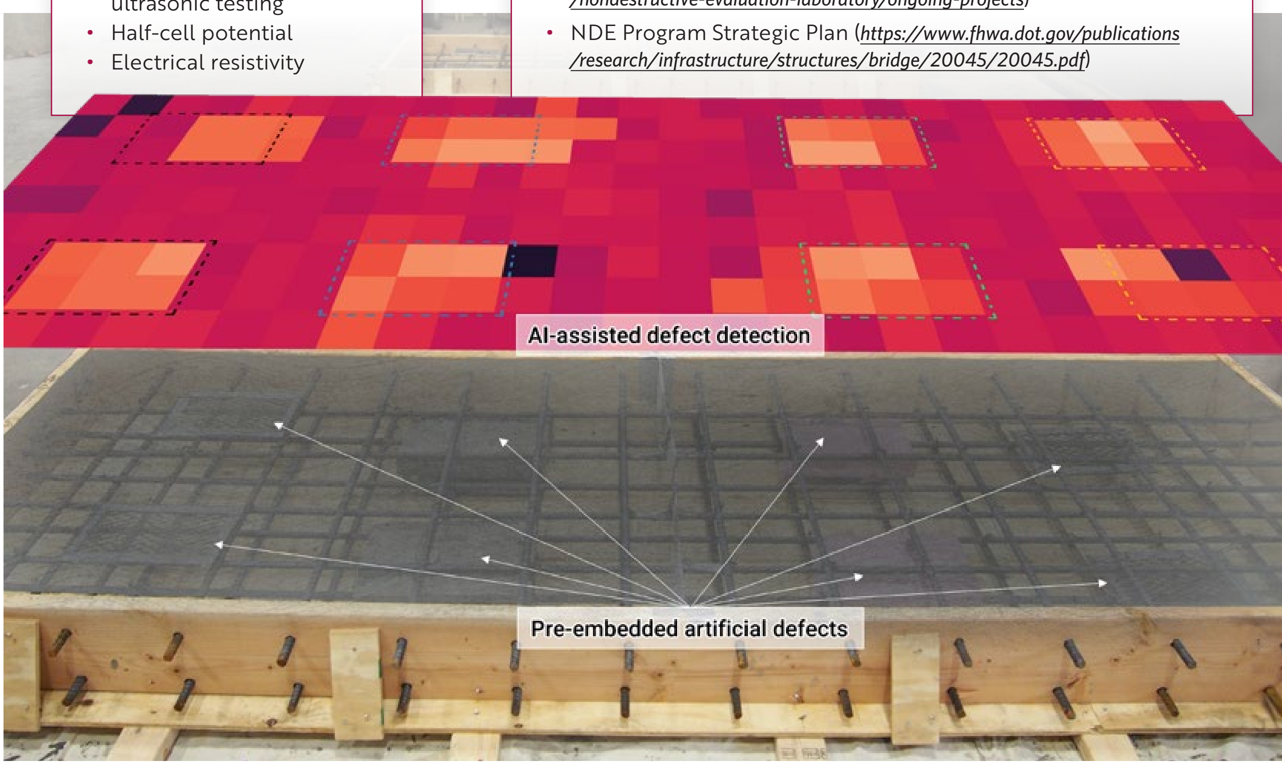
For more information, visit: https://highways.dot.gov/research/laboratories/nondestructive-evaluation-laboratory/ongoing-projects, or contact Hoda Azari at 202–493–3064 or Hoda.Azari@dot.gov.

### NDE Technologies Used for Concrete and Steel Testing

- Impact echo
- Ground penetration radar
- Phased array ultrasonic testing
- Half-cell potential
- Electrical resistivity

### Resources

- InfoTechnology™ (https://infotechnology.fhwa.dot.gov/)
- CHARISMA GitHub repository (https://github.com/TFHRCFASTNDElab)
- NDE laboratory (https://highways.dot.gov/research/laboratories/nondestructive-evaluation-laboratory/ongoing-projects)
- NDE Program Strategic Plan (https://www.fhwa.dot.gov/publications/research/infrastructure/structures/bridge/20045/20045.pdf)




The FHWA NDE laboratory fabricated multiple concrete specimens with pre-embedded artificial defects to conduct AI research. *Source: FHWA.*

# SMART COMMUNITY RESOURCE CENTER:

## Resources to Advance ITS Deployments

**The U.S. Department of Transportation has created the Smart Community Resource Center, an online collection of resources and materials, to advance the deployment of intelligent transportation systems.**

by **J.D. SCHNEEBERGER**

The Smart Community Resource Center (SCRC) is a collection of resources that can be used by practitioners to advance Intelligent Transportation Systems (ITS) and smart community transportation projects. Created and managed by the U.S. Department of Transportation ITS Joint Program Office (JPO), this website is a living resource that is routinely updated with new materials and tools to aid in deploying smart community technologies that will benefit U.S. communities in a wide variety of ways. A "smart community" is a community that uses innovative technologies, data, and analytics to improve the well-being of the community and address local transportation, safety, mobility, and equity challenges. The SCRC helps to advance deployment of ITS and emerging transportation technology solutions by sharing technical resources so agencies can better leverage funding made available through the Bipartisan Infrastructure Law (BIL), (enacted as the Infrastructure Investment and Jobs Act (Pub. L. 117-58, Nov. 15, 2021)) which provides a once-in-a-generation investment in our Nation's infrastructure.

### Transportation Challenges Facing the Nation

Safe, reliable, and equitable transportation is essential to moving goods efficiently and connecting people to jobs, education, healthcare, and recreational activities to improve their quality of life. "Communities face a variety of challenges, including safety, congestion, and barriers that limit accessibility for some travelers. Transportation also contributes to pollution and climate change," says ITS JPO Director Brian Cronin. "Across the country, communities are looking for proven and innovative solutions to address these challenges."

According to the National Highway Traffic Safety Administration, 42,795 people died on America's road in 2022—roughly 117 people every day. Traffic crashes are a leading cause of death for teenagers in America, and disproportionately impact people who are Black or African American and American Indian or Alaska Native. At the same time, traffic congestion results in delays for travelers and impacts the efficient movement of goods, while also increasing vehicular emissions and pollution. Finally, many citizens face transportation accessibility challenges. People that live in underserved communities and people with disabilities may be limited in their ability to use the existing transportation system to reach their desired destinations, services, and activities.

Fortunately, communities do not have to face these challenges alone. The USDOT is committed to working with communities to address these challenges through the deployment of ITS and emerging transportation technologies.

### BIL: Goals

On November 15, 2021, the Infrastructure Investment and Jobs Act (Public Law 117-58), also known as BIL, was signed into law by President Biden. The largest long-term investment in our infrastructure and economy in our Nation's history, BIL provides unprecedented funding over fiscal years (FY) 2022–2026 in new Federal investment in infrastructure, including roads, bridges, mass transit, water infrastructure, climate change resilience, and broadband. In addition to providing funding for infrastructure and ITS deployments, BIL also includes a requirement for the USDOT to "make available to the public on an Internet website a resource center, to be known as the 'Smart Community Resource Center.' "

This monumental piece of legislation has comprehensively influenced the goals and initiatives of USDOT, including improving public safety and climate resilience, creating jobs across the country, and delivering a more equitable future. It aims to address the challenges and risks affecting

**ABOVE:** The Smart Community Resource Center offers resources for the safe, efficient implementation of ITS technology. *Source: USDOT.*

communities across the United States, and the establishment of the SCRC is one way that it aims to do so. “The BIL includes an unprecedented amount of funding to States, Tribal governments, and local communities to advance the deployment of ITS technologies. The SCRC intends to supply resources to deployers to increase the likelihood of successful ITS deployments,” says Cronin.

More specifically, BIL requires that the SCRC exists as a compilation of resources or links to resources for States and local communities to use in developing and implementing—(1) intelligent transportation system programs; or (2) smart community transportation programs. It further states that the SCRC should include: “existing programs and resources for intelligent transportation system or smart community transportation programs, including technical assistance, education, training, funding, and examples of intelligent transportation systems or smart community transportation programs implemented by States and local communities.”

## How ITS Can Help Address Transportation Challenges

Smart communities use advanced information and communications technologies to find new ways to solve not only common problems like potholes, pollution, and traffic, but deep-rooted problems like safety, equity, and mobility for all Americans. These communities create an intelligent, integrated information network by applying sensors and wireless communications technologies to infrastructure, vehicles, wearables, and other physical devices, and communities use this network to receive, analyze, and share data in realtime to make better decisions and provide more responsive, efficient, data-driven services.

Smart transportation and ITS technologies are a key aspect to the successful functioning of a smart community. ITS technologies are used to monitor traffic conditions and are used to manage and operate transportation systems to enhance efficiency and safety, among other benefits. Some of the more traditional ITS technologies deployed across the country include traffic sensors, closed-circuit television cameras, and traveler information systems that allow public agencies to monitor traffic conditions and actively respond to congestion and incidents. Ramp meters, variable speed limits, and advanced traffic signal systems, and transit signal priority, among other solutions, have proven to be beneficial in enhancing safety and improving the efficiency of the transportation system.

Interoperable connectivity technology implemented into vehicles can deliver significant safety improvements and help communities move toward the goal of zero roadway fatalities. *Source: USDOT.*


Emerging transportation technologies have the potential to provide additional assistance—including transformational benefits to communities. Among these technologies are vehicle-to-everything (V2X) technologies that use wireless communications to enable vehicles to communicate with each other, with other road users such as pedestrians and bicyclists, and with roadside infrastructure. Data collected from connected vehicles as well as Internet of Things (IOT) devices will provide powerful insights that help agencies better operate transportation systems. Predictive analytics and artificial intelligence offer opportunities for communities to address problems in realtime. Finally, emerging mobility services, such as micro mobility services and shared vehicle services integrated with transit services, will make travel in communities more efficient and accessible. These services are evolving from an emphasis on private automobile ownership to more flexible options that incorporate shared-use mobility.

## Important Resources Provided by the SCRC

The SCRC features information for community leaders trying to advance the deployment of ITS and emerging technologies for addressing their real-world problems. The site is a regularly updated resource center with documents, publications, and other resources to help agencies plan and implement smart communities. Resources range from technical documents to information about funding opportunities.

"Our goal is to make it easier for deployers to find information. There are a lot of excellent resources on the Internet, but it can be challenging for people to find the information they are looking for—or to even know that some of these resources even exist. Our vision is for the SCRC to be the one-stop shop for ITS and smart community transportation information that is organized in a user-friendly way," says Cronin.

The SCRC is currently being updated to categorize resources in three sections: goal areas, technology areas, and enabling or crosscutting areas. The Goal Areas section—a work in progress—details current challenges and ways in which ITS can help in five areas: safety, mobility, equity, climate, and economic competitiveness. The safety goal area, for example, shares insight into safety problems plaguing our roads and intersections and ways where smart transportation can make them safer for all using innovative technologies, data, and analytics to address local challenges in urban, suburban, and rural communities. Site visitors can learn about the Safe System Approach, a comprehensive framework to address and mitigate transportation risks. The SCRC provides proven ways where ITS can benefit each of the five objectives in the approach: safer people, safer vehicles, safer speeds, safer roads, and safer post-crash care.

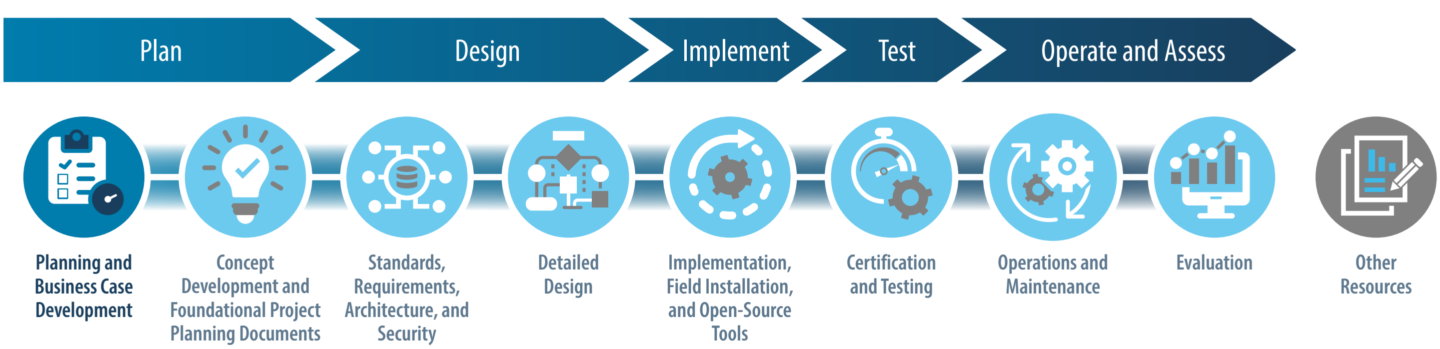
The Technology Areas section will include information and technical resources on emerging transportation technologies, including V2X interoperable technologies, vehicle automation, and innovative mobility solutions, among others. This section provides resources related to emerging transportation technologies that agencies may consider deploying to address their transportation challenges. For example, the ITS JPO created Interoperable Connectivity pages that include resources to help agencies deploying V2X technologies. These pages include planning documents, technical systems engineering documents, evaluation materials, and even access to open-source tools developed by USDOT and being used by agencies across the country.

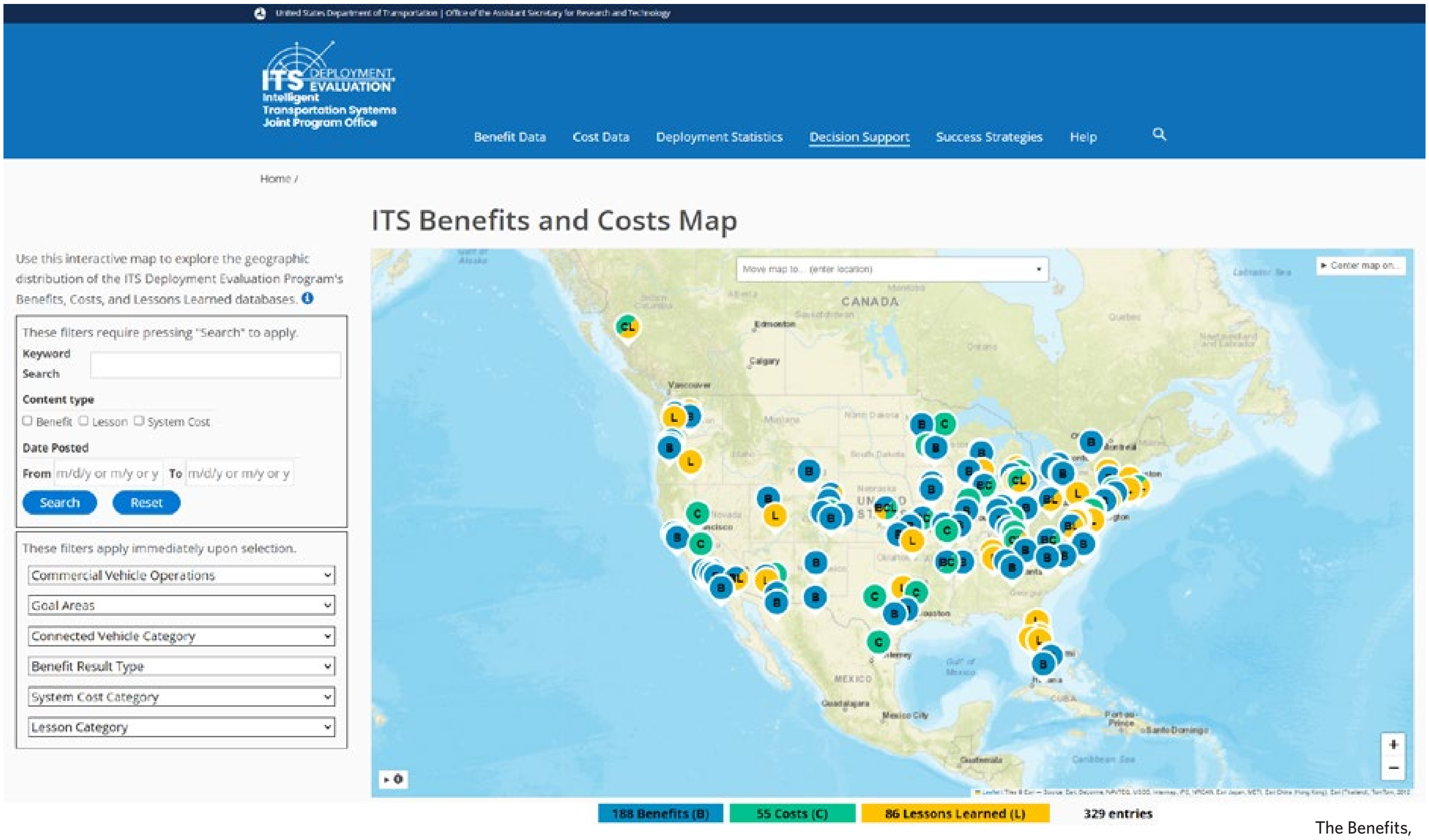
The Enabling Areas section will include information on crosscutting topics that are key enablers to successful deployments. Topics include systems engineering, ITS standards and architecture, cybersecurity, data management, and performance measurement and evaluation. A particularly effective source of information in this area is the ITS Deployment Evaluation Program, a program within the ITS JPO. The ITS Deployment Evaluation Program presents summaries on the benefits, costs, deployment levels, and lessons learned for ITS deployment and operations. It catalogs more than 20 years of ITS evaluation studies, research syntheses, handbooks, journal articles, and conference papers tracking the effectiveness of deployed ITS. While this program offers an abundance of resources to aid in ITS deployment, most recently, the ITS Deployment Evaluation Program launched the Benefits, Costs, and Lessons Learned Map, an interactive way for users to explore the geographic distribution of the ITS Deployment Evaluation Program's Benefits, Costs, and Lessons Learned database.

Finally, the SCRC provides information on the many USDOT funding opportunities made possible by BIL. The Strengthening Mobility and Revolutionizing Transportation (SMART) Grants program, for example, was established by BIL with $100 million appropriated annually for FY 2022–2026. The SMART Grants program provides grants to eligible public sector agencies to conduct demonstration projects focused

**ABOVE:** The Safe System Approach combines a few variables that can be prioritized to conduct a safely functioning community. *Source: USDOT.*

**BELOW:** Interoperable connectivity resources are available on the SCRC aiding in all stages of the implementation process. *Source: USDOT.*






The Benefits, Costs, and Lessons Learned Map is an interactive way to explore the geographic distribution of demonstrated examples of ITS benefits, costs, and lessons learned.
*Source: USDOT.*

on advanced smart community technologies and systems to improve transportation efficiency and safety. Grants are available for projects that demonstrate at least one of the following technologies: coordinated automation, connected vehicles, intelligent sensor-based infrastructure, systems integration, commerce and delivery logistics, leveraging the use of innovative aviation technologies, smart grid, and smart technology traffic signals.

"SMART Grants provide an opportunity for State, local, and Tribal governments to demonstrate how to navigate the unique technical and policy challenges in deploying cutting-edge transportation technologies, with aid from USDOT subject-matter experts and peers," says SMART Grants Director Stan Caldwell.

BIL has also funded the Advanced Transportation Technologies and Innovative Mobility Deployment program, also called the Advanced Transportation Technology and Innovation program, which provides competitive grants to deploy, install, and operate advanced transportation technologies to improve safety, mobility, efficiency, system performance, intermodal connectivity, and infrastructure return on investment. These funding opportunities are paramount to the goals of BIL; they create a dynamic and productive relationship between the USDOT and community members that will aid in improving public safety and climate resilience, creating jobs across the country, and delivering a more equitable future.

## Moving Forward: The Future of the SCRC

Since its publication in fall 2022, the SCRC has and will continue to evolve and grow as a premier, all-encompassing portfolio of USDOT, other Federal departments, and industry resources. While managed by the ITS JPO, the website will feature resources from across the USDOT modal administrations, including the Federal Highway Administration, Federal Transit Administration, Bureau of Transportation Statistics, as well as from other Federal agencies and non-Federal sources. Currently, the ITS JPO is working on updating the SCRC to provide further information on resources related goal areas, technology areas, and enabling areas.

"Our goal is to continue to expand the SCRC to include dedicated pages for crosscutting subjects such as systems engineering, data management, and cybersecurity, among others," says Cronin. "But more broadly, we hope that the site continues to be an important and demonstrable source of aid when it comes to deploying smart transportation and smart community technology, ultimately contributing to the success of the BIL."

With the resources on the SCRC, practitioners can find information about ITS solutions that can result in creating safer, more efficient, and more sustainable smart communities across the country, and ultimately serve in the implementation of BIL's goals.

**J.D. SCHNEEBERGER** is the ITS JPO program manager for the ITS Professional Capacity Building Program—the USDOT's primary mechanism for educating the transportation workforce about current and future intelligent transportation technologies. He oversees the management of the SCRC.

To explore the resources that the SCRC offers, visit: *https://www.its.dot.gov/scrc/#/*. USDOT will continue to add relevant smart community resources, including resources from other Federal agencies and external organizations. For more information regarding the SCRC, please contact *SCRC@dot.gov*, or J.D. Schneeberger at *john.schneeberger@dot.gov*.


# AUTOMATED DRIVING SYSTEMS
## Collaborative Research Framework

The U.S. Department of Transportation has created a new approach for facilitating cooperation between infrastructure operators and industry developers to ensure automated driving systems are integrated safely and effectively.

by **JOHN HARDING**

Over the last 100 years, the U.S. transportation system has been developed primarily for human operators. For example, roadway signs were designed to be easily seen, read, and interpreted by humans. However, as vehicle automation technologies have evolved, driving responsibilities have steadily shifted from humans to automated driving systems (ADSs).

ADS developers and infrastructure owner operators (IOOs) that manage the roadways want safe and efficient operation of automated vehicles, and, to achieve this goal, significant testing must take place. The Federal Highway Administration's *Collaborative Research Framework for Automated Driving System Developers and Infrastructure Owners and Operators* ("the Framework") facilitates the investigation of interfaces that will advance road-ADS integration.

**ABOVE:** Through evaluation and testing, automated driving systems will soon become common, everyday technology that will improve safety on the roadways. *© metamorworks / AdobeStock.com.*

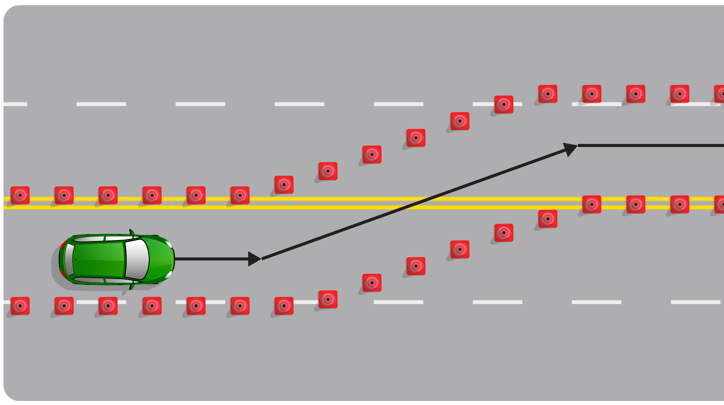
**RIGHT:** Example of a work zone navigation scenario. *Source: FHWA.*

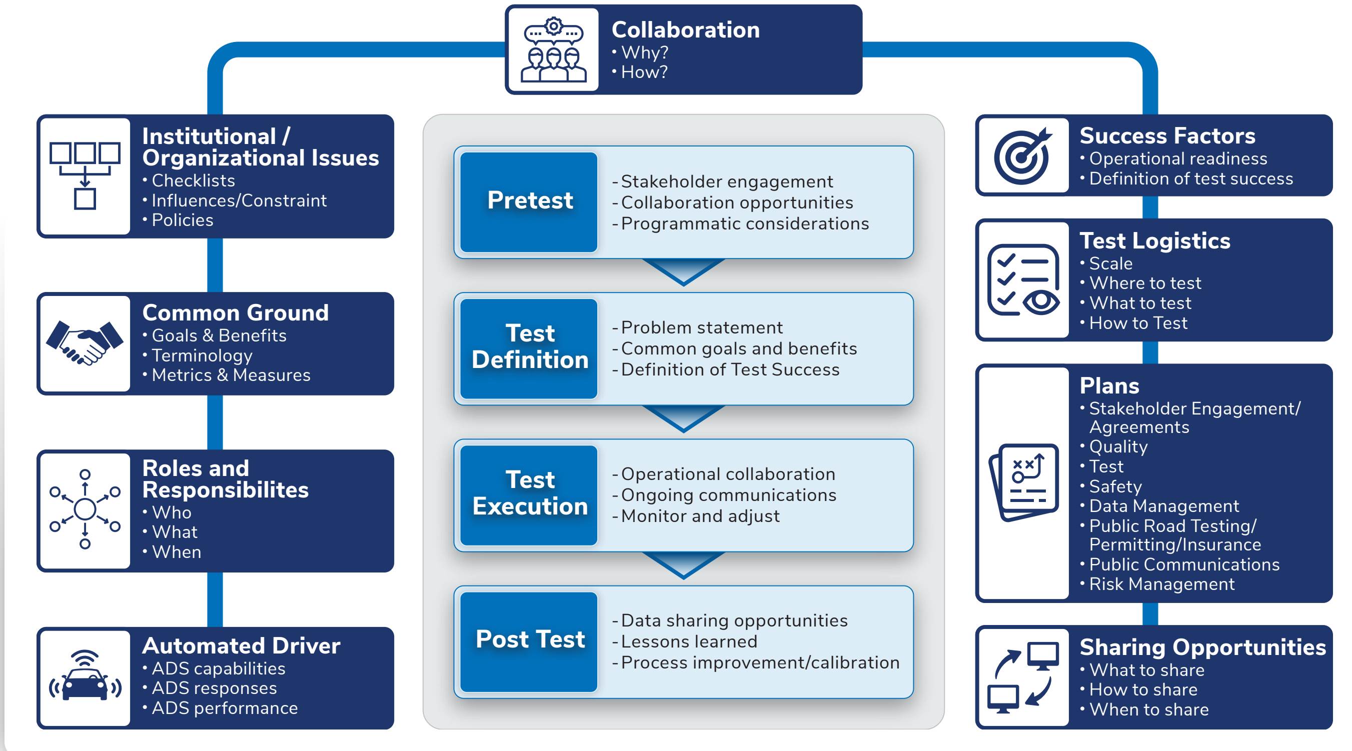
### Purpose of the Framework

Without standards or evaluation procedures for ADS testing and without collaboration between ADS development and infrastructure stakeholders, the widespread integration of this technology may be difficult when incorporating needed road improvements.

The successful operation of ADSs on our roadways heavily depends on the ADS being able to interpret and navigate its surrounding environment. However, with the development of ADS technology still in its infancy, ADS developers and IOOs have many challenges to overcome, such as ADSs navigating complex traffic scenarios and adapting in adverse weather as well as building supportive infrastructure. Given that ADS developers and roadway stakeholders seem to have diverse, but complementary, visions on the testing and evaluation needs, the likelihood of safe and efficient integration is necessarily contingent on productive IOO and industry collaboration.

Consider a typical State department of transportation (DOT) operations scenario where a busy highway is being resurfaced or expanded. Presently, the procedures and standards outlined by a State DOT are designed to maximize the safety of a crew within the work zone while still ensuring continual mobility for drivers. For instance, one direction of travel is shifted from the left lane over the center line into a lane



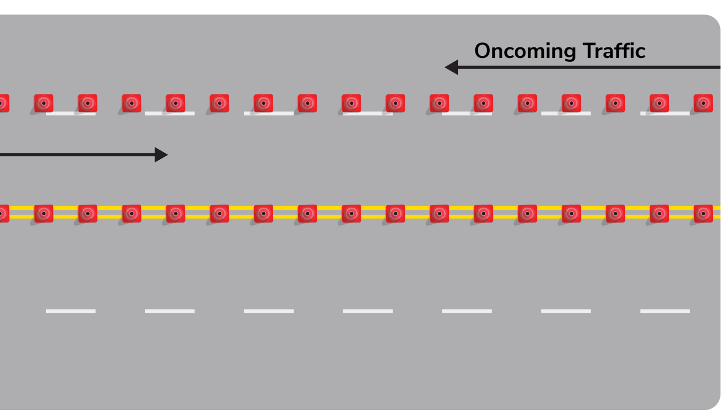



Collaborative testing framework for ADS.
*Source: FHWA.*

typically used for the opposite direction of travel. A work crew must ensure that enough advanced warning of the lane shift exists and that visible barricades are distributed with proper spacing, while drivers must steer through the exchange. A driver deviating from the marked lane shift could lead to worker injury, equipment damage, and/or a traffic collision.

State DOTs can expect that drivers have enough experience with work zone navigation to understand how to proceed safely. However, what might happen if the driver is altogether removed from the situation? Can anyone be certain that the automated vehicles of tomorrow will be able operate safely through a work zone? The answer lies in the quality and scope of testing performed on ADSs, which is expected to displace human drivers over the course of the next two decades. Both the developers of ADS and State DOT employees have a keen interest in how this testing is administered and evaluated.

Using a technology-independent approach (i.e., it does not matter what sensors the ADS uses), the Framework aims to bring these ADS and IOO stakeholders together through a broad set of processes and examples that advise without prescribing regulations or policy. Instead, the Framework adopts the notion that validation and testing of ADS technologies and various infrastructure features are essential to paving the way for safe integration of ADS-equipped vehicles into the road system. Aside from the sheer scope of the possible




testing that may be needed, a common understanding of the capabilities that need to be implemented either in the ADS or roadway domains is required by those participating in the collaborative testing.

Collaborative testing promises to provide resolution to these integration issues, resulting in a safe and efficient integration. Numerous stakeholders have recognized the need to investigate various ADS and roadway scenarios, including specific challenges to be addressed. Overall, these efforts will further advance deployment of ADS-equipped vehicles onto roadways throughout the United States, benefiting both ADS and IOO entities.

## Framework Overview

The Framework provides a broad suite of tools, perspectives, and approaches intended to facilitate collaboration between the ADS developers and roadway stakeholders. As demonstrated in the work zone navigation example, both ADS developers and State DOTs have a vested interest in the safe integration of ADS technology.

Thus, the Framework was developed with extensive engagement and input from both ADS and roadway stakeholders, including automotive original equipment manufacturers (OEMs), suppliers, technology companies, and State, Federal, and regional government entities. Their combined perspectives can accomplish a collective understanding of safe integration more rapidly and with fewer errors than the respective individual entities.

The Framework addresses nine overarching themes, which support various aspects of the test phases. The Framework includes contextual examples, real-world lessons learned, and various perspectives (e.g., ADS developers, IOOs, first responders, and fleet operators). All stakeholders are interested in—or will be impacted by—ADS deployments on the road network and have a responsibility to engage in the testing and evaluation of these technologies. The Framework enables collaborative support toward their shared goals.

## Themes

***Collaboration:*** Collaboration between ADS and IOO stakeholders is critical for successful testing and evaluation. Stakeholder collaboration enables early detection and resolution of ADS issues related to technical, organizational, and strategic test implementations. Collaboration also allows testing participants from diverse organizations, backgrounds, and skill sets to solve specific road and ADS challenges. Open and frequent interaction between stakeholders lead to improved test outcomes. The quality of the testing is also enhanced because input from various points of view can be collected.

> *"Using the Framework promotes collaboration between ADS developers and IOOs to achieve a common goal and provides each entity the opportunity to share their perspective. This collaboration results in increased success in testing and deployment."*
>
> Nick Hegemier, P.E.
> Managing Director—Infrastructure
> DriveOhio

For example, Pennsylvania DOT (PennDOT) has already recognized the need to prepare for ADS integration across the State. PennDOT assembled eight partners to change infrastructure to support ADS in work zones. They have been testing a variety of strategies, including using different work zone channelizers (cones, barrels, panels), using smart channelizer devices that broadcast their positioning, and generating high-definition maps.

In addition, the project will develop advanced mapping and communications systems for safe ADS navigation at and around 17 different work zones in urban, suburban, and rural areas. Prior to testing in active work zones, the partnership will conduct validation testing in virtual environments and then at a track at the Pennsylvania State University. By engaging automation development teams and creating a comprehensive plan for testing, PennDOT will better understand how ADSs operate in certain conditions and thus will be better equipped to fulfill its mandate for keeping Pennsylvania drivers safe and informed.

Another example of collaboration to achieve roadway safety goals is the Michigan DOT (MDOT) and 3M™ Connected Roads I–75 test corridor. MDOT collaborated with 3M to deploy a 100-day test of 3M Connected Roads prototype solutions in a 3.3-mile (5.3 kilometers) construction work zone. The collaboration involved 3M, MDOT, and a variety of automotive OEMs and sensor suppliers.

***Institutional/Organization Issues:*** Having organizational experts from both ADS and IOO organizations participate early and throughout the test phases will significantly aid in navigating any challenges. For road/ADS testing and evaluation, the Framework makes safety of all road users the highest priority. As a result, State and local regulatory policies must be developed, which requires that policymakers be well informed on relevant topics and kept up to date on ADS integration developments. The Framework aids in navigating challenges that IOO and ADS representatives encounter when conducting tests, evaluations, and pilots.

***Common Ground:*** This theme refers to creating a common or shared working environment so that ADS and IOO stakeholders fully understand each other, which is critical for tests to be successful. When executing road/ADS tests, all stakeholders will have clearly defined expectations, outcomes, and success criteria. There are three key components of common ground: common goals and benefits, common terminology, and common metrics and measures.

***Roles and Responsibilities:*** An important part of the process of IOO and ADS developer collaborative testing and evaluation is identifying who from the various organizations needs to participate, what roles within the organizations are needed, and when (i.e., which phases) they need to participate. Some participants may only be involved in one phase while others may be essential to all phases.

***A New Driver:*** With ADS, the new driver of tomorrow will be the system. The Framework is a document that provides examples and scenarios to aid the transition to a safe and functional road network that can support human- and ADS-driven vehicles sharing the road.

***Success Factors:*** Many factors influence the success of road/ADS testing and evaluation. The most critical success factors include enhancing ADS operation capabilities, comprehension of ADS, roadway test elements, the collaboration and joint testing process, stakeholder engagement and collaboration, and ongoing communication with the public. The Framework aids in assisting the ADS and IOO participants in defining test success factors within each test phase.

***Test Logistics:*** This theme refers to what, how, and where to test, including the development of test scenarios, methodologies, and environments. Test logistics are tailored to specific scenarios and what road features and characteristics and ADS are being evaluated.

> *"The Framework provides the tools needed to increase interaction among road/ADS entities to enable joint research and development activities."*
>
> Roxane Y. Mukai, P.E., P.T.O.E.
> Operations Engineer
> Maryland Transportation Authority

***Plans:*** For a collaborative environment to exist, stakeholders' participation as part of the plan for test design, data collection, and evaluation can be beneficial. For instance, road/ADS testing and evaluation need to account for roadway adaptations (i.e., changing the roads to enhance ADS integration such as different configurations and lane markings), which can be incorporated through collaboration with IOO.

One example is Waymo's first-responder engagement plan. The objective of this plan is to provide first responders with the knowledge they need to safely identify, approach, and interact with an ADS-equipped vehicle in an emergency scenario.

***Sharing Opportunities:*** Data are a key issue that require thorough discussions with IOO and ADS stakeholders to avoid challenges (e.g., proprietary data/information). Data are critical to evaluate the outcome of tests and ensure effective road network operations. ADS and IOO stakeholders can share a variety of resources, including skills, expertise, information, and existing data.

An example is Arizona's Institute of Automated Mobility (IAM), a consortium for collaborative data sharing. Arizona's IAM consortium leverages existing infrastructure to collect performance data on public roads. The research does not require a lot of data collection from collaborating partners. This practice may encourage greater openness and participation from ADS stakeholders.

## Framework Application

The activities for successful collaborative testing and evaluation can be categorized into four phases.

***Pretest Phase:*** The output of the pretest phase is a clearly identified problem statement that is based both on the internal needs of ADS developers and IOOs. A clearly defined problem statement supports collaboration among the test participants to then work on a test definition (which is the next step). Program risks, including operational, technical, data, legal, and financial ones, should be identified during this phase. Overall, this collaborative effort is designed to expand the scope of those impacted by the testing effort to minimize longer term issues and delay.

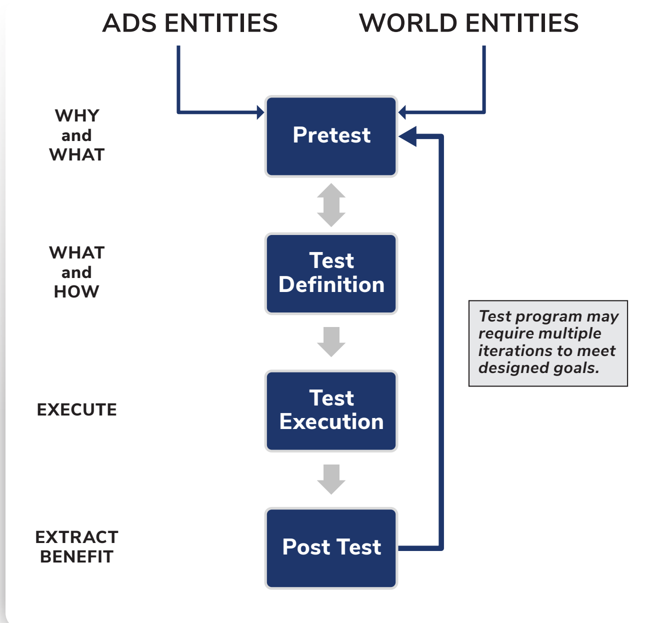
***Test Definition Phase:*** The objective of the test definition phase is to conduct activities that help define the technical and data facets of a collaborative test program. The completion of the test definition phase produces a plan for testing, data management, and quality control, which facilitates subsequent test execution. Critically, the success factors, both technical and organizational, are defined for the program. Having clearly defined success criteria ensure an overall higher test quality.

***Test Execution Phase:*** In this phase, both technical and data facets of the collaborative road and ADS testing proceed as defined in the plan. The focus is on efficiently collecting performance data. The phase includes operational collaboration, ongoing communications among stakeholders, test monitoring, and test adjustments. After completing this phase, ADS performance data are gathered and reviewed to determine if the system is ready to advance to the next phase. For example, if the performance failure at night is considered critical by the stakeholders, then new tests will likely be scheduled after making updates.

***Post Test Phase:*** In the post test phase, stakeholders aim to conclude the collaborative testing and evaluation activities. They review data insights, store data, discuss lessons learned, and evaluate the processes used (which drives future testing and evaluation). Overall, this collaborative effort directly leads to a higher level of confidence by the stakeholders, and by extension the public, that the ADS-equipped vehicles will be safely integrated among existing drivers.

## Conclusion

To date, collaboration between ADS developers and IOOs has not been the norm nor has testing ADS-equipped vehicles with varying transportation infrastructure components. ADS technologies have been developed and tested, traditionally,




Framework for collaborative testing and evaluation.
*Source: FHWA.*

with little or no discussion with roadway stakeholders. Communication between IOO and ADS stakeholders has focused mainly on gaining approval to test on a road network. Proprietary data concerns have been identified as a roadblock to the willingness of ADS developers to work collaboratively with IOOs. Other challenges addressed by the Framework include:

- Developing a consistent and agreed upon language between entities for both ADS and road features and components.
- Identifying and addressing the permitting process and insurance needs.
- Agreeing on common goals and outcomes for a joint test activity.
- Developing a working understanding of the compatibility of safety from both the ADS developer and IOO perspectives.
- Accepting the need to share roles and responsibilities for the test activity.
- Understanding the need to coordinate on any interactions with the public.

However, the Framework addresses collaboration from multiple perspectives throughout a test's lifespan. It provides examples of successful collaboration, the benefits of collaboration, and information on how and when to collaborate.

Ultimately, this approach focuses the efforts of both the ADS development teams and IOO stakeholders working toward the common goal of safe and efficient ADS integration.

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**JOHN HARDING** is a team leader with FHWA's Office of Transportation Management, Connected/Automated Vehicles and Emerging Technologies overseeing the integration of next-generation technologies into the U.S. roadway system. John holds a B.S. in civil engineering from the University of Pittsburgh and an M.P.A. from George Mason University.

For more information, see ***https://ops.fhwa.dot.gov/publications/fhwahop21012/fhwahop21012.pdf*** or contact John Harding (*john.harding@dot.gov*, 202-366-5665).

*Along the Road features current and upcoming activities, developments, trends, and items of general interest to the transportation community.*

# Technical News

## VTTI Celebrates 35 Years and the Future of Transportation Safety

In 2023, Virginia Tech Transportation Institute (VTTI) celebrated 35 years of innovative and impactful research in transportation. Research conducted at VTTI has effected significant changes in public policies for driver, passenger, and pedestrian safety. This research has also advanced the design of vehicles and infrastructure to increase roadway safety. Currently, VTTI is the second largest university-level transportation institute in the United States. As the organization solidifies its 36th year and maintains its status as a top transportation research organization, VTTI continues to support its original mission: to save lives, time, and money as well as protect the environment.

Naturalistic driving studies were born at VTTI. In the early 1990s, VTTI Director Tom Dingus acted on an idea to bridge the gap between research and real-world driving. As director for more than 25 years, Dingus placed cameras and sensors inside a volunteer's vehicle to assess driver behavior, crashes, and near-crash incidents.

Upon the creation of naturalistic driving studies, data acquisition systems (DAS) were constructed at Virginia Tech to store information from VTTI's investigations. The data has ultimately influenced improvements in the transportation system for all users. Collectively, the data acquisition systems hold data from nearly 7,000 vehicles—cars, tractor-trailers, bicycles, and e-scooters. For instance, in January 2021, VTTI produced statistics that showed the dangers of distracted driving for both cars and trucks as Virginia became the 22nd State to ban handheld phone usage while driving.

**ABOVE:** The Smart Road Bridge, the second tallest bridge in Virginia, is part of the Virginia Smart Roads, which are state-of-the-art, closed test-bed research facilities managed by VTTI in cooperation with the Virginia Department of Transportation. *© VTTI.*

In the 2000's, Dingus, alongside Andy Petersen (VTTI's chief engineer), helped create the first large-scale, naturalistic driving study: a 100-car study funded by the National Highway Traffic Safety Administration, which resulted in enhanced safety regulations and other aspects of transportation on both a national and international scale.

VTTI's current and future plans involve conducting field research on transportation's most advanced systems by collecting naturalistic driving data; implementing the #SharingTheRoadVTTI campaign by visiting schools to educate teen drivers on how to stay safe when driving around semi-trucks; and recruiting efforts for volunteers to participate in transportation research. Additionally, VTTI gives back to their community each year through the Commonwealth of Virginia Campaign, a program that supports more than 1,000 charities.

For more information on VTTI, visit: *https://www.vtti.vt.edu/*.

## Recycled Roadways Discussed at TRB

Touted as the most well-known gathering of global transportation leaders, including administrators, practitioners, policymakers, and researchers, the Transportation Research Board's 103rd Annual Meeting in Washington, D.C., took place in January 2024. Overall, more than 14,000 attended and saw more than 200 exhibitions and 600 workshops, lectern, committee, panel, and poster sessions.

Technology and policy leaders gathered to discuss highway infrastructure, including the benefits of using recycled materials and sending electricity through pavement. Such electricity—created by mixing carbon with cement and water and using recycled materials—could be used to recharge electric vehicles as they travel on roadways. An added benefit includes using electricity to keep pavement free of ice or wintry mix during cold weather months.

During a panel session on reinventing road pavement, several U.S. Department of Transportation officials weighed in on the direction of roadways and future goals, including USDOT Secretary Pete Buttigieg. "Our aim is to make infrastructure materials like pavement more effective, resilient, durable, and longer lasting than ever before," he stated. Dr. Robert Hampshire, USDOT's deputy secretary for research, also provided commentary, covering a range of topics alongside a host of other speakers.

For more information on TRB, visit *https://www.trb.org/AnnualMeeting/AnnualMeeting.aspx*. The 104th Annual Meeting will also be held in Washington, D.C., on January 5–9, 2025.

## Public Information and Information Exchange

### Beehives, Honey, and Transportation

The Federal Highway Administration's Turner-Fairbank Highway Research Center (TFHRC), a 40-acre campus of widespread forests, wildflowers, and pollinator gardens, is the home to more than 100,000 honey bees. With TFHRC's campus located near the George Washington National Parkway and Potomac River, the honey bees play a critical role in plant reproduction and the upkeep of the center's park-like environment. Consisting of two individual colonies, with each colony residing in its own beehive, the TFHRC bees are conversation starters. "As the resident beekeeper at the research center, I have the pleasure of discussing bees with co-workers and visitors," states Matt Gaillardetz, an FHWA systems engineer. "The research center's bees are a frequent topic of interest to guests that visit the center, including President Obama in 2014, and most recently, Transportation Secretary Pete Buttigieg in October [2023]. Both were gifted TFHRC honey with a label I designed specifically for the research center."

Conversations around the bees typically lead to their importance as pollinators to the environment. On a larger scale, honey bees play a critical role in pollinating more than 100 agricultural crops across the Nation. In addition to honey—a product of nectar, a sugar-rich liquid by-product of flower nectar and honey crop of a honey bee—the fascinating insects produce propolis (an antimicrobial compound used to treat various diseases and to heal wounds), royal jelly (used in high-grade cosmetics), and beeswax (used to create a variety of medical, cosmetic, and home care products).

Honey bees are a superorganism, the highest level of eusociality. *© Matt Gaillardetz.*

**LEFT:** The TFHRC honey bees are housed in two individual beehives. Each colony typically has a fertile female (the queen bee), worker bees (non-fertile female bees), and drones (male bees). *© Matt Gaillardetz.*

In 2014, former President Barack Obama signed a presidential memorandum directing the creation of the Federal Pollinator Task Force that encompassed 17 Federal agencies. The task force was charged with developing Pollinator Protection Initiatives, which continue in many Government agencies, State departments of transportation, and private landowners. The memorandum followed a revelation in Spring 2009, in which a White House carpenter disclosed his hobby as a beekeeper. The White House assistant chef and food policy advisor caught wind of the news and requested the carpenter supply honey for various recipes. Soon after, the carpenter relocated a honey bee colony to the South Lawn to help with pollination of the White House kitchen garden.

Like at TFHRC, the White House bees became a conversation starter. Congress held hearings on the plight of honey bee pollinators as a result of significant colony losses across the country. Around this time, Gaillardetz and other TFHRC beekeepers initiated discussions surrounding having bees at the research center "We collectively concurred that if the White House is going to have bees, why not TFHRC! … We had the ideal campus with plenty of diverse forage, natural water sources, good wind breaks, and 300 employees to share the importance of pollinators to our ecosystems," Gaillardetz reasoned. The idea was presented to TFHRC leadership and the rest is a 15-year history of honey bees at the center. The future of maintaining bees is promising so long as good stewardship of the bees is maintained.

## MnDOT's 2024 10-Year CHIP

In November 2023, the Minnesota Department of Transportation (MnDOT) published the *2024–2033 Capital Highway Investment Plan* (CHIP). Updated yearly, the document details the State's highway projects selected for construction over the next 10 years based on the *Minnesota 20-Year State Highway Investment Plan* (MnSHIP)—MnDOT's vehicle for deciding and communicating capital investment priorities for Minnesota's highway system for the next 20 years. This CHIP was developed during an update to MnSHIP, and is based on the draft MnSHIP investment direction for the years 2028-2033. Years 2024-2027 are based on the previous 2017 MnSHIP investment direction.

Like its predecessor, the latest CHIP is updated yearly to remove projects that are currently in construction, adjust the timing of existing planned projects, and add new planned projects. CHIP serves as a checks and balances method to ensure that MnDOT is meeting the investment levels and performance outcomes identified in MnSHIP.

MnDOT will complete many important pavement, bridge, safety, mobility/expansion, and flood mitigation projects. For instance, 2024 will see the completion of a Complete Streets reconstruction in Pelican Rapids and a resurfaced bridge over the Pelican River; construction of a roundabout in Glencoe at the intersection of Highway 212 and Morningside Drive; and reconstruction of Highway 93 (from Highway 169 to the flood wall in Henderson).

To view the 2024–2033 CHIP, visit: https://www.dot.state.mn.us/planning/10yearplan/.

**TOP:** MnDOT's 2024–2033 CHIP detailed State highway construction projects over the next 10 years. *© Minnesota Department of Transportation.*

## Rebuilding Illinois

In June 2019, Illinois developed its first and largest comprehensive, multimodal, 6-year capital plan—the historic *Rebuild Illinois*. As the sixth largest State in the Nation and a transportation hub for the country, the plan set out to repair crumbling roadways and bridges; create nearly 540,000 positions, including 431,600 jobs in transportation; and develop much-needed infrastructure in areas across the State, including Chicago, where $561 million will fund the construction and repairs of infrastructure and capacity enhancements (e.g., auxiliary lanes) from Bessie Coleman Drive to Interstate 90, improving safety and access to O'Hare International Airport.

By the end of 2023, *Rebuild Illinois* completed work on 5,659 miles (9,107 kilometers (km)) of their highway system, 578 bridges, and 862 additional safety improvements. From combined Federal, State, and local funds, *Rebuild Illinois* also

**RIGHT:** As part of *Rebuild Illinois*, the Village of Burr Ridge—a municipality in the State's Cook and DuPage counties—underwent resurfacing and pathway replacement projects. *© KirKam / AdobeStock.com.*

maps investments in transit, rail, ports, aeronautics, bicycle, and pedestrian infrastructure. As work approaches its fifth year, the Illinois Department of Transportation touts a plethora of accomplishments, including Federal approval for the department's first Vulnerable Road User Safety Assessment, which outlines strategies for programs and countermeasures to keep pedestrians and bicyclists safe. Other accomplishments include:

- Construction of a $18.3 million highway stormwater pump station at Deerpath and Skokie Highway in Lake Forest, IL.
- Federal approval for an Electric Vehicle Infrastructure Deployment Plan that maps the allocation of $148 million toward creating a network of public electric vehicle charging stations across the State.
- Opening of the Jane Bryne Interchange, a critical transportation hub for the region and the entire Midwest. As one of the State's most significant projects in size, the $806.4 million project utilized 52 million pounds of steel and 2,100 miles (3,380 km) of rebar in improving safety, reducing congestion, and increasing travel options for the nearly 400,000 drivers of vehicles and commercial trucks a day that the interchange serves.

To review *Rebuild Illinois*, visit: https://s3.documentcloud.org/documents/6189293/Rebuild-Illinois-Capital-Plan.pdf; for additional information and views of IDOT's accomplishments, visit IDOT's dashboard at https://idot.illinois.gov/transportation-system/transportation-management/transportation-improvement-programs/rebuild-illinois-capital-program-highway-accomplishments/dashboard.html.

## 2024 LTIP Student Data Analysis Contest Open

The Federal Highway Administration holds an annual contest for undergraduate and graduate students enrolled in degree-granting programs in the United States that support pavement or bridge curricula and research, including engineering, planning, statistics, materials, computer science, and economics.

The Long-Term Infrastructure Performance (LTIP) Student Data Analysis Contest is designed to encourage students to use pavement or bridge performance data to study the various factors affecting pavement and bridge lifecycles and to develop a technical paper to document their research. Students are encouraged to partner with State departments of transportation, transportation-related consultants, and school faculty members.

Source: FHWA.

The lead authors placing first- and second-place in the contest will receive an all-expenses-paid trip to the Transportation Research Board Annual Meeting held in Washington, DC, in January 2025, where they will present their winning papers. Papers are due Aug. 1, 2024.

To view the contest guidelines and the winners of the past contests, visit https://highways.dot.gov/research/research-programs/infrastructure/long-term-infrastructure-performance. For more information on the contest, contact LTIPStudentContest@dot.gov.

## BTS Publishes 2023 TSAR

Recognizing the importance of objective statistics for transportation decisionmaking, the U.S. Congress requires the Director of the Bureau of Transportation Statistics (BTS) of the U.S. Department of Transportation to provide the Transportation Statistics Annual Report (TSAR) yearly. In December 2023, the 29th TSAR was released (https://rosap.ntl.bts.gov/view/dot/72943).

The 2023 report is organized into seven chapters, in addition to an Introduction:

- **Chapter 1—State of the System** (discusses recovering from the COVID-19 pandemic)
- **Chapter 2—Passenger Travel and Equity** (discusses the COVID impact on passenger travel)
- **Chapter 3—Freight and Supply Chain** (discusses disruptions to the supply chains from drought)
- **Chapter 4—Transportation Economics** (discusses inflation and transportation)
- **Chapter 5—Transportation Safety** (discusses new standards in transportation)
- **Chapter 6—Energy and Sustainability** (discusses the transition to new energy sources for transportation)

Unlike past reports, the 2023 TSAR covers emerging issues; each chapter identifies notable emerging issues in transportation related to the subject area of the chapter. For example, Chapter 4 highlights how transportation costs can impact inflation from the perspective of the consumer, transportation providers, and nontransportation services.

For more information on BTS, visit: https://www.bts.gov/about-BTS.

## Nation's First NEVI-Funded EV Charging Stations Open

In December 2023, Ohio and New York opened the Nation's first electric vehicle (EV) fast charging stations. Funded through the National Electric Vehicle Infrastructure (NEVI) Formula Program, the two openings are part of a larger plan to build reliable EV charging stations every 50 miles or less from one another on our highways nationwide. EVs are essential components in the Nation's transition to clean transportation systems as they produce zero tailpipe emissions and reduce air pollution and greenhouse gas emissions.

In January 2024, the Biden-Harris Administration announced nearly $150 million in grants from the Investing in America agenda. The grants will be provided to recipients in 20 States to repair or replace approximately 4,500 existing EV charging ports to further fill gaps in EV charging, boost the reliability of the Nation's charging network, and make charging an EV just as convenient as filling up a gas tank. Also, in January 2024, the Federal Highway Administration announced $623 million in grant awards for the first round of the

Charging and Fueling Infrastructure Discretionary Program, funding 47 EV charging and alternative-fueling infrastructure projects in 22 States as well as Puerto Rico. Last year, FHWA approved all 52 EV charging plans from States, Puerto Rico, and Washington, DC. Nearly $15 million in FY24 NEVI Formula funding will be used to implement the charging plans. NEVI is a $5 billion program administered by FHWA and supported by the Joint Office of Energy and Transportation to help States build out EV charging. The Biden-Harris Administration is on schedule for accomplishing its goal of building a national network of 500,000 public EV charging ports by 2030.

For more information, visit https://www.transportation.gov/briefing-room/biden-harris-administration-celebrates-opening-nations-first-nevi-funded-ev-charging and https://highways.dot.gov/newsroom/biden-harris-administration-announces-grants-upgrade-almost-4500-public-electric-vehicle.

## Pennsylvania Awarded $132 Million for Bridge Repairs

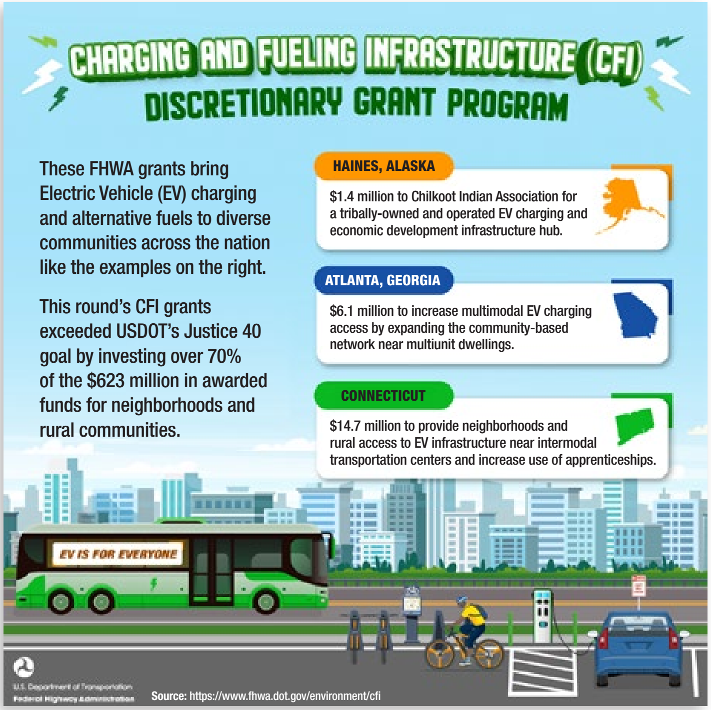
Announced in January 2024 by Robert B. Casey Jr., the U.S. Senator for Pennsylvania, the Pennsylvania Department of Transportation (PennDOT) will receive $132 million in Federal funding to fix three of the State's more than 25,000 bridges: McKees Rocks Bridge ($25 million), West End Bridge ($47 million), and the Fort Duquesne Bridge ($60 million). Funding will enable PennDOT to replace or repair the bridges' structural components, including decks, overlays, abutments, and piers. The McKees Rocks Bridge and the Fort Duquesne Bridge projects will receive direct funding from the Infrastructure Investment and Jobs Act, which has already delivered more than $1 billion to the repairing of Pennsylvania bridges.

Thousands of Pittsburgh residents and visitors rely on the bridges each day. The 92-year-old West End Bridge, officially known as the Allegheny County Bridge No. 3 Ohio River, is a steel, multilane bridge suspended by steel cables over the Ohio River. The bridge carries two lanes in each direction plus two pedestrian walkways. As the once longest-tied-arch bridge in the world when construction was finalized in 1932, it connects the West End area to the North Side. The historical McKees Rocks Bridge, which opened in 1931, is a steel trussed through arch bridge with three lanes. Pedestrian walkways are located on both sides of the trusses, and the bridge serves as a vital artery for industrial freight and commuters. The Fort Duquesne Bridge is a steel bowstring arch bridge that opened for traffic in October 1969. Taking nearly six years to construct, the bridge replaced the Manchester Bridge and spans the Allegheny River in Pittsburgh. It connects downtown Pittsburgh to areas to its north, east, and west and ferries commerce, travelers, and sports fans to the baseball stadiums on game days.

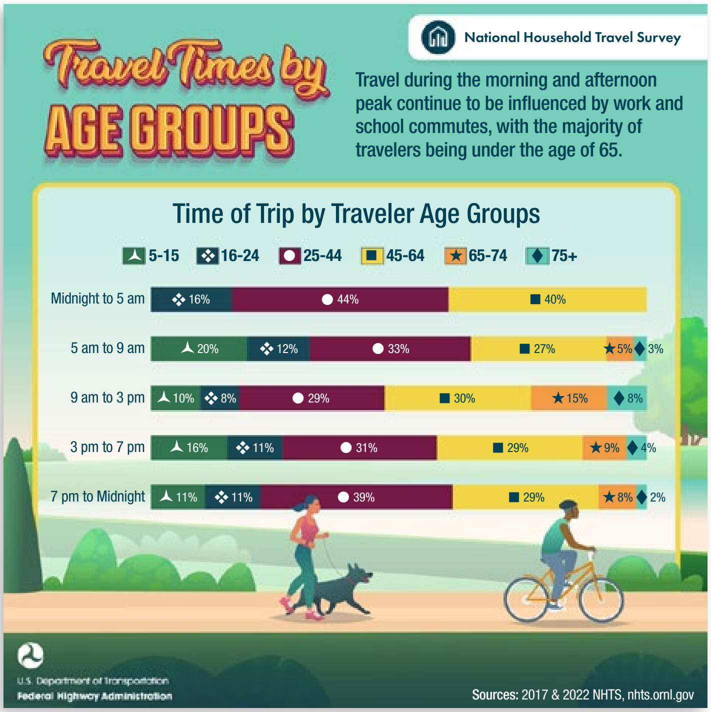
For more information on Pennsylvania's State-owned bridges, visit: https://www.penndot.pa.gov/ProjectAndPrograms/Bridges/Pages/default.aspx.

The Fort Duquesne Bridge, awarded funding for improvements, is a steel bowstring arch bridge that opened for traffic in October 1969.

# Interesting Facts









For more interesting facts, visit the Federal Highway Administration on social media: https://www.facebook.com/FederalHighwayAdmin, https://twitter.com/USDOTFHWA, https://www.linkedin.com/company/federal-highway-administration/posts/?feedView=all, and https://www.instagram.com/federalhighwayadmin/.


# NHI Empowers Professionals With New Training on Federal-Aid Highway Program Appraisals

by **JONATHAN STRAUSS**

The Federal Highway Administration's National Highway Institute (NHI) is dedicated to pioneering education in the professional highway transportation world. NHI prides itself on a learner-centric model, which is a cornerstone of its mission. This model differs from other education models by placing emphasis and responsibility on the course participant to actively engage in the learning process through self-directed learning modules, personalizing the learning experience, collaborating with other participants, and interacting regularly with the instructor. The learner-centric approach is driven by a team of experts, certified instructors, and state-of-the-art technology, all of which collectively ensure a clear pathway to educational success.

The NHI instructors play a pivotal role in educating transportation professionals. To celebrate their dedication and continuous improvement, NHI created the Instructors of Excellence award. This prestigious award recognizes instructors who demonstrate mastery in delivering courses and receive outstanding feedback from course participants, which is a satisfaction rating of 4.8 out of 5.0 on an evaluation scale. "NHI-certified instructors create a personal connection, no matter the size of the class, between the course content, the instructor, and the course participant," says James Pol, technical director for safety research at FHWA's Office of Safety and Operations Research and Development.

## New Appraisal Training

NHI has migrated more than 150 Web-Based Trainings to the new learning management system (LMS) Blackboard® to enrich transportation industry professionals' learning experience, and recently announced a new training, Practical Applications in Federal-Aid Highway Program Appraisals (FHWA-NHI-141054). With this Web-conference Training course certified by the International Distance Education Certification Center, NHI stays at the forefront of industry standards by designing courses that cater to the evolving needs of appraisers within the rules and regulations of Federal-Aid Highway Program Appraisals. Learners will gain insight into the Uniform Act, 49 CFR Part 24 appraisal requirements, and conformance with the law. A benefit of the law is the input and oversight from regulators that streamline processes to meet the demands of their jobs. Course participants will explore examples of typical mortgage appraisal assignments that demonstrate the regulatory requirements, learn how to determine the market value of the property, and understand compensation estimates for a property owner based on the laws where the appraiser is located.

The three remaining sessions of FHWA-NHI-141054 scheduled for 2024 can be found by visiting https://www.nhi.fhwa.dot.gov/home.aspx. Other courses available now in Blackboard include: asset management, business, public administration, and quality, construction and maintenance, design and traffic operations, environment, freight and transportation logistics, geotechnical, highway safety, hydraulics, intelligent transportation systems, pavement and materials, structures, transportation performance management, and transportation planning. A student orientation course for Blackboard is also available. For more information, visit https://www.nhi.fhwa.dot.gov/resources/BlackboardCourses.aspx.

Building strong relationships with stakeholders is fundamental for the success of any educational institution. Accredited by the International Accreditors of Continuing Education and Training, NHI offers continuing education units for participants in select NHI training courses. The accredited training for highway industry professionals ensures compliance and licensure with both Federal and select State operations. Partnerships with entities such as the National Cooperative Highway Research Program, whose design approach is used in the Geotechnical Aspects of Pavements course (FHWA-NHI-132040), contribute meaningful course content with real-world insights and opportunities, bridging the gap between education and the workforce.

For more information on the NHI LMS on Blackboard, see the Training Update article in the Spring 2024 issue of *Public Roads* at https://highways.dot.gov/public-roads/spring-2024/nhi.

**ABOVE:** Training and course lectures convene throughout the United States, where a subject matter expert course instructor educates course participants in person. *Source: FHWA.*

**ABOVE INSET**: *Source: NHI.*

**JONATHAN STRAUSS** is a communications specialist and project manager contractor with NHI.

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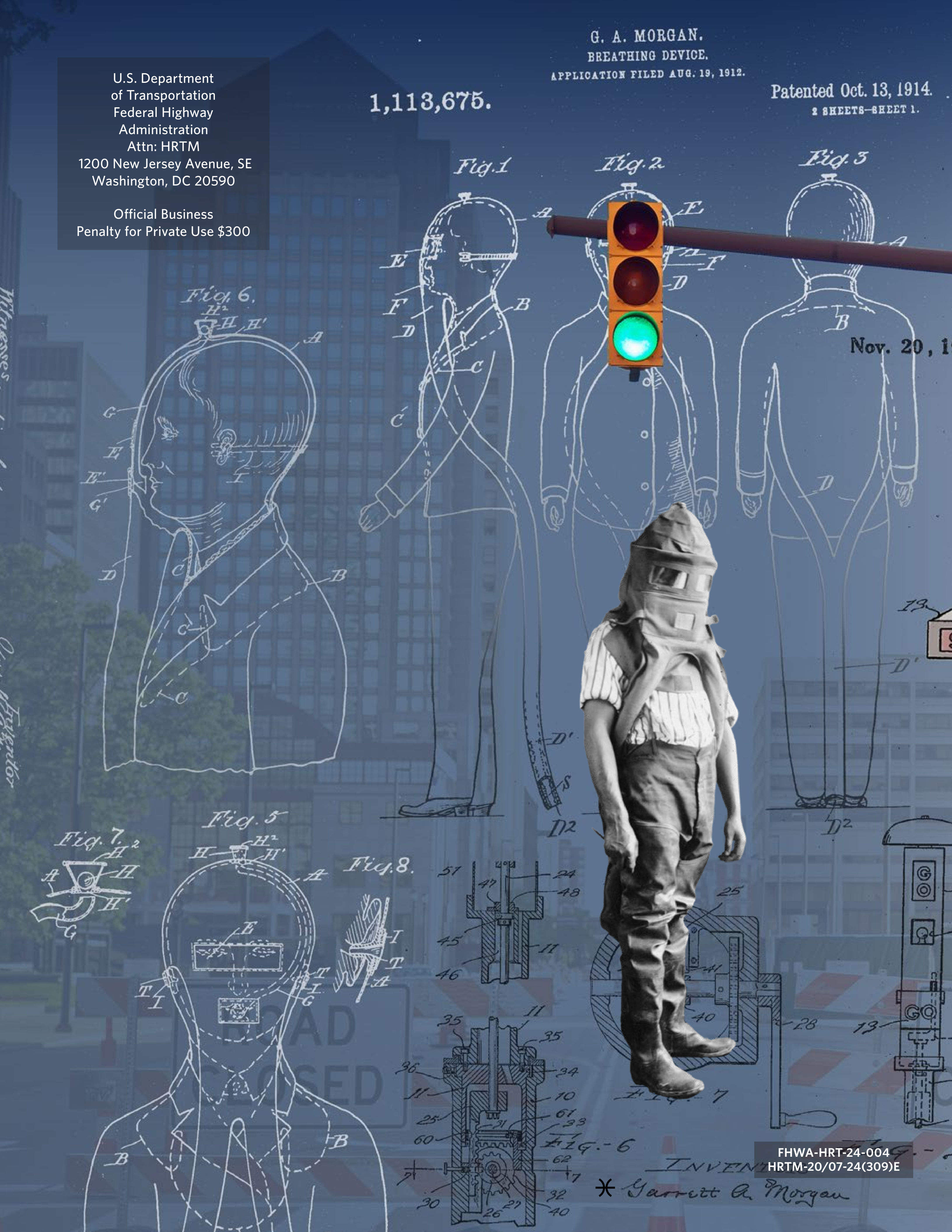


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